The History of Human Populations

Volume III

Births, Deaths, and Demographic Renewal

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For those who take the trouble to find this study useful, and employ its findings to do better.

THE HISTORY OF HUMAN POPULATIONS, VOLUME III: BIRTHS, DEATHS, AND DEMOGRAPHIC RENEWAL

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More generally, you will find explanatory notes in {braces} an in small blue type, like the one above, close to where an explanation was called for, which I signed with my initials: M[arianne] S[ophia] W[okeck] 31 July 2015}

Preface

This is the final part of a three-volume reexamination of the history of human populations. Scores of studies conducted since the middle of the past century have generated a rich and challenging, at times controversial, literature of historical demography. Inquiries, though most plentiful and detailed for western societies from the 1700s forward, have covered large and small, familiar and more exotic, populations from widely varying societies on all continents beginning with calculations for Rome and China in the first decades of the contempory era and estimates for prehistoric peoples.

The contributions of these many diverse investigations are better understood and related to each other when they are examined with an awareness of how much all demographic change follows just a few mathematically connected paths which incorporate, are based upon, positive or negative acceleration at a single fixed rate.

The new mode of analysis that this study introduces builds upon four well-known path-breaking contributions to demographic understanding: In 1751, the polymath politician Benjamin Franklin noted that the burgeoning, relatively unfettered population of the British North American colonies had for some time been growing at a continuous rate of roughly 3 percent, or doubling about every 23 years. He inferred that this was the maximum pace for unrestrained expansion with the most favorable conditions--in contrast to the marked hardships of Old World life. In 1760, the interational mathematician Leonhard Euler laid the foundations for modern stable population theory by demonstrating how, if birth and death rates remain constant, age structures and growth (or decline) in size will eventually converge to become log-linear. In the 1820s, the British actuary Benjamin Gompertz employed the generic kind of constant exponential acceleration that permeates the trends shapes proposed in this study to depict the increasing toll of mortality with age upon the population of England--without recognizing that the one standard .03 exponential rate applies to populations in general. In 1972, the modern demographer Ansley x Coale demonstrated how the significant root of the renewal equation for populations (?) had a frequency somewhat under 25 years. This study combine these path-breaking insights to create a fruitful new way to analyze populations.

Volume I showed how since records begin national, regional, and local populations have all expanded or contracted along just a few fundamentally related trajectories. Each of the half-dozen curves incorporates, is crucially based upon, the same exponential component of change. Growth along a path that constantly decelerates at a .03 rate, the G curve, has historically been far the most common phenomenon. Three other forms of expansion (log-linearly constant F at .03, more slowly decelerating H, and explosively accelerating E) along with two forms of decline (D which decelerates downward to reach a 'bottom,' or C, which continually accelerates toward complete extinction) have appeared less frequently. But, based upon the same .03 exponential rate of change discovered for G, they effectively and insightfully represent real, distinctive and insightful, experiences of populations in various historical circumstances.

Besides patterning growth in many different kinds of populations, this opening volume began to identify the types of historical conditions in which one of these half-dozen patterns of expansion or contraction has appeared rather than another. It also demonstrated how these few necessary and sufficient trends for representing long-term change in the size of populations were all fundamentally related to each other. The D, C, and E trajectories are just reversals (up and down, right and left, or both) of the G curvature on Cartesian coordinates. The F and H trends, respectively, represent increase with G deceleration that is stopped or reduced (fixed at .03, the slope for time zero, or slowed to bend only via the square root of G). While one might think such discoveries about the historical settings of the different trends their close relationships to each other would pique curiosity among students of populations, these two insightful and significant types of findings have regrettably been missed by more than one reader.

The second volume of this study demonstrated the way that migration, a frequent and sometimes substantial contributor to change in populations, has repeatedly taken the shape of the first derivative (G' or G prime) of the most common and most basic pattern of demographic growth, increase that constantly slows at the -.03 rate (G). This up-and-down G' path was shown to have ubiquitously characterized particular historical movements of humans between continents and countries, among regions within them, and into cities and towns (whether coming from far away or originating nearby). Composite migrations--mixed streams from or to different places--have instead taken the integrative G (not G') form or the more slowly decelerating H modification of G.

That specific flows into or out of populations have a 'marginal' relationship like G' to the most fundamental form of growth should not be surprising. The possibility that derivative-shape movements from the other G-related long-term trends appearing in growth might also occur more generally offers new ways to represent and to better understand the impact on population processes--and on related historical phenomena--of specific historical events, shocks, or other short-term stimuli. How are these reversible forces in effect "digested" by the long-term workings of demographic systems? The significance of the widespread marginal relationship between the G' for migration and the G found in most historical demographic growth again escaped some early readers. So did the nature and importance of G-based ties over time between migration and simultaneous historical processes such as urbanization, settlement, and economic development--connections repeatedly addressed in that second volume.

The present undertaking first traces how the little G-based "family" of trend shapes permeate all dimensions of demographic change--not just growth and migration, where they were first observed. This generalization is introduced by the historical experience of one society: England, from the 16th century into the modern era. Various components of change in populations are then shown to unfold these G-related ways globally, from crude rates of births and deaths to finer workings of fertility and mortality and to the way that populations replace themselves over time. Though inevitably incomplete, the evidence is extensive. While the earliest findings come predominantly from Europe, successive chapters can exploit more recent studies (later both in topic and in date of execution) to work with diverse and world-wide evidence and argue generality both chronologically and cross-culturally.

It would seem that, if one aspires to demonstrate generality--let alone suggest universality--it is important to include as varied evidence as is feasible. This reader, at least, would like to see more than the usual few cases mostly covering relatively short periods of time (typical of the journal literature). Furthermore, to see the commonalities and divergences among particular studies improves one's perspective on each. After decades of lively debate, for example, it now should be clear that even the long and rich demographic history of France is better understood if which aspects of it resembled, which diverged from, the experiences of England and Sweden is more definitively comprehended, as identifying the G-based trends involved makes possible. And how did demographic changes in early-modernizing countries like these compare with adjustments in peoples who 'developed' later?

A reader with less appetite for what has been common and what distinct within the sweeping variety of human experience may prefer to begin with the introduction, the especially rich English historical illustration of Chapter 1, and the patterning of historical crude rates of birth and death analyzed in Chapter 2 (the simplest far-reaching overview of international sharing and divergence), then take up Chapter 7. This surveys more refined demographic changes through time (mostly concerning fertility and crucial early mortality) in the mostly later-'developing' societies of Latin America, Asia, and Africa. These findings are compared there with insights from Europe and European-based populations of North America and Australasia--

the focus of Chapters 3 through 6--to summarize where trends have been similar or different. He or she can then look up at will in the intervening sections results and implications of the new trending and analysis for populations, periods, issues, studies, or authors that are of particular interest.

Chapter 8 then demonstrates how adult mortality has altered, both over time and by age at a given time, again and again in G-based forms. *Chronologically* these are the standard paths which life expectancy, survivorship, total age-specific morality, and casualties due to particular causes have followed as living conditions have improved or deteriorated and the ability of mankind to prevent, or to lessen the impact of, certain threats has evolved. Meanwhile, in all historical periods and cultural settings, the G-related shaping of mortality *by age* has given survivorship across most of the life cycle two distinctive forms which imprint special consequences upon age structure and how populations replace themselves. Short of fatality, meanwhile, deterioration of the human body with age follows paths that closely resemble those for sheer survivorship. Other species, furthermore, die off in a way that produces the same two-stage accelerating patterns in survivorship as for *homo sapiens*. Each, however, has its own characteristic exponential element--except for our close relatives, Chimpanzees and certain other large Old Word monkeys, who approximately share our .03 coefficient. It is through these apparently biologically determined, repeating G-based patterns of age-specific mortality and survivorship that G-related forms shape so much demographic change and so many other developments in human life that are sensitive to the numbers and types of people involved.

The insights thus far, while they should be suggestive and do much to clarify historical comparisons and contrasts, mostly rely on correlations. Chapter 9 advances to demonstrate through mathematical experiment the impact of certain forms of change, in both permanent and temporary fashion, upon demographic systems as they renew themselves through time. It examines whether expected trend shapes for certain demographic variables actually result from long- and short-term shifts in particulars of fertility and mortality. Chapter 10, finally, illustrates--again employing the rich historical example of England--the types of insight that can be had by recognizing the G-related forms that also occur in social and economic change and how these interact with demographic developments that follow such paths.

Scores of scholars have produced the evidence upon which this reanalysis relies. Thanks to their contributions, now over several generations, the kind of comparative, generalising study aspired to here would have been impossible. While trying to keep building upon their work, bringing fresh perspective to it, hopefully this author has treated those many valuable contributions with accuracy and respect.

Besides such usual indebtedness to those who have gone before, this study would also not have been possible without the support of the Department of History, Indiana University-Purdue University Indianapolis, who have generously made the requisite scholarly resources available for the past two decades. Certain grants and leaves have been acknowledged in previous volumes, upon which their support had most effect. Less academically, but no less essentially, several physicians and surgeons, through conservative, patient-oriented medicine in a challenging era for their profession, all too literally kept the author and this project alive. For even longer my wife, Marianne S. Wokeck, has kept him active, positive, and--hopefully the reader will find--productive.

Indianapolis 2013

Introduction:

Previous Discoveries and Further Findings

The first volume of this study (Harris 2001) established how growth and decline in recorded populations historically have taken six closely related shapes of trend: four of expansion and two of contraction. All of these share a single rate of exponential change that is imbedded in their formulas. The second volume (Harris 2003) explored a related pattern according to which various types of migration--free and forced, long-distance and local--have flowed and ebbed. It simultaneously probed the way that such relocations have interacted with various other developments affecting the populations into which people arrived and from which they came. While net migration generally plays a weaker role in determining population size than its companions, fertility and mortality, its historical behavior reveals much about the way that populations alter. These trends of demographic and related socioeconomic adjustment during migration, it is found in Volume II, follow the same set of a few simply connected patterns as the expansion and contraction of populations observed in Volume I. An implication of such findings is that not just movements in births and deaths, and in the replacement processes that these generate through age structures, have historically taken the same limited set of closely and fundamentally related paths. So have many less purely demographic changes in society and in human life.

Within the workings of fertility and/or mortality, in short, seems to be imbedded a mechanism that imprints over and over again just a few recurrent and simply related shapes on so much and so varied demographic, economic, social, and even cultural change. To illustrate the extent that this is so, and to determine how the imprint is made, are the objectives of this third and concluding volume of our inquiry.

PRIOR FINDINGS AND THEIR IMPLICATIONS

{Please note that the Introduction's Figures and Tables are not interleafed in the text but appear at the end of the Introduction (notes). MSW 31 July 2015}

Volume I established that human populations have for the most part enlarged in sequential trends of constantly proportionally *decelerating* growth. After some stimulus to expand occurs, the pace of further increase relative to the current number of people diminishes, and slows at a fixed -.03 rate--that is, via the G curve. This pattern is graphed in semi-logarithmic scale in Figures I.1a and I.1b. The formula appears in Table I.1. Historically, recorded population increase before the 1500s and the expansion of *local* communities (from hamlets up to great cities) regardless of time have unfolded this way (Harris 2001, 382, 384). So has demographic growth in those larger regions and total societies that have not enjoyed some continuing expansion in their resources that would permit population increase to escape the quick exhaustion of the more usual one-shot infusion of fresh opportunity or stimulus for enlargement that is represented by the decelerating, rapidly leveling-out G path.

The three expanding exceptions to the G form of demographic growth, that is, while based upon G mathematically (Table I.1), each require that significant increase in resources be sustained, that the "ceiling" implied by the asymptotic nature of G somehow be penetrated. In the longest-recognized set of circumstances, that of continental settlement--which was noted for British North America by Benjamin Franklin two and a half centuries ago (1751)--population growth enjoys enough continually available fresh resources or "room" to keep expanding at the steady .03 exponential rate without *any* deceleration. That constant proportional F slope is depicted in semi-logarithmic scale by Figure I.1a.

Beginning in the 1500s among developing countries and regions, on the other hand, has appeared a still decelerating but more *gently slowing* pattern of population increase. This involves some bend, but not as much as G. Such a "half-way" or H pattern between F and G, also graphed in Figure I.1a, summarizes more simply and more accurately the type of demographic expansion that Pierre-François Verhulst (1838, 1845, 1847) attempted to capture with his 'logistic' curve. The "half-way" nature of H is this: working from the same zero year (t_0), F is simply G divided by its first derivative or G/G', while H is G divided by only the square root of that derivative, or G/G'^{-2}--making the trajectory decelerate more slowly (Fig. I.1a, Tab. I.1).

The third growth exception to G, the E curve of Figure I.1b, is the mathematical inverse of G (G^I). It represents constant proportional *acceleration* at the .03 rate, or fixed .03 exponential increase in the exponential rate of growth. This shape of trend, also a relatively modern phenomenon in the historical record, characterizes "population explosion," a deep concern of 20th-century demography (though authors often failed to distinguish, and to understand the implications of, constantly accelerating expansion from rapid increase in *any* form). E-shape trends of growth cannot last for long. No economy, for example, can keep up with a challenge that magnifies faster and faster toward infinity. Nevertheless, for stretches of several decades at a time demographic expansions of this shape have played an important historical role. This could be negative, generating economic stress and political instability, but also positive, as in contexts of development where cheap mass labor proves useful (a phenomenon evident from the Industrial Revolution in the later 1700s to the wrenching international shifts of recent years).

The kind of socioeconomic change associated with the slowly decelerating H pattern of demographic increase has, on the other hand, been rather different. This was first illustrated simply in Volume I by identifying the kinds of nations and regions whose populations have expanded this way: from England and some North European neighbors during the agricultural revolution of the later 16th and early 17th centuries to many modern societies with growing economies, including present-day China, India, and still (for the time being at least) the United States of America, thanks in large part to its substantial immigration (both legal and illegal). Volume II subsequently showed how G-related trends of migration, occupational change, and urbanization have contributed to, and been shaped by, this H form of demographic expansion.

Like E, the two forms of *contraction* in populations are simple reorientations of G on the semi-logarithmic graph (Fig. I.1b). The D curve, Volume I demonstrated, captures the overwhelming majority of historically sustained movements of demographic decline. It is simply G upside down. After some adverse shock, loss is rapid at first, but then progressively bottoms out--even in cases as extreme as the disastrous experience of native populations during the 16th-century European invasion of the Americas. This form of contraction has already appeared among low-fertility populations of Europe, as in the DDR between World War II and the Wende, and will spread if immigration is restricted. It soon may appear in the most developed parts of Asia.[1]

Among the little handful of recurrent G-based historical changes in population size observed (Tab. I.1), finally, the C pattern of collapse is rare but insightful. It captures situations where populations seem to have lost their niche and have started to crumble, ever more rapidly. Few *recorded* historical populations so far display accelerating rates of loss towards extinction in this fashion. That is no guarantee, however, that *homo sapiens*, locally or as a whole, is immune to what has been the fate of many other species.

The relationships of these six trend shapes to each other most importantly inform further analysis of how populations change. Figure I.1a emphasizes how G, D, E, and C all involve just the same curvature flipped up and down or back and forth. F and H (Figure I.1b), in contrast, each incorporate a systematic lessening of the standard *bend* that alters at the .03 rate. Such modification in curvature occurs historically only in the growth of relatively large and composite populations in certain special circumstances for making use of their environments. This difference suggests that G, D, E, and C are likely to characterize the more basic forms of change *within* demographic systems while H and F reflect particular kinds of interaction *between* populations and their economic and social settings by means of which the rapid deceleration of G, the most usual form of growth after an opportunity opens or a stimulus is felt, can be escaped.

Each of the seven formulas in Table I.1, thanks to the constant exponential coefficient at .03, has just two parameters: 1) t_0, the *time* at which the logarithmic slope is .03 or -.03 for growth or decline, or where it is zero for G' (or perhaps the derivative of another of the G-based curves); and 2) P_0, the *level* of the curve (in Vol. I, the size of the population) at that point. In order to stress proportional error given that populations can multiply greatly across generations, the logarithms of the data are fitted with the models. This parsimony of only two parameters in each of the G-related formulas (no more than required for a straight line) is, along with the extremely simple relationships of the curves to each other and their apparent ability to represent expansion and contraction throughout the whole varied recorded experience of humankind, worthy of more attention than it has received.

Volume II then began to explore how a small set of closely related trend shapes like this might come about and could pervade the historical record of populations as thoroughly as they have. It did this by examining various types of migration and their consequences. Free and forced relocation, long-distance and local movements--all turn out to have evolved in G-related ways. And they have affected receiving and sending populations according to these same few, repeated shapes of trend.

Particular migrations, first of all, have flown then ebbed everywhere via the first derivative of G, the basic curve of population growth. Figure I.1b also depicts this G' pattern. The great transoceanic migrations of the 19th and early 20th centuries, earlier relocations to the New World from the 1500s forward (stretching from Canada to the Caribbean), and inter-regional movements--within both Europe and the Americas and across several historical epochs--have waxed and waned in this one G' fashion (Harris 2003, Ch. 1). So did specific flows that composed the much-studied, four-centuries-long Atlantic slave trade. Exports out of given parts of Africa and imports into various regions of the New World took this form (ibid., Ch. 2). The same G' pattern, furthermore, characterizes how people have for centuries gone to cities, indicates evidence from Europe, the Americas, and Asia (ibid., Ch. 3).

Compound aggregations of local movements, however, have taken G and D, and occasionally H shape instead. Examples include relocation to a group or class of cities (urbanization), the mix of slaves loaded along several coasts or sold in a variety of colonies by a national group of slavers (or the numbers of Africans caught up in the intercontinental slave trade as a whole), and comparable confluences of several contributing streams of G'shape--such as total migration to the United States in the 18th, 19th, and 20th centuries, or between Britain and several globally scattered dominions in the 1800s and 1900s.

Geographical movements of numbers of people in these few familiar and related patterns, Volume II next found, have interacted along G-based paths with change in the *composition* of the populations involved. This occurs both in a new society fed at first almost entirely by migration, as in a diverse range of colonizations by European powers from the 16th through the 19th centuries, and in a long-developing population continually supplemented by immigrants, as in many New World countries of the 1800s and 1900s or in the Netherlands during the 1600s and 1700s. Current additions to an accumulation of previous newcomers slow down then begin to diminish as early arrivals have children and grandchildren and circumstances normalize. These structural adjustments in populations, which first attract then discourage migration while being shaped by it, include sex ratios, age structures, racial composition, proportions native-born, and the presence of those with roots in particular foreign societies and cultures--unfold repeatedly in trends of G and D shape.

Migrations, though at times drawing mostly young men, typically include some women and children. It is not long before the sex balance begins to even out in the new population that is being generated and its age structure starts to normalize, containing a substantial proportion of children (and also more elderly persons). Evidence from many diverse European settlements in the Americas during the 17th and 18th centuries, from Dutch colonies in South Africa and Indonesia in the 1700s, and from New Zealand in the 1800s demonstrates that the percentages of women and children within a population in these circumstances increased in G form, though later sometimes slipped back a little via D. Comparable movements of demographic adjustment stand out since 1800 in the United States, in its white and black sub-populations, and state by state as settlement pushed across the North American continent. And, from Maryland to Bahia, they also characterize trends--between the 1600s and the 1800s--of at least partial demographic normalization that, in spite of averse conditions, emerged in African-American populations that were generated by the international slave trade (Vol. II, Chs. 5, 6).

One consequence of such demographic changes that devolved from the maturing of migration was that the percentage of the native born present in new populations of various types regularly rose via G. Besides the experience of colonies during earlier epochs, transitions of this shape appear during the first half of the 20th century within immigrant groups who came to America in the great waves before World War I. Among them, moreover--as for settlers of colonial Maryland back in the 1700s--the weight of second- and third-generation natives within the whole immigrant stock, not just the significance of all who were locally born, expanded in the same G form.

Data on population sizes and contemporaneous imports of slaves, moreover, reveal how before long in colony after colony the rate at which new Africans were brought in relative to the number already present generally shrank in D shape. The *numbers* coming in might rise and fall in G’ form; but soon the size of the continuing intake *relative to* the existing population of slaves contracted via D. Implied net natural replacement by slaves, meanwhile, tended to move in parallel fashion. Though some recorded African-American populations already produced G-shape gains of natural increase in the 18th century, for most of them D-form *reduction* in net natural *decrease* was the relevant phenomenon. In both cases, however, relative demand for fresh Africans was shaped demographically in significant ways. This development generated fundamental G-shaped consequences for the *business* of the slave trade, including not only the numbers shipped to various places and the proportions among them of males and females, adults and children but what happened to prices and profits.[2] Similar D-type declines in relative rates of migration for Europeans into colonial settlements, meanwhile, imply comparable processes that reduced need for ‘new blood’--and also reduced the appeal for free migrants to come as descendants of earlier arrivals generated more and more competition for the desired life chances.

A result of such repeated movements in G-based shapes is that the racial and ethnic compositions of populations have repeatedly altered according to these forms of trends. In place after place, persons of African descent became a larger and larger element within American colonial populations via G. Comparably, the balance and the blending, of peoples of European, native, and African origin in Spanish colonial settlements of New Mexico and Guatemala shifted in these patterns. So did the mix of several distinctive ethnic groups in 18th century Dutch colonial Batavia and the relative weights of immigrants from various sources in the population of New Zealand from the 1860s to the end of the 1900s.

In overall perspective, migration most often plays a smaller role in how populations expand or contract than the other two processes that shape demographic numbers, fertility and mortality. Does insight gained through observing how migrations develop and naturalize into peoples that experience normal demographic processes then have much value for understanding the behavior of more established, long-constituted populations in which external migration, at least, plays only a minor part?

It appears, that it does. Not only in maturing societies built from previous immigration like the United States and New Zealand, but also in ages-old populations such as those of England, France, the Netherlands, Sweden, and probably China, change in composition has consistently followed G-based trends. Demographic characteristics, notably age structure and the balance between the sexes, have repeatedly altered in G, D, C, and E patterns. Internal migration, especially urbanization and its links to changes in the countryside as well as innovation in cities, has meanwhile likewise followed G-related paths. Trends of these shapes in evidence from Europe, the United States, and other ‘modernizing’ societies insightfully reframe the analysis of international ‘development’ since the 1500s. This rich and challenging literature, Volume II demonstrated, like the slave trade provides insightful examples of the numerous, varied, and profound socioeconomic implications of the historical demographic patterns observed--implications which, it was thought, should spark considerable interest among students of populations and their relationships with their environments.

G-related movements found in the long-building, ample, and sophisticated study of European historical demographic data strengthen the suspicion--originating in insights from newer, migration-based populations--that somewhere in the behavior of fertility and/or mortality and their interaction, which determines the nature of demographic replacement, lies the source of the ubiquitous G-type .03 exponential bend. Identifying this mechanism and exploring how it works form the task of this third part of our study.

Evidence on migrations across the ages in Volume II has already revealed several clues as to how fertility and mortality also take G-related trends. First of all, changes in the proportions of the young and the old in populations imply related movements in birth and death rates. For example, C-shape declines in the percentage of children in in the populations of France, Sweden, England, and the United States suggest that C is perhaps the pattern by which the *birth rate* has fallen in country after country during the much-discussed but still imperfectly understood process of ‘demographic transition.’ Does the history of international rates confirm that? Repeated upward-accelerating paths for the weight of the old in these same societies, meanwhile, comparably indicates that *life expectancy* may have risen ubiquitously via E trends and *death rates* declined correspondingly via C.

G-based movements for the expansion and contraction of the elderly within populations, furthermore, have occurred--Volume II indicated--well beyond just familiar foci of historical demography like France, Sweden, and England. One clue comes from the 18th century G-type proportional increase for older slaves in the colonial Chesapeake. Simultaneously, G-shape trends for duration of marriages among Europeans in that region and the proportion of first sons named after grandfathers infer G-based patterns in mortality and life expectancy for that mature part of the population also. So do movements in the percentage of older men among males 16 *sui* or more of age in Liaoning Province of China between 1774 and 1873.

Direct knowledge of completed family size per woman and indirect perspective from ratios of baptisms or births to marriages in places like Batavia, Rouen, Geneva, Ghent, Worcestershire, and Nottingham, meanwhile, supplement implications from age structure that fertility altered in G-based forms. Such evidence sometimes provides insight where actual birth rates may never be reliably known.

In several settings explored in Volume II, moreover, actual calculations of birth and death rates have already been directly observed to take the G-based shapes expected. Such patterns have been identified in Nottingham across the 1700s and probably also for Newfoundland in this period. Among 19th century blacks in Cuba, the G-related character of the evidence seems firm. For slaves in the Bahia region of Brazil between the 1630s and the 1830s, the patternings are just suggestive--but intriguing. Death rates for indentured workers in various parts of the world during the 19th and early 20th century clearly fell in G-connected forms. Mortality rates per month during oceanic voyages, meanwhile--for both Europeans and non-whites, whether free persons, bound servants, or slaves--apparently diminished from the 1700s into the 1900s along accelerating C paths. Such movements suggest that the impact of improved medicine and public health as well as better living conditions reduced mortality in this accelerating form. Will the curbing of a new, contemporary threat to life like HIV-AIDS also progress this way? Such trending, it should be noted, has taken the same shape as the C-type decline in the *birth* rate that is considered, with different timing, to constitute the other edge of the opening then closing envelope of faster then slower population increase during ‘demographic transition.’

In all, several kinds of direct and indirect clues produced by the examination of various forms of migration in Volume II already have indicated that changes of fertility and mortality also alter according to trends based upon the G curve, though some readers have failed to note--or to acknowledge--the insightful implications of these findings.

Which G-related demographic patterns are followed under what conditions, and just how such movements come about, is the business of this third volume. It might have helped the reader if this discussion of origins had immediately followed analysis of growth and contraction in Volume I and preceded Volume II’s foray into the significance of consequences in areas like migration and related urbanization and occupational change. The author’s insight evolved in that order over the years , however, and completion of this present part of the study was regrettably delayed.

HOW THE ANALYSIS ADVANCES

The limited availability of suitable data biases reliable trending of even very elemental demographic particulars such as crude birth and death rates heavily toward relatively modern times. This distribution contrasts, for instance, to the way that estimates for the *size* of even very ancient populations could be patterned in Volume I (Harris 2001). Those societies which first began to keep reliable records, furthermore, are heavily over-represented in the available fund of knowledge. There exists, however, sufficiently varied and dependable information with which to fruitfully pattern, generalize, compare, and contrast several types of demographic trends since the 1700s. A few insights begin even earlier. A substantial array of movements, finally, can be followed in richly diverse international perspective since the later 1800s.

Chapter 1 exploits an exceptionally fruitful and enlightening historical example, the unusually long-running, detailed, a sophisticated record for the population of England since the 1540s, to illustrate the pertinence of G-related trends for many different aspects of demographic change. To begin, basic characteristics such as the crude birth rate, the gross reproduction rate, the percentage of the population under age 15, the crude death rate, and life expectancy at birth are simply and effectively trended mostly by just the four very simply related G, D, C, and E curves.[3]

These new patternings make sense against the background of previous findings, but simultaneously add fresh insight. Sometimes they specify and spell out in more definitive form arguments that have been less precisely or incisively made. Sometimes they reveal a phenomenon that has been overlooked. Occasionally, they suggest that a previously offered conclusion should in fact be changed or that an alternative interpretation of evidence should be preferred. Significant fresh perspective is provided on demographic movements in England's famous era of industrialization, on patterns that appeared within the long era of agricultural and protoindustrial change that preceded it from the mid-1500s to the mid-1700s, and, finally, on the shape and timing of trends for vital rates during what is considered to have been a broadly international phase of 19th- and 20th-century 'demographic transition.'

Evaluations of the pathbreaking *Population History* (Wrigley and Schofield 1981) proposed vital rates for England that differ somewhat from those argued in that original study, especially across the 1700s and first years of the 1800s. Neither these critiques nor the new perspectives from family reconstitution that were published in 1997 by the Cambridge Group themselves, however, significantly alter the *shapes* of successive trends in these fundamental demographic dimensions. To the contrary, because they approach the topic in rather different ways and yet produce similar patterning, the revisions in fact *strengthen* the argument for the G-related trendings proposed.

These verified movements for vital rates then make possible a fresh analysis of net natural increase in the English population between the 1540s and the 1990s and, by implication, allow meaningful approximation of net emigration. Movements thus estimated for this export of people can be shown to be compatible with patterns indicated by direct calculations of in- and out-flows for England--regularly since the early 1800s, and at a few points of time before then. Likewise, they can be linked to and compared with calculations obtained by working backward from colonial populations and what is known about *their* demographic behavior and intake of migrants (developed in Ch. 1 of Volume II). There emerges, in other words, a multi-dimensionally vetted, fundamental long-term understanding of how the demographic regime of England operated within the outlines of population growth that have been established in Volume I for various periods since the 1540s.

Important details of how this evolving demographic system worked during successive stages of its history have been fleshed out further in several more recent studies of the English population. These specific developments in nuptuality, fertility, and mortality clarify and fortify understanding of the cruder vital movements. They provide evidence on historical change in important contributing processes: the spread or contraction of marriage due to trends in celibacy and age at first union; where in the life cycle females bore children and how often they did so out of wedlock; loss rates for children and adults as life chances altered for the English people across the centuries. It is shown that these, and other, demographic particulars altered and interacted through time via the same few G-related shapes as the vital rates and population growth that they ultimately produced. How could just a few common and simply related patterns be repeatedly generated in population size, vital rates, natural increase, net migration, and particulars of demographic change that worked on and with each other to determine simultaneously the courses of fertility, mortality, nuptuality, growth, and migration for the country?

Were these G-based types of broad and more specific demographic trends that are evident in England then *general* across the many other populations whose relevant behavior has been adequately recorded or estimated in recent decades by international scholars? Chapters 2 through 7 present the case for a positive answer. Knowing what the particular movements were and how they were or were not shared by different peoples, or types of them, should assist scholars of both historical and current populations in choosing interpretations of demographic change while stimulating and guiding with fresh insight continuing research based upon these understandings.

To begin, several dozen national records (supplemented here and there with regional or aggregated local findings) provide the necessary information for trending in Chapter 2 *birth rates* and *death rates* internationally over substantial spans of time. These represent the crudest outlines of loss and reproduction; but they are the most immediate determinants for generating the paths of population size examined in Volume I. While there remain biases towards European and fairly recent evidence in these materials, quite diverse international perspective is nonetheless available. By means of systematic G-based modeling, comparison, and contrast of the movements in this cross-cultural, intercontinental data set, it is demonstrated how from the 18th century through the 20th particular groups of countries tended to share certain tendencies in their vital rates (as much the same populations had been seen to share patterns of growth or decline in Volume I).

This categorization to some degree resembles, but also to some extent revises, previous perceptions of the global distribution of modern demographic changes. As a framework for further, more detailed investigation, the new groupings should make it easier to identify the determinating properties of populations which display certain revealing movements, for instance: 1) the lag of decline in birth rates behind reduction in death rates (the defining characteristic of modern ‘demographic transition’); 2) the role of upwardly accelerating fertility as well as downwardly accelerating mortality in generating the ever-faster E-type ‘population explosion’ that challenged many societies beginning in the 18th century or sooner and persists in some ‘less developed’ countries today; 3) the combinations of vital rates which contribute to the only slowly slowing H-type demographic expansion that has so often accompanied long-term economic growth; and 4) the similarities or differences in cause and consequence where trends of fertility or mortality long ago resemble modern movements (how much, and how, does phenotype signify genotype?).

Chapter 3 employs several such international groupings of populations according to their historical combinations of trends in birth rates and death rates to suggest alternative ways of thinking about how movements in vital rates were generated, and interacted with each other (and with net migration) as populations expanded or contracted as set forth in Volume I. Familiar generalizations such as modern ‘demographic transition,’ frontier conditions (as in American exceptionalism), a distinctive demographics of slavery, or pervasive ‘Malthusian homeostasis’ are shown to be special cases of common dynamics that occur all populations. Sometimes (but not necessarily) distinctive demographic phenomena have resulted simply from lags between changes in birth and death rates of C or G shape. Other sets of demographic interrelationships, meanwhile, have not been optimally specified and evaluated--such as an exceptional historical demographic impact of French culture, the tendency for shared population trends to appear in countries that followed the industrializing model of modern socio-economic change first evident in England, or possible demographic heritages of later-developing peoples due to their Latin, Anglo, or Asian roots. A diverse but nonetheless ordered array of permutations and combinations among trends in birth rates, death rates, migration, and growth frames basic questions about how human populations might, on the one hand, typically *react* to exogenous stimuli of natural or man-made origin in G-related fashion, or--due to their own endogenous workings--might instead *generate* such patterns in social, economic, and cultural developments for their societies.

Starting with the extensive studies conducted by Ansley J. Coale and the Princeton group of demographic historians, Chapter 4 next reexamines patterns of change in particulars of fertility, nuptuality, and childhood mortality in Europe since the middle of the 19th century. During the hundred years leading to World War II, in one after another of these two dozen countries both overall fertility rates (I_f) and infant mortality tended, as one might expect, to decline in the C form that is identified for crude rates of birth and death in Chapter 2. Fertility within marriage (I_g) largely followed suit, making births within formal unions somewhat parallel reductions in the rate at which babies were lost--a familiar phenomenon, within families and in aggregate, as practices of fertility control have disseminated in the modern world.

The repeated substantial *lag* of decline in fertility behind infant mortality that the theory of ‘demographic transition’ posits, however, appeared in only about half of the recorded populations of Europe. Where it did emerge, and also generated the expected ever-faster ‘explosion’ in population size--in only about a third of all European nations--was (except briefly in immediately post-revolutionary France) during only the late 19th and early 20th centuries in peoples whose economic development and typically related social change lagged considerably behind the countries of the northwestern and central regions of the continent. Prior accelerating population increase in the E form, which ‘transition’ theory expects to derive from lagged C trends in death rates and birth rates, was powered in those other, developmentally leading countries rather by *fertility gains* in this same ever-faster E shape, which occurred mostly during the 1700s. By the 19th century, demographic expansion in these first-developing nations instead began to take the slowly decelerating H form associated with economic growth and urbanization.

The third of Europe’s populations had significant lags of fertility decline following comparable C-type curbing of infant mortality, but did not experience the expected accelerating ‘transition’ surge of demographic expansion. This could happen because nuptuality decreased in C fashion in these lagging populations--the way that births had traditionally been curbed through less frequent, later, and shorter-lasting marriage--while in those counties having earlier fertility control nuptuality could and did increase in G form.

Fertility rates outside of marriage, meanwhile, instead took G’ patterns all across Europe. These movements seem to have fallen away along that shape of path from crests reached during years of maximum disruption for demographic regimes from the social and economic changes involved in ‘modernization.’ These G’-shape indications of stress in the form of illegitimate reproduction peaked earliest in northwestern Europe (where socioeconomic change arrived first), then penetrated southward and eastward. In northwestern and central parts of the continent, meanwhile, marital fertility *also* tended contemporaneously to take G’ paths (which capture these movements more exactly than the more general alternative of C decline). In these more actively developing societies, rates of childbearing within marriage and without *both* crested then fell off via G’ as socioeconomic change simultaneously strained reproductive relationships and provided new opportunity to marry.

Following World War II, also, G’ patterns in marital fertility (‘baby booms’), and now also nuptuality (‘marriage booms’), distinguish the ways that some European populations adjusted to new conditions from the behavior of others. So do further decreases of infant mortality in decelerating D form rather than via accelerating C. These D declines currently lead toward a ‘bottoming out’ of reduction in the loss of young children even in the age of modern medicine.

Studies of certain regional or local populations of Europe, or of particular social groups within them, supplement information from a just a few available nationwide records with historical depth, and make it possible to identify trends in fertility and related developments like early mortality and family formation well before modern ‘transition’ picked up steam in the 1800s. Chapter 5 uses some of these findings to expand and strengthen understanding of change in fertility across the centuries.

First of all, national data from England, France, and Sweden--and shorter series from a few other European populations--indicate that the kinds of G and C trends that characterize marital or extramarital fertility, nuptuality, and infant or childhood mortality from the 1800s forward were typical *before* then, too. Evidence is available at least as soon as the later 1500s. For such earlier times, the G' shape once again captures the rise and fall of extramarital fertility, just as during the modern 'transition.' As is well known, the chief *new* demographic development of the 19th century was how reduction in marital fertility now widely replaced a decline of nuptuality in collectively regulating births. The G-related trends along which the principal components of net reproductive change adjusted--marital fertility, extramarital fertility, nuptuality, and infant mortality--retained, however, the same forms that had appeared for centuries.

Total fertility in certain social groups (mostly elites) is seen to have declined in C fashion during the later 1500s, the 1600s, and the 1700s. And the role of family limitation in this process increased via G--first in northern Italy and Switzerland, soon evident in France and Belgium, but not reaching the aristocracy of England before the 1800s, it seems.

Findings of community studies from the 1600s forward, meanwhile, show how C-shape contractions of completed family size diffused from early centers of demographic change like Geneva and Rouen across many parts of France in between, also from regional centers to lesser communities around them, and likewise from middle to lower social classes. Similarly, the fertility rates of specific age groups of women display declines of C form (once again, in more than one trend of this shape). Older cohorts of females generally led the reduction, whether one considers the general population of Geneva or the elites of Milan and Florence in the 1600s or French, German, and Hungarian communities from the middle 1700s to the early 1800s. Evidence from German villages and from Swedish national data, however, reveal how reproduction by women of younger ages could simultaneously increase in opposition to these movements among older women, holding overall fertility high or even increasing it because of the special weight of young mothers in total reproduction for a population. The role of declining (or increasing) infant and childhood mortality in fertility trends, meanwhile, can be observed from northern Italian communities of the 1600s to German villages and regions in the 1800s, and a recurrent G pattern in adopting fertility control (*m*) can be traced from the elites of northern Italy and Geneva in the 1600s to settlements of the Hungarian frontier in the waning 1700s and early 1800s, and to weaker family limitation in German villages later in the 19th century.

Demographers, finally, have long struggled to assess the role of values--particularly religious ones--in the determination of fertility. Conventional religious categorizations prove tricky in such analysis--for instance in Catholic but revolutionary France, which secularized significantly. The concluding section of Chapter 5 shows how in France and neighboring territories, especially Belgium, indicators of secularization tended to surge and recede in G' form. Such patterns appear in rates of illegitimacy, premarital conception, the abandonment or neglect of children, and extramarital fertility. They related to movements of this G' shape in the frequency of marriage, the rate of childhood mortality, and fluctuations of the economy. The rich, long-accumulating body of local and regional data, in short, adds valuable perspectives--in subject as well as in historical depth--to the national evidence for understanding the demographic development of Europe. And the analysis of these patterns relative to each other clarifies the role of temporary G' surges in historical phenomena as well as the longer-lasting G-based trends in demonomic systems.

Chapters 6 and 7, then, examine these kinds of demographic and related change in populations outside of Europe. Not only do the G-based patterns appear globally; they provide fresh and fruitful perspective on issues of international comparison and contrast, and elucidate what might cause those similarities or differences.

In societies founded by British colonization, and to the present time still composed principally of persons with European roots--the United States, Canada, Australia, and New Zealand (Ch. 6)--prior to World War II fertility contracted in C fashion, as in contemporary Europe. What has followed, however--for instance shared G' 'baby booms' from the late 1930s through the 1950s, then distinctive D' decrease in the United States and Canada followed by exceptional G-shape gain in the U.S.A. since the 1980s--has insightfully differed from European patterns.

The decline of fertility in C fashion that is so characteristic of ‘demographic transition’ in fact appears consistently in parts of what became the United States--in a variety of documented territories and communities (in New England, the Mid-Atlantic, and the Upper South)--from the third quarter of the 18th century forward. Though having different starting levels, these trends closely parallel contemporary proportional contractions of C shape for total fertility in France--even in its regions of earliest demographic adjustment: Normandy and the Southeast Paris Basin. They exceed C declines in contemporary Sweden and the Southwest of France. It is England that stands out in contrast internationally. There, total fertility rose in upwardly accelerating E fashion between 1725 and 1815, almost exactly opposite to the C-shape decline in Britain’s own colonies and the trends for other European powers. While local trends of urbanization and shifts in employment from agriculture to manufacturing in eastern Massachusetts closely resembled the patterns of industrializing England, whose economic development the region quickly mimicked, fertility even there contracted in C shape rather than rising via E.

Prior to the middle 1700s, *increases* of fertility in G shape in New England and the Chesapeake likewise paralleled gains in this form observed for England, Normandy, and France’s Southwest. During this era, peoples on both sides of the Atlantic evidently shared some stimulus to produce more children. The historical succession of first G expansion then C contraction in fertility, moreover, also appeared subsequently--before and after the early 1870s--as Mormons settled Utah and neighboring regions of the West.[4] This kind of finding, along with state-by-state assessments of white fertility across the first half of the 19th century (and some analysis of the composition of colonial populations in Ch. 6 of Vol. II), indicate that as New World settlements aged, the G-then-C succession of movements in fertility rates was ubiquitous.

There is also some evidence that the G’, up-then-down pattern of fertility found in early New England towns, which stripped Harvard College of entrants in the early 1660s to the dismay of President Charles Chauncey, occurred in tidewater Maryland, where comparably an early wave of settlers of concentrated age enjoyed exceptional ‘virgin soil’ opportunity to form and support families before competition rose and conditions normalized. This same type of G’ movement, furthermore, crests around 1850 in a nationwide study of American genealogies, a time when robustly reproducing families poured settlers westward to man the archetypical Turnerian ‘frontier.’

When settlements matured, women of child-bearing age became a larger portion of the total population. As had happened in colonial times, across the first half of the 19th century in state after state women 16 through 44 composed proportionally more of all U.S. whites in G fashion. They were no longer pressured to marry as early--which had been the case during early, predominantly male settlement--and bore fewer children. Very generally, in fact--not just in the special historical context of demographically normalizing colonization--age at first marriage, age at birth of the last child, and duration of marriage all increased or contracted from the 1600s forward according to the same few G-based paths encountered in Europe.

Between 1798 and 1878, meanwhile, celibacy for U.S. women surged via G’ through a crest about 1840--the up-and-down pattern encountered twice, for example, during the shifts in English life that had characterized the 17th century. Overseas colonization and continental settlement frontiers were not the only ways that the opportunity to have a family opened up or closed off. Economic change could have similar effects. Like celibacy, rates for premarital pregnancy and illegitimacy tend to reflect times of stress--in repeated G’ surges. Sometimes these North American patterns paralleled movements of that form in France or elsewhere in Europe. Sometimes particular trends occurred in different periods and with distinctive timing.

Age-specific fertility in sub-populations of British North America and the United States established out of them increased or declined much like what has been observed for European populations--from 17th-century Geneva, Flanders and Brabant, England, and the elites of Florence and Milan, to early-20th-century Sweden. In Nantucket during the early 1700s and later-settled Sturbridge during the second half of that century, the G' surge reflecting new opportunity to raise children appears for most ages of women. Decline in C fashion soon became general there and in other communities or sub-populations. Tendency for older wives to reduce fertility more robustly than younger ones (to do so along C trends with earlier zero years), another European phenomenon, can be seen across the 1700s and the early 1800s in Nanucket, Deerfield, and Sturbridge, among early Mid-Atlantic Quakers and elite families in Philadelphia, and for the U.S. population between about 1840 and 1870. This distinction by age, however, does not appear in a national collection of U.S. genealogies, perhaps because of the way that women of various ages in a family did or did not participate in migration to new settlements, which had higher fertility. This international tendency for older but still fertile women to experience stronger decrease in reproduction raises the topic of family limitation.

Most historical decline in births before the 19th century has been attributed to reduced nuptuality. Females married later. Fewer ever wed. Unions were broken by high rates of mortality before reproduction was no longer possible. Contrary to an emphasis upon French exceptionalism in the literature, however, and to the prevailing view that nuptuality accounted for any English reduction in births until very late, fertility *within marriage* in North America--not just overall fertility--diminished via C trends that generally paralleled movements of this shape in contemporary France. This similarity is evident in national data from 1840 or earlier. In the older-settled regions of New England and the Mid-Atlantic, though, such contraction in C fashion parallel with reduction in France had begun already as soon as the 1740s.[5] What *did* set France apart was the way that Normandy had *previously* experienced some C-shape contraction in marital fertility between 1730 and 1770 and how the trend in the Paris basin had commenced its much flatter decline as of 1700, though marital fertility in the Southwest continued to increase gradually via G until 1790. From the middle of the 18th century forward, nonetheless, the two society-wide sequences of C-type trends were very similar.

Reduced fertility within marriage, most of all among older wives, suggests the dissemination of some conscious control of fertility. Though it, too, followed a path of G shape, it was the 1890s before the *m* index for parity-related family limitation for the United States as a whole (among whites, at least) increased as strongly as has been observed in the elites of northern Italian cities and Geneva or the French peerage as early as the 1600s and 1700s. Already between 1820 and 1890, however, the national G-shape increase of *m* resembled in level family limitation during the 18th and 19th centuries for several (though not all) communities of Hungary and Germany that have been studied and, it seems, among the Belgian aristocracy. Lagging groups such as the Mormons and the Old Order Amish display strong G gains in family limitation only during the 20th century. Conclusions based upon the levels of these trends must be constructed carefully. Reliance upon local insights from one population and aggregate data for another can easily distort international contrast or comparison. The repeated G form for adopting fertility control, however, is clear internationally across the centuries.

Evidence as to *how* fertility may have been limited in the United States has repeatedly changed in G-related patterns. The spacing of births increased through time at successive parity levels along G and E paths--both in Nantucket from 1700 to 1830 and among Utah's Mormons between the 1860s and World War I. Time of husbands at sea, introduced to explain this change on Nantucket, of course did not apply in the Great Basin.

The average frequency of coitus for middle-class married women in the United States, on the other hand, increased in G fashion from the 1890s through the 1930s as couples could manage reproduction more and more reliably. Reliance upon traditional methods for curbing births--abstention, withdrawal, douching, and copulating only during "safe" periods of the menstrual cycle--each became less frequent in C fashion over this same period. Specific modern techniques, meanwhile, became more popular in G' shape. First it was the use of condoms, pessaries, and diaphragms between 1894 and 1935, cresting in the mid-1930s. The employment of suppositories, jellies, and other 'chemical' means followed--between 1922 and 1944 the frequency of their use headed toward a maximum in the late 1960s. Did adoption of “the pill” take the same G’ track subsequently? Together, however, between 1894 (or sooner) and 1935 reliance on the modern techniques--both ‘mechanical’ and ‘chemical’--became more frequent among U.S. women in G rather than G’ shape, as the use of older, less effective methods of family limitation contracted in C manner.

In all, from broadest outlines of change in fertility and marriage to finest details of mechanisms bringing about this change, G-based trends pervade in New World as in Europe. Recognizing these shapes makes for netter contrast and comparison.

Modern populations of the United States, Canada, Australia, and New Zealand, after all, grew out of European societies. European settlers (who, region by region, soon overwhelmed indigenous peoples) brought European institutions, customs, and values with them, which established a hegemony over many aspects of New World life. This was especially true before the middle of the 20th century, when the roles of those with origins in Africa and of recent migrants from a variety of non-European sources became more significant. Why shouldn’t their demographic behavior resemble that of Europe? Did the same patterns of historical change, however, pertain elsewhere--where the bulk of humans have in fact lived?

Chapter 7 first of all demonstrates, how, while fertility rates in the populations of particular continents have each contracted along one G-based path or another since about 1970, they have done so in quite different ways. In northern, western, and central Europe and in the “offshoot”, once British colonial countries of Chapter 6, total fertility between 1963 and 2003 dipped in D’ fashion (via the first derivative of D), bottoming out in the late 1980s. In eastern Europe and Russia, two such sags occurred, before and after 1988. One minimized in the mid-1970s; the second is projected to do so about 2020. In Latin America and the Caribbean and in the sometimes huge populations of eastern, southern, and central Asia, total fertility declined instead in a single D trajectory between the late 1960s and the early 2000s, in each area with a zero year in the late 1960s--or in very parallel ways. In western Asia and in Africa, in contrast, fertility still shrank along the kind of C path found before the middle of the 20th century in Europe, America north of the Rio Grande, and the large countries of Oceania. Up into the 1960s, though, fertility was still collectively increasing via G. For North Africa and western Asia together, the zero year for C arrived about 2005; for Sub-Saharan Africa, it is not projected to come until some 40 years later. For all of humankind, the average rate of total fertility from the 1960s through the 1990s contracted in D fashion with zero year about 1967. In these broad continental terms, components of modern demographic transition are seen to diffuse around the earth in a way that shifted fertility decline from accelerating C though decelerating D to actually bottoming out and beginning to rise back somewhat via D’ after seemingly overshooting a new equilibrium.

Patterns for some individual nations that have accessible historical records clarify and further systematize how such change unfolded globally. In the Western Hemisphere south of the U.S.A., C-shape decrease in fertility is evident by about 1900 in Argentina, Brazil, and English-speaking countries of the Caribbean (except Guyana), while mostly G-type increase continued elsewhere until the 1960s or 1970s. In most nations D’ dips began by the 1960s or 1970s. (Decelerating but not yet rebounding D trends of decline for some reason appeared about 1970 in Venezuela and Panama, the only modern national cases observed globally for this trend in fertility.) In Mexico, Guatemala, Ecuador, and Peru, the shift from C took place only in the 1980s, while for Nicaragua, Honduras, El Salvador, Bolivia, and Paraguay transition occurred as late as the 1990s or 2000s. Generally speaking, the less developed a society, the more delayed was its demographic transformation--whether shifting first from increase to decrease in fertility or then from accelerating (C) to decelerating (D’ or D) fertility decline. Having larger indigenous majorities and less continuing influence of European origins (in some cases significantly reinforced by recent immigration) has likewise been a significant factor in retarding demographic transition.

In the meantime, among documented countries of eastern, southern, and central Asia, fertility rates for Japan and Korea distinctively began to contract in C fashion by the 1920s, while elsewhere the 1950s and 1960s were more common points of transition to this path from G increase--though colonial India's Punjab had switched by about 1940. Subsequently, in India as a whole, Indonesia, Pakistan, Nepal, Viet Nam, and (probably for different reasons) Japan, transition in fertility decline from C to D' did not occur until about 2000. A turning point in the 1970s or 1980s was more common, while in Singapore and the Punjab the shift had taken place already by about 1960.

Where adequate records exist in western Asia and northern Africa, C trends in total fertility had mostly started by the 1960s. For poor, strongly traditional Yemen, G-shape increase exceptionally continued to as late as about 1990. The subsequent shift from C to D' mostly appeared only in the vicinity of 1990 (closer to 2000 in Algeria and Morocco). It happened earlier in Turkey, Cyprus, Egypt, and especially Israel (by 1953 or possibly sooner).

In Sub-Saharan Africa, the French islands of Mauritius and Réunion stand out for D' trends that began in the 1960s. South Africa and Kenya display this kind of dip starting about a generation later, Otherwise, the shift has not yet occurred. Combining observed rates so far and recent projections, C-shape decrease in fertility everywhere but in Réunion, Mauritius, and South Africa is expected to last for more years to come, as late as the 2030 in Côte d'Ivoire, Burkina Faso, Nigeria, Cameroon, and the Democratic Republic of the Congo, on the one hand, and Sudan, Ethiopia, Tanzania, Uganda, Malawi, and Mozambique, on the other. In all other African countries and on all other continents, this particular component of classic 'demographic transition' appears finally to have been completed by now.

The Sub-Saharan populations of Nigeria, Zambia, and the Democratic Republic of the Congo, finally, between about 1950 and 1990 produced increase in fertility that took E rather than G form. Elsewhere in modern times, this phenomenon has also occurred in Brazil between 1945 and 1965, Guyana all the way from the 1890s into the 1950s, and Bangladesh in the period

1953-1973. Earlier in time, exceptional accelerating E-shape fertility increase in England from about 1750 into the early 1800s, and its impact upon real wages, were exploited by entrepreneurs in generating the Industrial Revolution. Other northern European societies display comparable tendencies, judging by the E pattern of their birth rates, though specific evidence on fertility as of the late-18th and early 19th centuries is slight. Did the industrialization of Brazil and the sugar industry of Guyana to some extent benefit comparably from this type of demographic change? What happened in the rare recent cases of Asia and Africa?

This global panorama of trends in rates of fertility was shaped by several familiar historical changes, which appeared well beyond the European and Europe-based societies where they were first and most fully observed. In each case, the trends in such factors affecting fertility took G-based forms. These patterns in turn help to unravel the impacts of such developments upon reproduction and related early mortality.

As conditions for human life improved globally from country to country in the 20th century, early mortality fell, first via C then "bottoming out" in D' fashion. This pressured fertility to alter in parallel paths, though these did not always have identical timing. Any ensuing delay between decrease in death rates and decline in birth rates made populations grow--often along accelerating E paths in developing nations. Similar close links between infant mortality and fertility also occurred in much earlier times. In the Chinese imperial lineage between 1700 and 1830, the movements were parallel (first via C then according to E) as they had been in England from 1640 through 1730 (via G). Thereafter in England, however, fertility rates rose in E fashion, clearly *opposite* to the C path of decline in infant mortality. That magnified the pressure for population to grow during this transformative era for Western life, fostering urbanization and feeding industrialization with cheap labor (not foreign, in the fashionable present-day economic model of outsourcing, or through immigration as in the United States during the 1800s, but from domestic sources).

Aggregate levels of urbanization, education, relocation from agricultural employment to manufacturing and services, and gross domestic product per capita have historically tended to increase together, globally as well as in societies with primarily European roots. Their paths, while comparably G-based, have not been similar from country to country--which has been the case for modern trends of early mortality and fertility. The most frequent parallel (evident in Latin America across the 20th century, for example) has been between gains of G shape in education and wealth. This has occurred, however, while fertility and early mortality followed a variety of G-based paths, even among populations that shared the distinctive H pattern of population growth that has characterized robustly developing countries such as England, Sweden, and the United States from about 1850 to World War II or China, Indonesia, Thailand, and again the United States since about 1950. Nevertheless, variables thought to shape historical population change have in Asia, Africa, and Latin America altered in G-based patterns as much as in earlier-developed countries of the world; and observing the related nature of these movements provides further insight into how populations have evolved over time.

As work outside the home has become available for females, their average age at first marriage has increased. This in turn has lowered fertility as women (like New England 'mill girls' in the early1800s) have chosen income, freedom, and lifetime living standards over starting to have children right away. Accelerating E-shape gains in mean age at marriage may appear small in number of years, but they lowered fertility in substantial reciprocal C fashion--in England across the first two-thirds of the 1600s and in the United States during much of the 1700s and the early 1800s. Comparably, during the second half of the 1900s, E trends in age of first marriage for females were accompanied by C-shape declines for fertility in Japan, South Korea, Hong Kong, Taiwan, Indonesia, India, and Pakistan, to cite some Asian examples. In China, exceptionally, while the female age of marriage likewise rose via E from 1945 through 1980, fertility *increased* somewhat in G fashion between 1930 and 1970. Harsh reproductive policy was one result.

The ways in which women of different ethnic backgrounds within a given country participated in the changes of employment and reproduction taking place likewise took G-related forms. Chinese women in Malaysia and Singapore, for instance, married later along an E path like rural and urban women in China and females in Hong Kong and Taiwan. Malay women in Malaysia also married later between 1950 and 2000; but their increase instead took decelerating G shape as for Malay wives in Singapore, Brunei, Sabah and Sarawak, and Indonesia. For females of their distinctive Malay background, the opening for change quickly began to close rather than growing wider and wider with time. This distinction in trends for age of marriage conforms to what is known about the cultural history of the ethnic group in recent Malaysia, where a resurgence of Muslim religious traditionalism in the later 20th century shaped the experience of women. The experience of Indian females in Malaysia for some reason paralleled that of Malays, though in India the E trend occurred instead. Recognizing the G-related shapes of change, not just its net direction, helps understand what might have driven the relationship between age of marriage and fertility under various historical circumstances and how its connection to education, employment, and social values evolved through time.

In more recently developing societies and well as their predecessors, fertility for women of different ages likewise took insightful G-based paths. In Peru, for example, from 1940 or sooner to the 1960s the older the mother the more robustly fertility rose via G. Thereafter, it fell in C fashion--the older the woman, the more steeply. Older females were more responsive to either increasing or decreasing their reproduction. This age-related tendency had appeared in Flanders and Brabant between roughly 1630 and 1775 (shifting from G to C in the vicinity of 1685), in England between about 1610 and 1740 (though down to the 1660s, up thereafter), among U.S. Mormons between the 1840s and the 1920 (peaking near 1870), and on Nantucket from the 1690s through the 1820s (though the rise that preceded C decline, which began around 1740, took G’ rather than G shape).

In Asia during the second half of the 1900s, in contrast, while in Singapore, Pakistan, and the Philippines there was some tendency for women at the very end of their reproductive span--in their 40s--to reduce fertility via C more strongly than younger wives, and in Sri Lanka there was some tendency of mothers under 30 to lag in C decline, no systematic weakening across the fertile span of their lives appears, the phenomenon common to the demographic histories of Europe and North America. Among Bangladesh wives under 30, fertility increased rather than declining via C as it did for older women, In China, where fertility at most ages decreased exceptionally in D fashion across the 1970s and 1980s, trends for the young bottomed out sooner and therefore more weakly than among older wives. These sometimes similar, sometimes divergent patterns across the historical record help to reveal better how overall fertility decline was taking place.

Crucial for modern reduction in fertility has been the dissemination of methods for preventing or terminating conception. Internationally--for example, in several Asian countries between about 1960 and 2000--adoption of particular techniques has taken G' shape. This is the same pattern found for the use of various measures by middle-class U.S. wives between about 1890 and 1940. One difference stands out, however. In much of modern eastern and southern Asia the aggregate frequency for all methods bends in G' manner rather than accumulating via the constantly decelerating but continually increasing path of G. The popularity of intervention in general, in other words, has expanded as if driven by an event or a policy action rather than the dissemination of a practice, whatever method was preferred. This distinction would seem appropriate for the way family limitation spread historically between the 1890s and World War II among middle-class women of the United States as opposed to the its nationwide promotion since the middle 1900s in countries where population was 'exploding' at considerable socioeconomic cost.

In modern Asia, the crests of these G' curves of adoption have been, or will be, reached much later. The frequency for all methods, for example, has followed G' curves with zero years near 2000 in India's Punjab and Sri Lanka, 2010 in rural and urban China, 2030 in India as a whole and Bangladesh, and only 2040 in Nepal and in Pakistan (based on the 1990s). Within Peninsular Malaysia, the adoption of 'efficient' methods in the North and the South lagged 10 years behind the East, and 20 years after the Central region, a geography significantly linked to ethnicity within the country. Reliance on 'safe periods,' sterilization, abortion, injection, pills, and other methods each increased in G' shape from country to country. The patterns should help delineate how various techniques spread from one kind of women to another and what made them popular or less used. In the details of family limitation, as for so many other aspects of demographic change, the recurrent trends are G-based and global.

What made G-related movements so ubiquitous? Chapter 8 pursues that issue through the nature of human mortality. Rates of death in childhood make a major impact upon population growth, and have been seen often to imprint their paths of change through time upon fertility. Patterns of *adult* mortality, particularly across the long segment of the life cycle between puberty and old age--the active years of work, family formation, and power--do much to shape how populations replace themselves, to determine how demographic systems work internally and interact with their environments.

On the one hand, many aspects of mortality are observed to change over time along G-based paths. Not just the crude death rates and rates of infant and childhood mortality examined in previous chapters have bent this way.

Life expectancy at birth in Europe, for example, increased twice via G between 1800 and World War I. Then it accelerated upward in E fashion to the middle of the 20th century before improving again in slowing G manner to 2000. Trends in Japan, Oceania, and the Americas rose in parallel fashion, though in the United States between about 1790 and 1880 life expectancy at age 10 instead distinctively declined via D then D', presumably as a result of the large-scale migration and urbanization taking place there. Earlier, however, from the middle 1700s into the early 1800s life expectancy in the United States and in England had risen together in E manner. Across the 20th century, moreover, the G or E trends in several nations paralleled gains of those same two shapes in gross domestic product per capita and--less frequently--literacy (which increased via G whether life expectancy and GDP rose via G or E). Once again, the G-related trending helps link significant historical changes with each other.

Behind these increases in life expectancy, furthermore, in country after country across the later 19th century and the early 20th century particular causes of mortality have each became less, or more, frequent in G-based patterns. With advances in medicine and public health, contagious diseases have taken only a markedly reduced toll from populations. Their frequency declined during the later 1800s and early 1900s repeatedly in C' form (accelerating downward via the first derivative of C, which is the vertical reciprocal of the E shape taken by life expectancy and has internationally been the path of crude death rates and the rates of infant mortality during 'demographic transition') until--beginning about the 1940s--'floors' in the later 20th century have been approached as further improvement has become more and more difficult to make. This 'bottoming out' in mortality rates, including some rebounding increase here and there, has followed D' paths (the first derivative of D, which is the reciprocal of G, the most recent trend for rising life expectacy at birth).

For other, more endogenous threats to the human body, death rates have repeatedly risen in G' fashion. For cardiovascular issues and neoplasms, such movement appeared mostly twice in a country, up to and after about the 1930s. For degenerative disorders, rates increased once into the 1940s in G' form, after which their frequency headed in D' fashion for minima in the later years of the century.

Particular historically notable causes of death have comparably become more common then tapered off along such G' trajectories. The frequency of plague cases within the European population followed one such path from the 1580s all the way through the 1820s. This early modern resurgence of that notorious killer maximized in the first years of the 1600s. Recurring

G’ movements, meanwhile, characterized rates for small pox in Geneva and London and for neonaticides in New England, in each case between about 1650 and 1830. Homicides in New York, Chicago and Los Angeles surged repeatedly along G’ paths between 1800 and the 1990s. Malaria fatalities in the Punjab between about 1880 and 1940 crested in the vicinity of 1890 before receding. Like all forms of the disease together, in the United States across the second half of the 20th century the modern scourge of death from lung cancer expanded then began to contract in G’ manner, maximizing for men about 1990 and for women some 15 years later. The prevalence of obesity, a leading threat for the future, has shown signs of peaking near 2009 for non-hispanic whites, blacks, and also hispanics in the United States. The depth and severity of obesity comparably promise to crest via G’ for whites and blacks in the 2020s, for hispanics a decade sooner. Last--but far from least--according to data and informed projections covering from 2000 through 2050, the frequency of HIV-AIDS cases in the world’s population aged 15 through 49 has been following a G’ path timed to have maximized about 2003. The G’ pattern, in other words, very generally captures the historical spread of a threat, whether this has arrived fresh on the scene, has somehow received new stimulus to increase, or has simply been left to dominate mortality more significantly as other risks have been controlled.

Mortality *by age* also has ubiquitously followed G-based patterns. Between childhood or adolescence and the 60s or 70s, life expectancy has repeatedly decreased in C manner. From there into the 80s, C’ shape prevails instead as the hardiness of those who have survived so far and the ultimate mortality of mankind vie to shape the net path. This succession of C then C’ trends is ever-present in 20th-century populations, but (both contemporary and modern studies show) also in historical ones back through the 17th century (in Europe, Asia, and North America) and even appear in Ulpian’s analysis for 3rd-century Rome. The level at which the C path begins (reflecting the amount of childhood mortality that has taken place) and the age at which the shift from C to C’ occurs change. The shapes of the two patterns and their order remain the same.

The same sequence of trends applies to survivorship--what proportion of an initial population remains alive at a certain age. Again the findings are global, both national and local, and recurrent since the 1500s; and C and C’ trends with age shift the same way--by starting level and duration for C. While C’ begins at different ages (later for modern people), the zero year for its curvature is more stable (mostly about age 20 to 30) because the trend soon comes up against the inevitable mortality of individuals.

Interestingly, furthermore, the erosion of human capabilities--as measured by strength or health according to age--follows the same types of C then C’ paths. Those who in the 19th century paid farm labor in England or bought slaves in the American Old South adjusted for these tendencies, judging by the wages or prices that they paid for labor.

The recently popular study of stature as an indication of health through time, moreover, provides considerable evidence of internationally shared D-shape decline during the second half of the 18th century (and some during the early 19th in the United States and the Low Countries). Subsequently height increased via G in the United States and some locales of the Low Countries and Argentina, a pattern of improvement also found earlier--in France and Bavaria and among U.S. whites between about 1690 and 1750, and in England and France from about 1790 to 1830. For particular groups in particular circumstances, however, G’ could be the form of temporary gain in stature. It was among emigrants from northern India during the second half of the 19th century and refugees from North Korea who were the same age between the 1930s and the 1980s. In the context of mixed “pushes” and “pulls” that typically characterize migration, each movement at a certain point attracted the most fit participants in its history.

Survivorship patterns are the residue left after age-specific mortality rates have done their damage. They have very generally taken E’ shape (the first derivative of E, which is the reciprocal of the C pattern that prevails in survivorship across most ages after childhood). While survivorship followed C then C’ paths, two such E’ trends from early adulthood forward have been most common (though sometimes more have appeared). This phenomenon implies a somewhat different relationship between age-specific mortality and survivorship during those ages when the latter takes C form than when it follows C' (C' being simply the reciprocal of E', while C is rather the reciprocal of the *integral* of E', or E). These combinations of patterns are found among Durham monks between 1400 and 1530 and members of the Chinese imperial lineage during three successive periods from 1640 through 1890. They appear in mid-19th century Britain and New York and characterize a variety of modern populations on all continents.

It is well known that certain hazards typically threaten individuals of particular ages. These impacts by age also have taken G-based shapes historically, from one country to another. For the most part, the accelerating E' path with age has represented the frequency of adult mortality from influenza, pneumonia, and bronchitis, diahrreal disorders, other infections and parasites, and miscellaneous and unknown causes of death. The older the individual, the more and more dangerous these hazards have become. From neoplasms and certain degenerative diseases, in contrast, the toll with advancing years tends to slow down via G', often twice (to about age 60 or 70, then once more). The death rate from cardiovascular disorders has left a mixed pattern: first, mostly via E' through young adulthood and again through middle age; but subsequently more often via G'--or approaching some ceiling--after about age 50 or 60. Mortality from respiratory tuberculosis, a historically famous killer of the young, before 1950 contracted in accelerating C' fashion with age. Subsequently, with some successful control the frequency of death from TB with age has risen in E' fashion. The casualties (before new deadly strains appeared in the late 1900s) were now those who had contracted the disease long ago. Exploring variations from one country to another, or contrasting pre-1940 patterns with those for later times, should provide insights into the nature of specific diseases and the prospects for controlling them, and help reveal how particular societies did or did not act upon various threats.

The way that mixes of risks, varied and changing combinations of them, have repeatedly shaped human survivorship into C and C' trends with age suggests some very fundamental source of such generality. To begin, the phenomenon is not limited to historical populations. Also in pre-modern and prehistoric peoples, C followed by C' has been the patterning for survivorship. Present-day populations of forager-agriculturalists and even hunter-gatherers display those tendencies as well. In some of these groups, the levels and the age spans for the C and C' trends have closely resembled the declines of survivorship across the life cycle found in the 1600s in the population of London or the Qing imperial lineage--or in Breslau in the 1690s, Sweden about 1750, Italy and England and Wales in the later 1800s, Chile, the U.S.A., Japan, Peking, and Taiwan in the early 1900s, and Madagascar and Cameroon as late as the 1960s.

Other species, moreover, display similar tendencies in survivorship. Among the closest relatives of *homo sapiens*, captive chimpanzees die off in such a way as to shape survivorship via C then C' in paths which closely resemble those of prehistoric humans. The C' declines after about 40 in both cases drop more severely than in the earliest historical records and the experience of contemporary hunter-gatherers and forager-agriculturalists. What distinguishes wild chimpanzees from captive ones, then, is at how low a level the C decrease begins after several years of "childhood." Unassisted, the young die off more frequently. For large Old World monkeys more generally, and even more so among New World primates, shorter life spans mean that the terminal C' decline seen for *homo sapiens* replaces C earlier in age. If life span is adjusted to that for humans, however--roughly doubled for Old World Monkeys and almost quadrupled for New World ones--the C and C' decreases closely match those for prehistoric humans. In effect, each species other than the chimpanzee has its own version of the C curve, with its own exponential rate of accelerating decline. This phenomenon is characteristic, too, of creatures other than primates. For some varieties of mountain sheep, whales, rabbits, birds, and even barnacles C then C' phases in survivorship appear when life span is adjusted to simulate that of our own.

There is, in other words, apparently a very general biological basis for survivorship in these successive C-type and C'-type forms. *Homo sapiens*, like other species, has its own particular potential life span and .03 curvature. These are shared closely by *Pan* (the chimpanzee), a near relative on the evolutionary tree. For other fauna, the downward-accelerating trends of survivorship in real life bend more swiftly (or more slowly, as perhaps for the elephant or the Galapagos tortoise). But a characteristic constantly accelerating trajectory like C followed by its derivative are the paths repeatedly followed.

Age structures have long been recognized as significant shapers of demographic change. A result of having life expectancy and survivorship take C then C' form during all but the last years of the adult life cycle, when families are formed and procreation takes place, is that age structure is continually sculpted in these same patterns. That tendency is observed from England in the 1540s down through a rich variety of contemporary populations. Within a given population, fertility and/or mortality may fall or decline. The C and C' patterns, nonetheless, keep reappearing--shifted upward or outward, backward or downward. And they perhaps cover rather different years within the life span. For all that, they almost always retaining the same *shape*. Occasional aberration, such as log-linear rather than accelerating decline during what should be the C phase of the life cycle, is both rare and temporary. It soon reverts to the usual form. Of course, shocks have sometimes disrupted populations--such as wars, famines, bumper harvests, 'baby booms', or revolutions in values and priorities. The bulges or dips that they imprint upon age structure, however, are before long digested into the normal C then C' flow of demographic renewal. And the timing of such temporary aberrations, how they first appear and then leave 'echoes'--is itself shaped by how demographic change repeatedly curves in G-based ways. Certain short-term and long-term movements reinforce each other.

These are quite fundamental and far-reaching reinterpretations. Can the dynamics described be demonstrated? Chapter 9 introduces several forms of change into model or actual demographic regimes to determine whether the results turn out as would be expected from the analysis so far.

These mathematical experiments------- {*nota bene*: Harris was working on those mathematical experiments in spring 2013 but did not have time to add his findings to the introduction. Also, Chapter 9 remains incomplete for the same reason. MSW, summer 2013}

Given different interests of readers, three ways to address this volume might be useful. Those suspecting at once that the English evidence for demographic trends in G-related forms may be idiosyncratic to one particular national case or method for studying it can see in Chapters 2 through 7 just how pervasive these patterns are historically, and what kinds of societies seem to have which combinations of them. Readers who are immediately curious about what could possibly imprint so many G-connected patterns upon so many kinds of demographic change may wish to go at once to Chapter 7, which summarizes global data in examining the demographic experience of later developing countries; and to Chapters 8 and 9, where some universal characteristics of human life tables and their consequences for all kinds of change as populations renew themselves are analyzed through historical exploration then mathematical experiment. Those wondering from the start what useful difference does re-trending by the proposed underlying G-based forms might make, on the other hand, profitably follow the English demographic case of Chapter 1 with the preliminary linking of these movements to historical economic and social changes in that country that Chapter 10 employs to illustrate a potential broader relevance of the new G-based approach for the social sciences.

All of these expositions can be expanded and improved. Hopefully, however, they show the possibilities if this kind of analysis is refined and applied, and stimulate other students of populations to go farther and do better.

NOTES

1. One reader of Volume I complained about excess coverage of growth in populations given that the future of demography would be preoccupied with decline. This was to overlook that within the historical era to date, by far the most change in population size has in reality been increase, and to ignore that many diverse and famous cases of demographic loss--due to various conflicts, famines, and epidemics, from ancient Rome and China to behind the Iron Curtain during the Cold War--were actually discussed . Most disappointing, no thought was given to what the implications might be of having most demographic contraction repeatedly take just the upside-down version of the most common curve of expansion and how that relationship could be so simple, constant, and ubiquitous.

2. Two chapters on changes in slave populations and in some characteristics of the slave trade were included in this second phase of the study, to the displeasure of at least one early reader of Vol. II, precisely because--thanks to a generation of dedicated and fruitful scholarship--records from the 17th, 18th, and 19th centuries for these valuable pieces of property were generally more informative than those for contemporary free persons and servants, and permit exceptional insight into interactions among demographic and economic developments.

3. Some movements take the reversing G’ form (the first derivative of the G curve)--like migrations in Vol. II--or 1/G’; but the F and H patterns necessary for representing some population growth are not needed for the internal dynamics of demographic change.

4. And probably likewise occurred in late-settled western Massachusetts during the waning 1700s while mostly older-established areas of the colony/state began to see fertility contract via C.

5. Marital fertility for Mid-Atlantic Quakers from 1738 through 1793, for example, declined along with the C trend for Normandy between 1770 and 1810, while in genealogies still coming primarily from the east coast of North America C decline from 1748 through 1829 paralleled that for the southeast Paris basin through 1790.

Table I.1
G and Related Formulas

G $P_{(t)} = P_0(e^{1-e^{-.03t}})$

or $\ln[1-\ln(P_{(t)}/P_0)] = -.03t$

F $P_{(t)} = P_0 e^{-.03t}$

or $F = G/G'$

$D = 1/G$

H $P_{(t)} = P_0[e^{e(1-e^{-.03t/e})}]$

or $H = G/G'^{-2}$

C $P_{(t)} = P_0(e^{1-e^{.03t}})$

G' $P'_{(t)} = -.03P_0[e^{1-.03t-e^{-.03t}}]$

$E = 1/C = G^{I}$

t = time t minus time 0 $(t-t_0)$. For C and E, time is reversed (t_0-t) by change from -.03t to .03t.

Figure I.1a

G–Based Curves:
G, H, F, and G'

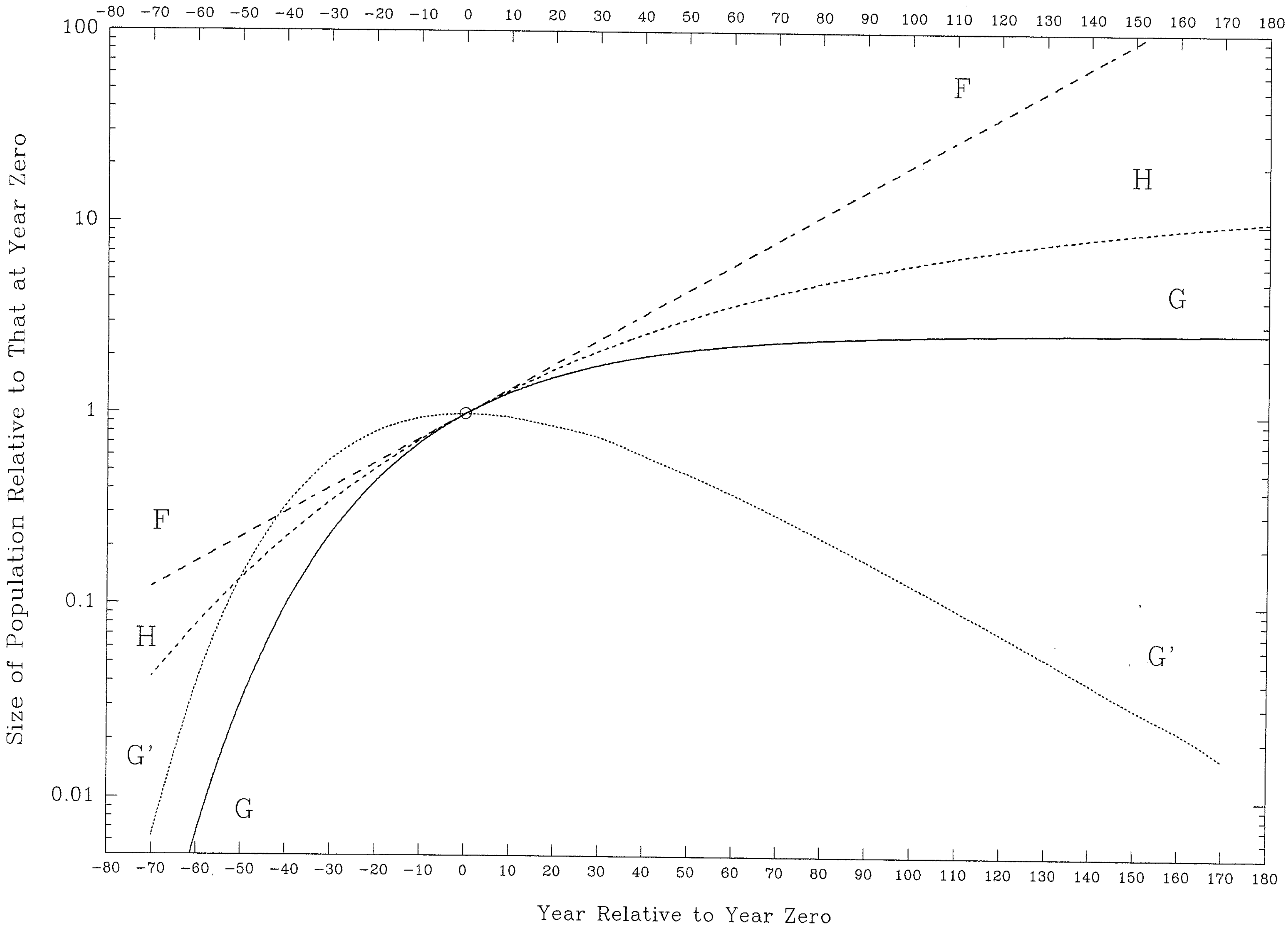
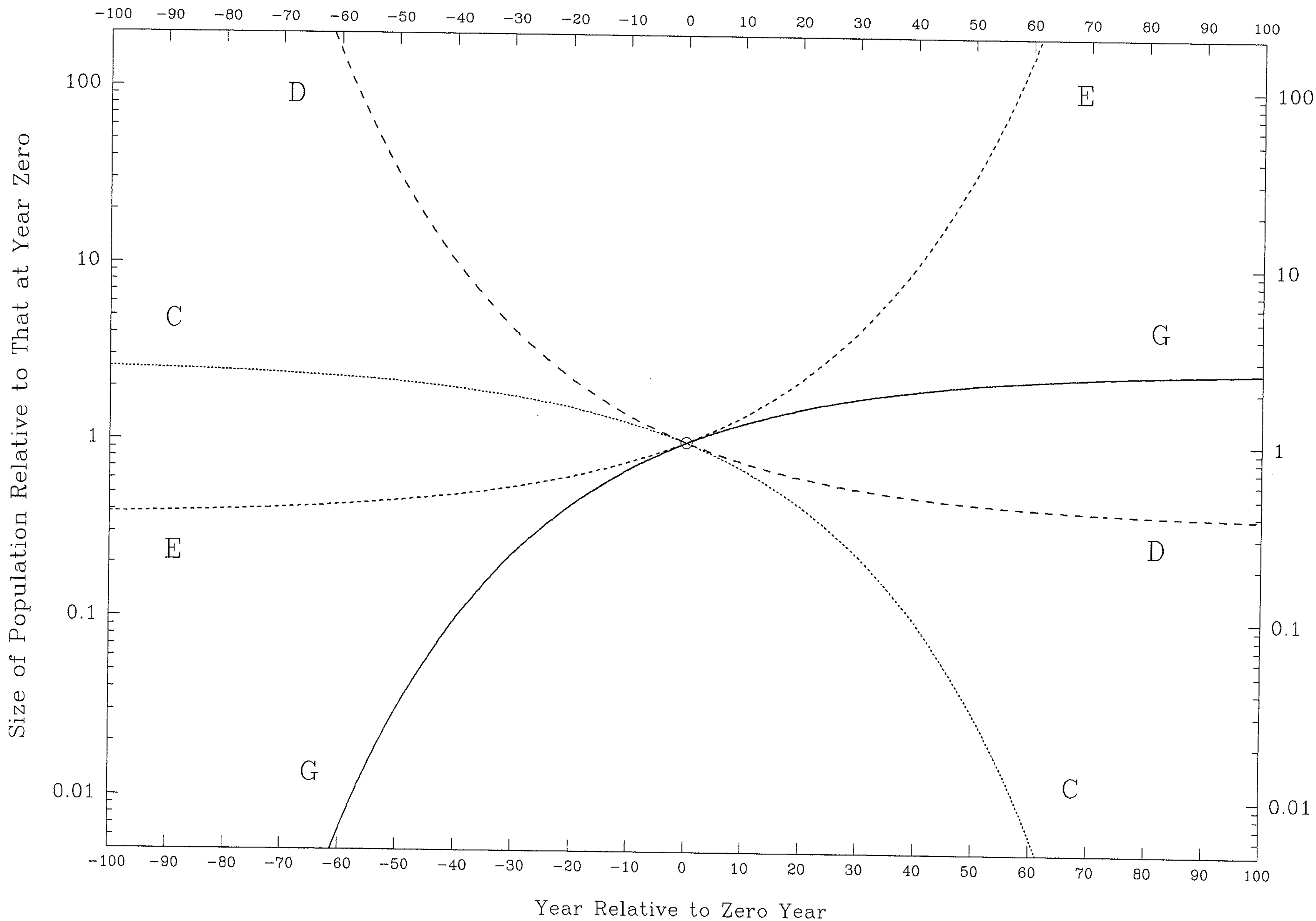


Figure I.1b

G–Based Curves:
G and Its Transformations D, E, and C



Chapter 1

The Long-Term Example of England:

Illustrating the Pervasiveness of G-Related Trends in Demographic Systems

The rich and extensive record of the demographic history of England, and social and economic changes that interacted with it, reveal much about how populations have evolved since the passing of the middle ages. This national illustration contains exceptionally regular, long-running, and multidimensional evidence as to how fertility, nuptuality, and mortality--the shaping forces of demographic renewal--evolved across four and a half centuries of development in a modernizing society. When what has been discovered about English migration is added (Harris 2003, Ch. 1), this distinctively full case study illustrates how a population has modified and replaced itself repeatedly and continually in G-based movements, an example that fruitfully informs the study of other demographic histories.

The path-breaking *Population History of England* (Wrigley and Schofield 1981) first of all provides a large and detailed base of evidence for showing how G-related demographic trends have shaped the development of one particular population. Various critiques and expanded analyses conducted over the almost three decades since the *Population History*, by the Cambridge Group and by others--especially the meaty companion volume based upon family reconstitution in some parishes (Wrigley et al. 1997)--then reveal still more about how births and deaths have waxed and waned in G-connected patterns. In the end, the accumulating, multi-authored English case study, though it still contains gaps and imperfections, commends employing a G-based framework for comparing and contrasting, and interpreting more productively, other historical records of demographic change that are not so complete or so long-term in perspective.

Within the now considerable array of known populations, the English experience was not always the most typical or the most unique. The conclusions of the literature on England--as rich, stimulating, and unusually full as that body of findings may be--is not offered as a model for all demographic history, or even for all early-modernizing populations. What this one important and exceptionally full aggregated body of evidence does do, however, is to provide valuable insight for approaching in new and fruitful ways most of the fundamental issues of global population analysis, demonstrating how these are better structured and pursued when their repeatedly G-related patterns are recognized. The commonalities and variations discovered from place to place, and the understanding to be gained from such international contrast and comparison, are then addressed throughout the remainder of this volume. Here, as a start, the experience of England from the 1540s to the 1990s serves to put forward the proposed new mode of analysis in one well-documented setting, to demonstrate its value in at least one particular demographic history (if the approach has any merit, it should both fit what is known and add further understanding to this important case), and--drawing upon the English evidence--to frame topics for globally comparative exploration.

ADDITIONS BY BIRTH AND SUBTRACTIONS BY DEATH

Figure 1.1 draws upon the *Population History* to 1871 and various census documents thereafter to demonstrate the G-based nature of trends in crude birth rates and crude death rates in England between 1541 and 1990 that created the patterns of national growth and decline

{Please note that the Figures and Tables of Chapter 1 are not interleafed in the text but appear at the end of the chapter. MSW 31 July 2015}

observed in Volume I (Harris 2001, 148, 150-51)--movements in the way men, women, and children were added to or subtracted from the population. Also included in the figure are trendings for life expectancy at birth, the proportion of the population estimated to be under the age of fifteen, and the gross rate of reproduction.[1] Table 1.1 summarizes the chronological patterns of these measures to facilitate comparison among them, and relates the vital movements observed to the trends of population growth and decline identified for England in Volume I.

Some alternative paths suggested by critics of the early birth rates employed by Wrigley and Schofield are incorporated in Table 1.1 for later discussion. Figure 1.2, furthermore, will graph patterns for several variables in Figure 1.1 that are indicated by later work of the Cambridge investigators themselves employing family reconstitution (Wrigley et al. 1997, 614). Table 1.2 will compare the 1981 and 1997 versions of fitted G-based trends. For the most part, they are very similar in form and timing. A later section of this chapter discusses how patterns of net migration that are implied by proposed rates of births, deaths, and growth through time encourage using the original aggregate outlines of vital rates in the *Population History* rather than the patterns of its successor volume based on family reconstitution.

The first thing to note from Figure 1.1 is that all five demographic variables, calculated at five year intervals, did indeed take successive G-based paths for the 450 years from 1541 through 1990. Prior to the baby boom that followed World War II, the percentage of the English population under fifteen most stably adhered to these familiar trajectories. Quinquennial data for the crude birth rate (CBR) and the gross reproduction rate (GRR) also hung quite tightly around the proposed models.[2] It was the crude death rate (CDR) before about 1760 that most noticeably wobbled or swung about the longer underlying curves. Such stronger short-term movements of the death rate in pre-modern periods are familiar (for example, Livi-Bacci 1992, 107; Dupâquier 1997, 250, from Wrigley and Schofield). But the somewhat less volatile patterns for life expectancy at birth (e_0) confirm--upside down--that mortality in England, like fertility, since the

16th century has clearly changed across time according to a sequence of G-grounded paths. As part of this framework of demographic change, between 1681 and 1731 and again between 1731 and 1761 there appear temporary sags of reduced mortality and surges of increased life expectancy that take 1/G’ and G’ shape respectively. Such movement according to the first derivative of G has been appeared pervasively in other temporary demographic phenomena, like specific historical migrations (Harris 2003).

The second finding that stands out from the figure (and from Tab. 1.1) is that the *accelerating* members of the G family of curves, E (up) and C (down), were much more common in these changes of demographic process and structure than among trends of growth or decline in the size of historical populations that were identified in the first volume of this study (Harris 2001). For England since the 1540s, in fact, they considerably outnumber the decelerating trajectories G and D. Meanwhile, the H and F compounds of G that appear for growth only in large aggregate populations (Vol. I) and occasionally in compounded migrations (including urbanization, Vol. II has shown) are totally absent. If this distribution turns out to hold elsewhere, the most fundamental mechanisms of demographic change seem to follow even simpler empirical ‘laws’ than the population sizes that they produce: all four recurring shapes (G, E, D, and C), that is, are just reorientations of the one G or .03 rate of constant proportional bend on the Cartesian plane as expressed in semi-logarithmic scale (Fig. I.1).

Turning, in the third place, to examine just when trends of the four recurrent shapes appeared, Table 1.1 juxtaposes the patterns of the five demographic variables to movements that have been established for changes in the size of the English population since 1541 (in the left column). According to the calculations of the *Population History*, from the middle of the 1500s to the middle of the 1600s, the birth rate began to fall in accelerating C fashion along with the gross reproduction rate and the percentage of the population under 15. Meanwhile the death rate, though fluctuating more, began to rise along an E path; and, in approximate upside-down image, life expectancy at birth began to decline faster and faster. These movements may seem strange--

initially counter-intuitive--when the English population has been seen to *enlarge* along an H trajectory from 1561 through 1656. What happened was that the substantial stimulus from a significant reduction in the level of deaths that Wrigley and Schofield reported for the 1560s (the second plot in Fig. 1.1 with solid circles)--shortly after Elizabeth I came to the throne, stabilizing the Tudor succession and bringing to an end a period of considerable disorder--was progressively chipped away by these trends of the CBR and CDR, making growth decelerate rather than continue to swell constantly at the new rate along some Eulerian log-linear track.[3] Gradually dwindling fertility and rising mortality, that is, combined across a century to give the 1561-1656 H trend of population increase its somewhat flattening *bend*, to slow down progressively the substantial rate of growth that had been introduced into the English demographic regime by the drop of mortality into the early 1560s.

By the 1660s, however, the rise of the death rate and the fall of life expectancy were becoming less and less gentle every year, following accelerating trends that lasted into the early 1680s. In these long-term, systematic movements the return of the plague to England in the 1660s seems to have been just one contributing factor, not the determinative one. This ever more severe effect of mortality, magnified simultaneously by continually more significant atrophy in the birth rate as far as the early 1660s, sent the size of the English population into outright decline from 1656 to 1686, the nation’s 17th-century era of net demographic loss--a D-shape atrophy that was shared by several other European countries somewhere between 1600 and 1700, (Harris 2001, 148-52, 157-59). That this demographic shrinkage from the later phase of the Commonwealth into the reign of James II began right away to decelerate, and bottom out in D form, is due in large part to the fact that by the 1660s births began to be more abundant again, along a G trend that lasted into the 1700s. Starting in the early 1680s, furthermore, the death rate was depressed for a while in 1/G’ (D’) form, while life expectancy improved for the same period in G’ trajectory.

The natural increase that these movements generated powered the new H trend in the size of the English population that ran from the later 1680s into the 1720s. This roughly paralleled and continued (was somewhat later in base year and therefore currently steeply than) the H trend of growth from the 1560s to the 1650s. Though the birth rate and associated measures of the gross reproduction rate and the proportion of the population under 15 kept improving slowly across the early 1700s, the death rate soon turned along its 1/G' path to rise back toward 1731, while life expectancy inversely retreated from its temporary G' surge of improvement. In still further short-term movement, though, mortality then reversed to become--once more in 1/G' manner--less of a drag on population growth between 1731 and 1761. These relatively brief saggings in the death rate may have resulted from temporary improvements in the standard of living, or through temporary relief from one or more of the diseases that ravaged England in the late 1600s and early 1700s. Inviting opportunities for further explanation present themselves for a literature that already actively debates the impact of sickness and nutrition. A sag of the CDR in 1/G' form, furthermore, was not just an English phenomenon. Chapter 2 identifies several international parallels, though not with the same timing.

The long E-shape acceleration of population increase that England experienced from about the 1720s into the early 1800s was generated by *both* rising fertility *and* falling mortality. The CBR, the GRR, and the percentage of the population under 15 all edged up faster and faster along E paths, as Figure 1.1 indicates. But these relatively shallow curves would have reached their zero years only in the 1860s, while population growth was exploding along a track aimed some 40 years sooner (at a t_0 in 1822) and was therefore noticeably steeper. It managed that stronger increase because from 1761 or so onwards, building upon the preceding 1/G' and G' movements, the death rate declined and life expectancy improved gently along C and E curves, respectively (with their t_0's as late as the 1880s, as Tab. 1.1 summarizes). The two sets of increasingly rapid trends together, three reflecting fertility and two mortality, interacted to augment the number of English people at a visibly accelerating rate during the age of early industrialization.

After relatively short D-shaped movements of the fertility-connected variables in the early 1800s (which applied deceleration to guide the H path of population increase between 1811 and 1861, along with an end to the 1761 to 1831 C trend in the death rate), both mortality and fertility in England fell away in ever-faster C fashion forward into the early 1900s. The not very steep but only slowly slowing H-shaped growth of the English population from 1861 through 1939, in other words, emerged out of the relatively small differences that existed between these not quite parallel trends of the CBR and CDR--and from what happened in the 19th and 20th centuries to net emigration, a topic that has been ignored for the moment in the interests of simplicity.

These paired movements of the vital rates call to mind what is frequently discussed as modern international ‘demographic transition.’ Several decades ago, Frank W. Notestein (1945) coined that term for an assumed adjustment in which first mortality then fertility declined as populations moved from pre-modern to contemporary conditions. The English patterns in Figure 1.1, however, underscore some weaknesses that have been noted in that classic, and still sometimes current, attempt to generalize about historical demographic change.[4] For one thing, over the typically emphasized modern period birth rates and death rates in England have mostly gone down *together*, each in C curves. As Figure 1.1 and Table 1.1 both demonstrate, starting about 1840 neither change much *led* the other. To the contrary, as far as the inter-war years the CBR and the CDR fell away in very *parallel* fashion with base years for their C trends at 1933 and 1936 respectively. There is no sign here of the significant lag between mortality improvement and fertility management that transition theory characteristically expects.[5] For England, one has to go back to the era of accelerating expansion between the 1720s and the early 1800s to find the CDR coming down for a long period of time without the CBR. There, though, the birth rate was not just staying high, as depicted in the usual ‘transition’ model, but actually increasing faster and faster before declining via D between 1815 and 1850. This combination of 18th century trends for England in fact looks suspiciously like much recent ‘Third World’ demographic experience. To what extent did the English population that far back in time go through what in many countries have been very recent forms of demographic change? And what are the implications if it did?

Following the Great Depression (and England's numbing slump both in spirit and in fatherhood due to the cruel losses of World War I), the crude birth rate and the percentage of the population under 15 have roughly followed new C trends into the present time. Evident within these long-term movements, though, are the effects of the postwar 'baby boom' that stands out in the GRR. Note, however, what happens by the time this exceptional burst of fertility is weighed relative to the total numbers of people in society, as in calculating the crude birth rate: the great postwar wave starts to become just a series of ripples spreading across a new C-shape undercurrent for the CBR from 1933 through 1990. And, when the accumulative effect on the English age structure in terms of the percentage of all persons who were under 15 is considered, the great 'boom' becomes merely a gentle bump during the 1970s above a possible underlying C curve for 1941 through 1990. Thus are demographic shocks softened and humbled by the way populations digest them over time through their age structures. Such smoothing out is a familiar demographic process that has to be examined carefully in probing the origins and the interactions of so universal G-based trends in the history of populations.

Life expectancy at birth, meanwhile, improved in two fairly clear E paths from 1921 to 1951 and then, less steeply, from 1951 to 1988. On the whole, the crude death rate since the 1970s has declined along much the same timing of C curve it followed between 1923 and 1948, but at a higher level. Intermediately, from 1948 through 1978, there was a tendency of the CDR to rise, perhaps along something like the very flat G path offered in Figure 1.1 and the Table 1.1. This temporary reversal of trend would seem to reflect age structures and health distributions generated by World War II and/or by immigration from former colonies since then.

Finally, it must be recognized that a few points of sudden, brief, but significant shift in the level of demographic movements remain even after all the apparent G-based trends are identified. The most obvious examples of Figure 1.1 show up in life expectancy and the crude death rate when mortality for the English people, which had overall been worsening from where the calculations begin in 1541 up to 1561, then improved substantially in the middle 1560s. The dynamics of such unusual one-time realignments have to be carefully explored and the shifts proven to be genuine historical phenomena, not artifacts of what data exist and how they have so far been handled. This particular late Tudor disturbance in deaths, though, happens to be well known. It has been debated as “Jack Fisher’s ‘Flu.” Even more than the parish accounts upon which the *Population History* is based, probate records suggest a brief but severe mortality crisis in the late 1550s.[6]

These findings conform to how the authors of the *Population History* interpreted their evidence. They also advance analysis beyond these conclusions.

The *Population History*, like the present interpretation, observed that fertility fell from where the study began as far as the third quarter of the 17th century. This decline (whose shape was not specified) was followed by “sharp recovery to late-sixteenth-century levels” and then a “gently rising trend” to 1756. For the birth rate, Wrigley and Schofield recognized the accelerating nature of further increase to about 1816, and also the bottoming-out tendency of decrease that then lasted through the remainder of the period that they examined (1981, 229). Mortality, they wrote, went through more short-term fluctuations, as Figure 1.1 reaffirms in both the crude death rate and life expectancy at birth. Its first long-term trend was one of increasing severity, from 1566 to about 1676, though they made no mention of the way their graph displayed accelerating decline in life expectancy, which Figure 1.1 shows to take the C form. They also noted the up-and-down hump in life expectancy between there and 1731 that stands out in their Figure 7.8. Similarly, they perceived the rising life expectancy that followed from the 1730s through about 1830, though not realizing that after the 1740s this, too, involved *accelerating* change--here upward. (Fig. 1.1 and Tab. 1.1 identify E trajectories for both life expectancy and the gross reproduction rate.) From the relatively flat rates of 1831-1871 near the end of their period of study they could not discern that a new acceleration of life expectancy was beginning, which would last until after World War I (234). In all, the more tightly specified, mathematically connected patterns of demographic change offered in Figure 1.1 and Table 1.1 thus do not violate the broader conclusions of the *Population History*.

They do, however, seem to reveal rather more. Besides showing just how universally G-based patterns of demographic movement shaped growth or decline for the people of England during all successive phases of its four and a half centuries of recorded history, these new trendings begin to demonstrate more clearly the way that movements of reproduction and death participated in demographic change as successive trends in population size unfolded. For the simplicity, net migration is for the moment still not considered. In the leftmost column of Table 1.1 there are seven phases of change in population size to analyze after 1561: one E, one D, one G, and four H's.[7]

During the English acceleration in population growth across most of the 18th century, the E trajectory was supported by a birth rate also rising in E form (though more slowly) and a decline in the death rate that took an oppositely accelerating C track by about 1760, having swung up and down somewhat across the earlier years of the century. Compatibly, life expectancy improved via E--the upside-down counterpart of C--from 1761 (perhaps 1736) through 1831. To what extent has 'population explosion' always been the product of accelerating increase in birth rates *combined with* accelerating decline in death rates? Was this the case in other European countries that, Volume I has demonstrated, subsequently at various times during the 18th, 19th, and early 20th centuries shared England's experience of proportionally accelerating E-type growth? Did this particular kind of interaction between vital rates likewise underlie the E trajectories of increase that emerged as some 'New World' populations recovered from demographic disaster, whether in Spanish America in the later 1600s or in the South Pacific in the early 1900s? Most recently, have paired E-type accelerating additions to births and quickening C-form reductions in deaths typically acted together to drive the 'explosions' of 'Third World' populations in the 20th century, some of which continue today? In short, how uniform or how varied across human experience has been the mix of contributing demographic dynamics that has generated the E trend in the size of many populations?

Clearly there has been *no* simple uniformity in how H patterns of demographic expansion were fed by changes in fertility and mortality, even within just the one country of England. During the long Tudor-Stuart H trend of growth from 1561 to 1656, births tapered off via C while deaths began to rise in E fashion. In marked contrast, Table 1.1 shows, both births and deaths together followed closely parallel C trends during the modern H phase between 1861 and 1939. From 1811 through 1861, meanwhile, the H trend of growth for the English people was based upon a D-shaped decline in the birth rate and two successive C-form reductions of the death rate. And the H of population increase between 1686 and 1726 involved a G pattern in the CBR along with back and forth 1/G' movement in the CDR.

In the case of England, then, since the time of Elizabeth I there certainly has been no recurrent pairing of trends in birth rates and death rates that has produced the H type of population growth. Instead, four *different* combinations of movements in CBR and CDR have underlain the four observed H-type trends of expansion. This finding indicates that the H pattern of population increase has indeed largely been given its shape by some kind of systematic and sustained interaction between demographic and economic or social change. The shape of the contributing trends in births and deaths may have endogenous origins inherent in the nature of human replacement; but the way these movements interact to generate overall H patterns of population increase seem to be dictated by change that goes beyond demographic dynamics alone. That conclusion was anticipated in the first volume of this study from the socioeconomic nature of the populations in which the H trend has occurred. Volume II (in Ch.'s 3 and 4) then demonstrated key contributions of migration, urbanization, and agricultural change in which the H form was imbedded in familiar dimensions of modern 'development' as population expanded in H fashion.

The discovery of so much variety in the mix of G-based trends for births and deaths during demographic increase of the H shape in England's history raises questions as to whether *other* G-related patterns of change in population size, of which there are but single examples from the record of this one country, are likewise produced by more than one combination of trends in vital rates. Are, for example, the flattening but nonetheless rising G in birth rates and upwardly accelerating E in death rates that generated demographic decline along a D trajectory for England between 1656 and 1686 likely to be the only combination that produces population loss of this type? That particular combination, for example, seems unlikely to apply to the several aging and contracting European populations of the present time where, among other things, the birth rate is clearly *falling*. Or is a C in the CBR and two flatter C's in the CDR (interrupted by an interval of slow G increase) the only way to get the G-shape kind of expansion that the English people have experienced since World War II? This last specification is especially unlikely since G is so patently the most ubiquitous form of demographic increase historically (Harris 2001, 382). In the end, as noted, the internal dynamics of fertility and mortality for the English 'population explosion' of 1726-1806 may well also prove different from comparable movements of that historical era, or E trends of growth that occurred in later periods--as in modern 'Third World' societies of the 20th century.

Critics have challenged some of the rates established by the *Population History* upon which conclusions here so far are based, especially births for the crucial period of the later 1700s and early 1800s. Does some or all of the G-based nature of these patterns presented in Figure 1.1 depend simply upon assumptions that the investigators of that study may have made or procedures of back-projection that they employed?

Table 1.1 includes particulars of trends that are fitted to alternative birth rates which were advanced following the publication of the *Population History* by Peter H. Lindert (1983) and Peter Razzell (1993). These both raise the level of the CBR for England in the 1700s relative to the early 1800s.

The long-range regressions of Lindert (trends denoted by “L” in the table) suggest somewhat higher birth rates all the way back into the 1500s, and somewhat lower ones for the first decades of the 19th century relative to what Wrigley and Schofield proposed. Lindert called the latter an “artifact” of their procedures of estimation employed in the *Population History*, especially how they accounted for underregistration across the years. “A strange new Wrigley-Schofield history of the birth rate” he labeled the results. For various plausible historical and economic reasons he criticized the ‘baby boom’ during the industrial revolution that their calculations generated (Lindert 1983, 144-45, 139, 134). Unlike Lindert, Figure 1.1 recognizes this pattern in the birth rate, and in the population growth it powered, to be a long-building ‘explosion’ not a short-term ‘baby boom’ shock.

Actually, if Lindert’s corrections are accepted, not much changes in the curvature and timing of the G-related movements that are being discussed. As Table 1.1 indicates, his version of the CBR also rises across the 18th century in an accelerating E pattern beginning in the 1720s, very much like that of Wrigley and Schofield. The difference is that this increase is ended by the outbreak of chronic war with France in the 1790s, assuaging concern that Lindert raised about the impact of the war years upon fertility as opposed to the Wrigley-Schofield model, which has the birth rate keep rising on to 1816. Do populations have more or fewer babies in wartime and during concomitant urbanization and industrialization? From 1795 through 1845, however, Lindert’s revisions make the English CBR first relatively flat for a few decades, then start to go down faster and faster--beginning to take the C pattern, in other words. This contrasts with the differently curving D indicated for 1816-1846 by the calculations of the *Population History*. (Lindert’s alternative movements have been fitted in graphing that is not displayed). Earlier, however, Lindert’s CBR trend for the century from the 1660s through the 1750s very closely resembles the G from Wrigley and Schofield, though at a somewhat higher level. Likewise, Lindert’s computations of the birth rate between 1575 and 1665, though higher, move in a C path very parallel with that for 1556 to 1661 in the *Population History*, Table 1.1 indicates. The one new or different path that Lindert's recalculations make before the 1790s is a possible D trend for the CBR during the messy mid-Tudor period of 1541-1575. Figure 1.1 hesitates to derive any patterning this early.

In short, Lindert for the most part indicates somewhat higher birth rates across the three centuries before about 1840. These proposed revisions, though, usually do not alter the *shape* of trends derived from Wrigley and Schofield in Figure 1.1. The one minor potential change of CBR pattern that does result from his estimations is the relatively flat 1795-1845 C trend in lieu of the somewhat more substantial 1816-1846 D-shape net decline of Wrigley and Schofield.

More recently Peter Razzell (1993) has, like Lindert, claimed that Wrigley and Schofield insufficiently adjusted birth registrations, especially for the early 1800s. However, while Lindert relied upon regression of the CBR on the Wrigley-Schofield residual adjustments for birth registration up to 1810 to estimate his corrections, Razzell related information from the 1851 census simply and directly to birth registers for 44 parishes scattered about England for the period back to 1761. The trends preceded by "R" in Table 1.1 emerge from his recalculations, which reestimate by this method the extent to which births failed to be registered. Whereas his birth rates between 1750 (where his evidence begins) and 1795 are elevated even more than Lindert's, the E trend in them is almost identical in timing with such curves fitted both to the data of Wrigley and Schofield and to the recomputations of Lindert. From these three parallel but quite differently derived sets of calculations, in other words, there seems little doubt but that 'explosion' of the historically recurring E shape formed the path for England's CBR from the 1720s to the 1790s.

For the next era, though, there does arise some divergence of pattern. Splicing Razzell's data from 1795 through 1835 to evidence for the 1840s (which hardly varies between Lindert and the *Population History*) produces a D trend for 1795-1845 that is only, Table 1.1 shows, just somewhat flatter (having a rather earlier t_0) than the 1816-to-1846 D from Wrigley and Schofield. While the successive decadal differences in CBR between the two sets of corrections are slight after 1795, Razzell's results fail to produce the differently curving C type of decline that is suggested by Lindert's calculations. Some further debate about the pattern of birth rates during this crucial period may be appropriate. It seems, though, that the D-shaped sag indicated both by Wrigley and Schofield and by Razzell will hold up as the better interpretation. Meanwhile, neither set of proposed corrections--by Razzell or by Lindert-- weakens the pervasive "G-ness" of all movements in the data.[8]

Both Lindert and Razzell expressed concerns about underregistration of *deaths* as well as births. They offered less revised and reinterpreted data on this topic than for births, however.

Unlike his recomputations for birth rates, Lindert found no "suitable regression equation" for explaining the death rate and no significant evidence that the Wrigley-Schofield calculations underestimated deaths as the authors projected them back in time. He remained skeptical, however, that in their operations undercounting deaths could be less serious a problem than missing births, and recommended as a working hypothesis the same proportional corrections, decade by decade, as he made for the CBR. Though not plotted here, these revisions and some of their consequences have been graphed. They require some changes, but leave most trends with the same shape for the same years.[9] Raising birth and death rates comparably of course leaves the rate of natural increase unchanged--and also implied migration, since Lindert accepts the quinquennial population numbers of Wrigley and Schofield.

While Razzell provided no foundation for trending an alternative CDR series as he did for the CBR, he offered some useful insights into possible sources of change in the level of mortality through time. Most of his investigation, which generally runs from the late 17th century to the end of the 18th, supports the kinds of G-based trends in death rate and life expectancy that are encountered in the *Population History*. The one indication that his analysis gives about *level*, furthermore, says that between 1700 and 1749 and then again from 1750 through 1799 life expectancy for males at age 25 in the *Population History* was virtually *identical* with the average for several groups of young men for whom independent data exist:

33.6 vs. 33.8 and 35.4 vs. 36.2 years, respectively (1993, 765). Earlier--from 1650 through 1699 and, most of all, from 1600 through 1649--the gap indicating lesser mortality in the Wrigley-Schofield calculations opens up rather more, identifying 3.4 and 6.1 additional years of life expectancy for males of 25 during these halves of the 17th century. Nonetheless, the two types of clues from the critique on *adults* that Razzell offered--concerning *shape* of movement on the one hand, and *level*, on the other--suggest leaving the trends of the proposed CDR of the *Population History* as is until better evidence to the contrary is provided. Appendix A addresses several details of Razzell's contributions. Figures A.1a and A.1b and Table A.1 present the G-connected trends that seem to be inherent in some information on rates of mortality and life expectancy that he adds to the analysis.

In the end, mostly at issue seems to be the fate of infants and children, whose loss does so much to affect the crude death rate, which considers all ages. From Razzell's way of thinking, Wrigley (2004, 436) shows life expectancies at *birth* that are markedly lower (as much as half) than those of the Cambridge Group's reconstitution project from the middle 1500s through the middle 1700s. Their shorter-term movement within that era, however, is very similar; and Wrigley argues convincingly how excessively high the death rates implied by Razzell's analysis must be. The reuse of names for children in the community of Colyton, moreover, which Razzell himself employs as an indicator of early mortality (Fig. A.1a), trends upward in E form between 1569 and 1675 closely in the company of the CDR of the *Population History* and then downward via C across the 18th century in tightly parallel fashion (Tab. A.1). Between 1680 and about 1740 the 50-year interval of the Colyton evidence alone probably masks the two 1/G' dips in the national CDR data.

In a different line of criticism, Richard H. Smith (1999, 19-31) challenged the view of the *Population History* and some subsequent commentators that, from the 16th century (or sooner) into the early 19th, the English demographic regime constituted a self-regulating homeostatic system in which nuptuality and fertility followed mortality in short-term adjustments by means of changes in age of female marriage, proportion of women never marrying, and rate of remarriage by widows. Instead, he employed the data of the *Population History* itself to show how, unlike the dynamics argued for France, mortality, fertility, nuptuality, life expectancy, and the intrinsic growth rate of the English population each responded systematically in long-term movements “to secular change in its social, economic, and biological milieu” (ibid., 21-24). These behaviors, he concluded, were incompatible with the Malthusian ‘positive-check homeostasis’ proposed, though that mechanism might have been more relevant during part of the 16th century (24).

While the precise nature of interaction between such external forces and observed change in populations is addressed only in a subsequent chapter that begins to reexplore the characteristics of the joint English historical demographic and economic (‘demonomic’) case, Smith’s “long, often century-long, waves of growth and decline” (20) for fertility and mortality between 1541 and 1816 (and, it will shortly be seen, for nuptuality as well) view the data of the *Population History* very much like the patternings offered in Figure 1.1 and 1.3 and Table 1.1. Compared with Smith’s even broader strokes, however, the trendings of the present study, capture more accurately the outlines of actual movement, and do so by means of a few recurrent patterns that can more insightfully be related to each other and to the kinds of demographically exogeneous stimuli that he invokes.

Finally, in 1997 Wrigley and others of the Cambridge Group, complemented the original back projection approach of the 1981 *Population History* with revised procedures and assumptions that they termed ‘generalised inverse projection’ (GIP). Using this technique they offered a complete, new alternative set of quinquennial data series for the outlines of historical demographic development in England from the 1540s through the 1860s (614-15). Does this new version, more full and sophisticated than the criticisms of Lindert and Razzell, itself invalidate conclusions about trend shapes developed from the data of the *Population History* that appear in Figure 1.1 and Table 1.1?

The answer is almost totally no, Figure 1.2 and Table 1.2 reveal. While the levels of some trends are altered a little, the *patterns* of movement in almost all cases remain virtually identical. Small shifts in the dates across which they run largely reflect simply that the original back projection analysis of fertility and mortality in 1981 made the successive “census” years midpoints of quinquennia while the GIP procedure worked with the five years that followed those dates (Wrigley et al. 1997, 613). The trends in the proportion of the population under 15 are so similar from one analysis to the next that they are not included in Figure 1.2 or Table 1.2.

A minor difference of patterning appears in life expectancy at birth. In the more recent GIP version, the kind of E trend observed from 1761 through 1831 in the *Population History* extends back to 1731, eliminating the second G’ surge of 1731-1761 found in the original estimates. The one potentially significant divergence of pattern between the two studies, on the other hand, appears in the crude rate of natural increase from about 1690 to 1726. In the new GIP presentation, Table 1.2 indicates, CRNI rises in G form across the whole period from 1686 through 1761, while according to the *Population History* between 1691 and 1726 it first declined in C shape before shifting from there through 1816 to increase in G fashion much like the 1761-1821 movement of the GIP analysis.

HOW BIRTH RATES, DEATH RATES, AND NET MIGRATION HAVE INTERACTED DURING ENGLISH DEMOGRAPHIC GROWTH AND DECLINE SINCE THE 1500s

The crude rate of natural increase is the current birth rate minus the current death rate. For five-year periods the estimates can be quite volatile. Birth and death rates and the natural increase (or decrease) that they generate, furthermore, while crucial, do not by themselves determine patterns of growth or decline in populations, a fact sometimes overlooked in demographic theorizing. Net migration, one aspect of how populations interact with their environments, can provide some give and take for a demonomic system. How, then, did birth rates, death rates, and net migration in fact add up to give the population of England its successive H, D, H, E, H, H, and G trends of expansion and contraction between about 1560 and 1990 that Table 1.2 displays? The way that this interaction worked according to the two sets of national demographic outlines provided by the Cambridge Group suggests some advantage of one version over the other as a basis for analyzing relationships such as those between demographic development and social or economic change.

Figure 1.3 draws upon the *Population History* (1981, 528-29) to present apparent underlying trends in the compound growth rate of the English population, its crude rate of natural increase (the birth rate minus the death rate), and the rate of net migration (on average, *emigration* from the 1540s into the 1920s) that is implied when the pace of natural increase is subtracted from the rate of growth or decline. Once again, it should be kept in mind that quinquennial rates derived this way can be very volatile--much more so than current population numbers, for instance. The plots in Figure 1.3, especially the one for estimated migration rates, contain several averagings of neighboring quinquennia in order to smooth very short-term switches of sign whose means generally adhere to trends that run before and after the points averaged. These averagings appear in the figure as two or three successive symbols with no change of level.

The top plot of Figure 1.3 displays as hollow circles the compound growth rates (e^x) of the English population quinquennium by quinquennium. From 1656 through 1681 the solid downward triangles plot the rate of *negative* change in size as the population shrank. The '[-]' at 1671 and at 1556 indicates that the sign of change for this five-year period is distinctively opposite to the values of the trend surrounding it. Around 1671 the population expanded during a period of contraction; around 1556, during the Catholic restoration under Mary, it shrank in the midst of a long era of growth.

The log-linear trend lines that accompany this top plot in Figure 1.3 represent *model* slopes for trends of G, D, H, and E shape. Their heights are set arbitrarily to approximate the level of actual current growth rates. Their purpose is to illustrate how such rates, calculated quinquennially, for all the short-term volatility in them tend to follow the paths expected by the types of trends that are identified (originally in Harris 2001, 148, 150-51) for change in the size of the English population during various periods of time. For example, from 1561 through 1641 the quinquennial compound growth rates fall close to a slope of $e^{(-.03/e)t}$ ($e^{-.011036t}$), the model incline for deceleration in the H trend. More roughly, from 1656 through 1681 the English rates of population *decline* (except around 1671) approximated a trajectory of $e^{-.03t}$, the model slope of D in negative values. Accelerating E, on the other hand, calls for CGR to increase at $e^{.03t}$, which the calculations of the *Population History* generally do from 1726 to 1801. While the successive H, D, H, E, H, H, and G trends for the size of the English population between 1561 and 1990 that have been posited in Volume I and summarized in Tables 1.1 and 1.2 cover slightly different spans of time (for instance, 1561-1656 rather than 1561-1641, 1656-1686 instead of 1656-1681, and 1726-1816 compared with 1726-1801 for the H, D, and E phases just discussed), the quinquennial evidence on rate of change for the most part reflects the patterns of population growth and decline that Volume I has identified for England over that span of time.

The second or middle plot in Figure 1.3 trends quinquennial crude rates of natural increase, represented by hollow squares. These are derived simply by subtracting the current crude death rate from the crude birth rate (Wrigley and Schofield 1981, 528-29). From 1666 through 1686 the values are on average negative and are not graphed. In each phase of change from the mid-16th century through the 20th the rates slow down, bending below the more log-linear trends of compound growth. (Calculations for the 1930s fall exceptionally far but then are followed by the compensating rebound of the familiar mid-20th-century ‘baby boom’). How general in other populations is this distinction between the CRNI and the CGR? As noted, the trends of natural increase also have slightly different time spans than those for compound growth.

The dotted line that wavers around the trends for the CRNI as far as the 1860s (except 1656 through 1681) in Figure 1.3 records the quinqennial values for this measure from the GIP analysis (Wrigley et al. 197, 614). Importantly, comparison of these movements with those of the hollow squares from the *Population History* demonstrates how calculations for just 1721, 1726, and 1731 in the more recent GIP reconstitution procedure virtually alone generate the difference in trends of natural increase between the two studies that might be thought to have occurred during the early decades of the 18th century (Table 1.2).

The contrasts between the paths of natural increase and the patterns of growth estimated for the English population (Wrigley and Schofield 1981, 528-29), meanwhile, suggest movements in the rate of migration, which are usually negative (net emigration) before the 1930s. Figure 1.3 plots emigration rates that are *implied* by subtracting, quinquennium by quinquennium, the current rate of crude natural increase from the compound growth rate. This is because the CGR consists of natural increase (CRNI, or the birth rate minus the death rate) plus the rate of migration (here typically negative). Estimating from quinquennial rates of growth and natural increase like this generates considerable instability in the pace and sometimes even the temporary net direction of the migration that appears. Figure 1.3 reduces this variability by averaging several pairs or triplets of quinquennial results. Where this has been done, there is no change in level for the successive symbols plotted.

The migration rates presented by Wrigley and Schofield (ibid., 219-20) were, in contrast, constructed on the basis of average annual migration totals in a quinquennium. Their computations appear as the dotted line that weaves its way among the solid squares of emigration estimates as far as the 1860s. These amounts had been derived by their system of back projection based upon estimated birth cohorts, as a proportion of population size at the beginning of each five-year period. Their calculations are more stable than just CGR minus CRNI, creating smoother movements; but they do not always add up to what the simple subtraction of current rates of natural increase from current rates of growth employed in Figure 1.3 calls for. From about 1691 through 1786, the migration values of the *Population History* run considerably and consistently higher than what the difference between CRNI and CGR usually supports, while from 1601 through 1626 these estimates are appreciably lower(Wrigley and Schofield 1981, 219, 227, and 531-35 vs. computations of implied migration from CGR and CRNI in 528-29.) During other periods between 1541 and 1866, the results are mostly quite comparable over the longer haul.

Immigration rates for England after 1961 in Figure 1.3 come from O.P.C.S., *Population Trends*, 66: 58. For 1876 through 1958 the general level of net emigration for England is estimated by subtracting crude natural increase for England and Wales from compound growth for the same larger area.[10]

Across the bottom of Figure 1.3, as a dotted line, appears the version of the migration rate per 1,000 from the GIP analysis (divided by 10 for visibility). This series is virtually identical with what one gets by subtracting the crude rate of natural increase from the crude growth rate in that study (Wrigley et al. 1997, 614). While this calculation eliminates disparities between more complexly estimated rates of net migration and those implied by simple subtraction of natural increase from growth rate, which Figure 1.3 shows to have characterized the original 1981 study, the values of this series are suspiciously inert across time. Was the pace of emigration from England so steady and so stable over so long an era? There is independent historical evidence that suggests it was not.

In contrast, quinquennial estimation from the *Population History* of net migration as the CGR minus the CRNI (the solid squares in Figure 1.3) indicates that between 1541 and 1661 the net flow of emigrants relative to the size of England's population pushed significantly upward--fleeing the wrath of Bloody Mary and then the Erastian conformity of Elizabeth, occupying Ireland, sending soldiers and sailors abroad to support the international Protestant cause, colonizing parts of the Caribbean and North America. Across what is probably most precisely an underlying G trend (the medium dashes), peaks may have occurred around 1606 and 1656--the first probably concentrated on Ireland, the second is characteristic of what is known about English migration to the New World. Another surge occurred around 1556, but in the figure is averaged with the *return* of many of those same Marian exiles in the next quinquennium around 1561. Though similar smoothing of very short-term swings blurs other dips somewhat, troughs for emigration appear around 1576 and 1631 (in the latter instance, just the unaveraged quinquennium of 1626).

Much of the time, the implied individual quinquennial migration rates fluctuate greatly. Two forms of approximate underlying trending are worth noting, however. While the averaging of neighboring 5-year periods in Figure 1.3 suggests that a G shape with zero year in the 1540s is perhaps the more precise summary pattern for 1541 through 1661, the kind of H path presented (shorter dashes) for these same years, which would have a base in the 1480s, also effectively summarizes the long-term movement of the emigration data. The close relationship of this alternative pattern to other H-shape demographic and economic trends during the era, such as for agricultural change and urbanization (Harris 2003, 224-47), provides valuable insight for subsequent discussion of interaction between population and economy.

It should be noted that the seminal movements to establish America colonies did not pull a significantly larger share of English men and women out of the country than before. Instead, they just sustained a substantial and increasing long-term proportional level of emigration that had been building up in England over the preceding half century. If English society had not already been accustomed to net out-migration at something like these rates, primarily for Ireland, its colonies in North America might never have received the substantial peopling that distinguished the success of English settlement at the expense of Dutch, Swedish, French, and Spanish competition for control of the New World.

The long-term G- or H-shape deceleration in apparent net emigration from 1541 through 1661 that runs through the observed fluctuations for a considerable time (to about 1620) allowed net natural increase to decline more slowly than the growth rate of the English population (Fig. 1.3). Then, however, natural increase fell faster than the growth rate into the 1660s, becoming negative thereafter. The GIP calculations do not display substantial long- and short-term movements in net migration, in spite of considerable evidence that England's interest in Ireland and America was, unlike Dutch and French New World colonization of the era, backed up by increasing numbers of settlers--expanding into the early 1600s to Ireland, peaking near mid-century to the Caribbean and the North American mainland (Harris 2003, 70, 52-53).

Thereafter, fewer people left England. This approximately D-shaped contraction in the rate of implied net emigration was most extreme between 1656 and the 1680s, but in the longer term continued--on average--into the 1730s, perhaps even the 1780s. Initially, one might think that the temporary end of demographic growth in England made less surplus population available to relocate. Emigration, however, did not respond simply to this influence.

It has been noted that 58 percent of the population loss of 416,000 in England between 1656 and 1686 is explained by current net emigration, without counting the effect of children born overseas rather than at home (R. H. Smith 1999, 39; based on Wrigley and Schofield 1981, 528-29). Figure 1.3 indicates, however, that this was precisely when what had by the early 17th century become a relatively stable long-term rate of emigration (2 or more per thousand)--first to Ireland, then to the New World--*fell off* sharply. The key to this conundrum is that natural additions to the population deteriorated in accelerating C fashion appreciably more than the D-shape decelerating losses by emigration (Fig. 1.3).

Estimated current external migration absorbed about 58 percent of the natural increase of England in the vicinity of 1640, 77 percent around 1650, and almost 5 times as many people as natural gain produced about 1660 before starting to decline (Fig. 1.3). Even as the pace of emigration slowed significantly thereafter, around 1670 about 1.3 per thousand emigrated while natural increase contracted -0.5 per thousand. By 1680 some 0.75 per thousand left while natural increased fell to -5.3 per thousand (Wrigley and Schofield 1981, 528-29). The rate of emigration fell, but not as much as the plunging, soon negative rate of natural replacement. The overseas settlements, and Ireland following Cromwell's reoccupation, regardless of demographic crisis at home, still drew young English people--if collectively fewer than before--and shaped this contracting draft to colonial needs not simply the demographic stagnation of England. Colonial changes even helped shape decline in England by aggravating rates of homeland mortality. A rather different interpretation is required.

Dynamics on both sides of the Atlantic were at work. Opportunity overseas weakened relative to prospects in England, while the rise of the domestic death rate in accelerating E form, overwhelmed more gentle increase in the birth rate after the 1650s (Fig. 1.1) and pushed natural increase negative, contracting the national population somewhat between 1656 and 1686.

The significant drop in English emigration during the 1660s, 1670s, and early 1680s is familiar from various sources. Across the second half of the century average annual numbers going to the New World apparently shrank from over 7,000 per year to under 3,000 (Harris 2003, 57, Figure 1.18, from Gemery 1980).[11] Servant migrants coming to the Chesapeake peaked then fell away for the time being, as did all servants departing England via the key western port of Bristol.[12] Colonies of the West Indies and the southern American mainland avidly replaced British servants with African slaves, which--among other advantages--constituted valuable and reliable inheritance for the children who were appearing in increasing numbers in the families of European planters (Harris 2003, 160-64; 306-16; 409-19). Their intakes of new white labor plummeted by half or more from the 1650s into the 1680s (ibid., 52-57). New England, meanwhile, thrived on natural increase of its own by the 1640s, not migration (except for a few of the Puritan faction who found it dangerous or intolerably uncomfortable to live in Restoration England and Scottish prisoners after Dunbar). The region itself *exported* settlers into the Middle Atlantic and even the Carolinas. Quickly in New England, before long in the Chesapeake, new arrivals had to compete on unfavorable terms for work, land, labor, and capital with the children of established settlers as increasing proportions of women and children appeared in colonial populations (ibid., 409-19). The price of land rose, especially more productive or more accessible land. Average estates and landholdings became larger. Labor became more expensive, especially as the switch to slaves required more investment than using European servants for labor. Native-born inheritors with capital constituted an increasing proportion of planters or farmers. Emerging creole elites came to control the terms for enjoying life, liberty, and property.[13]

As a result of the demographic normalization of the colonies, on the American mainland at least, the ratio of incoming Europeans, who as far as the early 18th century were mostly English (Harris 2003, 59), to the existing white population declined all the way from the 1630s into the 1740s via a D trend with t_0 at 1678 (ibid., 72). This movement parallels closely the D path from 1656 through 1736 for the rate of implied net total emigration from England in Figure 1.3, with its zero year at 1689--and the possible longer underlying D movement, with still stronger swings about it, from 1656 all the way through to 1786 with t_0 at 1688, which is also shown in Figure 1.3 (with a lighter line).

As resettlement in the New World became less enticing for ordinary English men and women, owners and managers of the new Restoration colonies turned in the late 17th century to diverse, more marginal religious and national groups with distinctive motivations to try to make their projects pay in a competitive environment. To make up for the scarcity of English volunteers as the luster of emigration to New World faded, recruitment ties with Scotland, Ireland, Germany, and refugee French Huguenot populations were established, as were connections with sects little represented in the early, mostly Anglican and Puritan colonization--such as Baptists and Quakers.

In Ireland, meanwhile, though the Cromwellian reoccupation entailed an inflow from England during the 1650s and 1660s that significantly exceeded relocations to America in those years, in the 1670s and 1680s the island then received fewer English than the declining flow to the American colonies (Harris 2003, 70), presumably as Cromwellian settlers consolidated opportunities provided by the conquest for the benefit of their own families while hard-pressed native Irish did the best they could to preserve their own prospects against even further intrusion.

A substantial decline of real wages in England, driven by the long-term inflation of the 16th century that plagued several countries of Europe, had indeed established a context favoring emigration upon which planters of Ireland and the New World colonies could draw. This wage decline, however, reversed directions (both in countryside and in town) by the 1610s while emigration first to Ireland and then to America held strong to mid-century.[14] The continued gain in real wages during the second half of the 1600s was then generated primarily by falling prices--by a cheaper cost of living, not by greater demand for workers relative to reduced supply from a contracting English population. The shift of people out of agriculture into rural trade and crafts and urban employment, meanwhile, continued long-term tendencies evident by 1600 or appreciably sooner (Harris 2003, 224-41). This flow particularly included women, many of whose potential husbands had been disappearing in predominantly male emigration to the New World (R. H. Smith 1999, 39). Reduced attraction of new English migrants to the Western Hemisphere, in short, clogged the far-reaching and long-established flow of migration by uprooted young adults (male and female) from countryside to regional center, thence overseas.

Their accumulation in cities, where real wages were rising in spite of the effects of the demographic backup from colonies, aggravated mortality even while having fewer young people emigrate tended to lift nuptuality and thereby total fertility beginning in the 1660s (Fig. 1.4, below). The deficit of births relative to deaths in London alone from the years around 1600 to those around 1675, rose in G’ fashion from consuming just 3 percent of the excess produced in the rest of England to 1.9 times that surplus (Wrigley and Schofield 1981, 167-69; graphed in Harris 2003, 187). The crest of this surge, about 1675, did much to drive the crude death rate of England, which had been progressively accelerating upward in E manner since the 1550s to its culmination around 1681 as the ‘safety valve’ of emigration tightened up and expanded the urban target for the plague and other disorders that struck much of Europe in the mid-to-later

17th century (Harris 2001, 148-52, 157-59; 2003, 258). Appropriately for this interpretation, nationally it was the mortality of younger adults in their reproductive years that visibly surged in G' form into the 1680s, a pattern not observed for other age groups (Tabs. 1.5, 1.4; Figs. 1.9, 1.8a).

After swinging back to positive in the 1690s, then, during the early 1700s natural increase in England returned via a G path to its levels of the later 1500s. Older estimates by Deane and Cole (1967, 115) roughly presaged calculations of the *Population History* that are displayed in Figure 1.3 by likewise indicating G-shape gains in the rate of natural increase across the 18th century: for England as a whole, and for the North, Northwest, and South separately. The regional exception was for the counties around London (Essex, Kent, Middlesex, and Surrey), where negative natural increase occurred for 1701-to-1750 and 1751-to-1780 but then turned positive for 1781-to-1800 and 1801-to-1830. About 1780 London in particular shifted from devouring English population to providing some surplus (Harris 2003, 187). In the North and Northwest the base years of the likely G trends in natural increase arrived in the 1720s; in the South, the 1740s. The different behavior of the London area pushed the zero year for all England in these estimates of Deane and Cole onward to the 1750s, like the Wrigley-Schofield calculations of CRNI from 1726 through 1816 that are presented in Figure 1.3.

Emigration once more followed its own path independent of the rate of natural increase. After spiking during the mobilization of the French and Indian and Seven Years Wars, from the 1760s into the 1920s, the rate relative to the current size of the English population seems to have increased generally along an G path with a zero year around 1806, although significant shorter-term fluctuations appear. The main exceptions to what alternatively might be a trend of H form for the implied rate of net emigration out of England all the way from the 1720s through the 1920s involve very low average values from the later 1760s through the 1780s, then also the 1810s. These are omitted from fitting such a possible H curve for those two centuries in Figure 1.3.[15] During that first group of low years, significant military forces came home from one intercontinental struggle with France--in Europe, Asia, North America, and the Caribbean--before engaging in the next, North America became a font of Loyalist refugees rather than a magnet for further English emigration, and the substantial regular export of convicts (mostly to Maryland) was interrupted until the development of Australia as a penal colony, beginning in the very last years of the 18th century. During the 1810s, once again large numbers of military personnel returned. In both periods of low emigration, meanwhile, across most of the years between 1763 and 1818, the development of industry in England attracted Scottish, Welsh, and Irish workers--immigration that was made less attractive by the recession that followed peace in 1815.[16]

Other peaks and troughs between the 1650s and the present time, including the implied break in positive *immigration* since 1931 that culminated around 1971 (the bottom right corner of Figure 1.3), also need careful examination against occasionally known particulars of migrant flows. In such analysis one must continually keep in mind that the unknown balance of demographic exchange with Scotland and Wales (and, for many periods, equally obscure results of flows to and from Ireland), along with losses at sea and in military operations abroad, probably had a significant impact upon net *English* differences between natural increase and population growth. As Wrigley and Schofield indicated for their back projection, such unknowns also affect how to interpret estimates from other methods (1981, 220-21).

Keeping in mind that the G trend may make a better fit after the 1760s, it should be noted that the longer alternative H path for net emigration rates from England all the way from 1726 to 1926, with zero year at 1693, closely resembles how, from the 1750s or somewhat earlier in the 18th century into the 1830s the proportion of laborers among all persons who worked on farms seems potentially to have advanced in H fashion with t_0 about 1710 (Harris 2003, 241-43). From 1800 through 1930 the percentage of employment in all developed countries that was industrial then followed a comparable H trajectory with base year in the vicinity of 1700 (ibid., 294-95). This suggests, not surprisingly, that first rural then urban proletarianization shaped the emigration rate for England across the 18th and 19th centuries. The shift of traditional modes of employment to wage labor seems to have shaped emigration both before and after the industrial revolution. In the 19th century, for example, labor productivity in agriculture in Britain (and in Europe more generally), which improved along a somewhat flatter H path with t_0 around 1650 (ibid., 291), contributed to both fundamental change in employment and net emigration.

Earlier, between about 1550 and 1650, the implied rate of net emigration from England had also risen, via an H trend based in the 1480s, approximately parallel with certain fundamental social and economic developments: English population increase from 1561 through 1656 enlarged in this manner with t_0 at 1461 (Fig. 1.1). From 1520 through 1670 the numbers of rural people who were occupied *outside* agriculture, in particular, expanded this way in H form with base year at 1452 (Harris 2003, 233). The urban population of England may also have grown in this manner between 1520 and 1600.[17] Then from 1600 to 1670 the *percentage* of English people living in towns and cities gained along a somewhat steeper H trajectory, with zero year around 1500 (ibid., 225). In short, a freeing up of labor from farming during an era of population increase simultaneously supported emigration, the growth of rural crafts and businesses, and urbanization, all in generally contemporaneous H form.

Such connections, in both earlier and later eras, firm up suspicions from the historical location and timing of H-type population growth voiced in Volume I that this kind of increase, more slowly decelerating than the more common G-shape expansion, depends upon support from fundamental economic and social changes, developments often associated with 19th- and 20th-century modernization--but not limited to it.[18]

Such potentially insightful connections to socioeconomic trends within England would, among other things, seem to strengthen the case for preferring the patterning of growth minus natural increase in Figure 1.3 to the back-projection computations for migration rates from the *Population History* during the period from 1691 through 1781, where the two series of quinquennial or decadal estimations significantly differ (the dotted trend vs. those with medium dashes).[19] Both of these sets of calculations, furthermore, seem significantly more compatible with the known historical record on emigration than the series implied by the GIP method (Wrigley et al. 1997, 614).

PATTERNS IN AGGREGATE FERTILITY AND NUPTUALITY

Moving ahead productively over the past quarter of a century, continuing research given momentum by the *Population History* has established much more about the nature of trends in English fertility, nuptuality, and mortality. Those findings help to better understand this particular historical case of national demographic evolution. The patterns observed, furthermore, assist in comprehending the development of other populations (most of them less richly documented) that shared or did not share movements observed in England.

Wilson and Woods (1991, 414-15)--building upon the research of the Cambridge Group and the analysis of historical fertility since the middle of the 19th century that was developed by Ansley J. Coale, his associates, and investigational heirs--calculated four indices that help in further understanding reproduction and marriage in England from the 1500s into the 1800s. Their findings and the G-based trends imbedded in them are plotted in Figure 1.4.

First of all, fertility in marriage (I_g), their calculations say (the hollow squares across the middle of the graph), remained almost completely constant all the way from the 1540s to the 1870s, with only very slight decline from 1543 through 1743 and very slim increase from there through 1873. As is generally thought for societies before the era of modern demographic transition, it was nuptuality (I_m), the extent to which women of fertile age were married (the solid squares), that primarily determined trends of overall fertility (I_f)--births for females of successive fertile ages, married or not, measured against a hypothetical maximum schedule of reproduction (the Hutterite model). In all, the English crude birth rate in Figure 1.1 fell and rose as it did up through the middle of the 19th century because, for one reason or another, more or fewer of all potentially reproductive women were in marriages.

Between 1558 and 1663, nuptuality and overall fertility (the hollow circles) declined together in C form with t_0's at 1712 and 1707.[20] That is how, in Figure 1.1, the CBR and the GRR in England took C paths from 1556 through 1661 with target years for the curves at 1710 and 1701 respectively. Fertility outside of marriage (I_h), though less important for total reproduction, also contracted significantly between the 1550s and the 1650s (the bottom plot in Figure 1.4, with hollow triangles). It did so, however, in a G' pattern that--following sharp decline from 1541--had bulged to a crest around 1600 before falling away still further into the middle of the 17th century. The share of illegitimate arrivals among total births in England between 1575 and 1675 comparably rose then fell in G' fashion with peak at 1600 (Bardet 1997, 337, from Laslett; fitted in Fig. 1.7, below).

Then from the 1660s into the middle of the 1700s nuptuality (I_m) in England increased again, taking overall fertility (I_f) with it in closely parallel G trends which had t_0's at 1618 and 1624 respectively. The crude birth rate and gross rate of reproduction, meanwhile, display accompanying movements with base dates of 1602 and 1615 (Fig. 1.1; Fig. 1.2 and Tab. 1.2 for the GIP versions), while the crude marriage rate climbed from 1661 through 1756 along a G path with zero year of 1606 (Wrigley and Schofield 1981, 528-29; fitted but not shown). Extramarital fertility (I_h), however, from the 1650s into the 1750s rose from its nadir during the Commonwealth in more robust, less rapidly decelerating H form. With t_0 in the vicinity of 1640 rather than 1600, this trend follows a generation or so later the H-shape pattern that may characterize the growing percentage of workers in the agricultural work force who were just wage laborers between 1599 and 1705 (Harris 2003, 241; from Kussmaul 1981, 12-13). The proportion of English births that were illegitimate, however, increasing in H fashion between the 1650s and the 1735 from a base in the 1590s, parallels very closely without lag the change in agricultural labor (Fig. 1.7). Did rural proletarianization and the monetarization of relationships between workers and employers--including more separate residence-- before long drive up the rate of extramarital fertility? While urbanization also may have increased in H form for England between 1670 and 1750, its pace of change--with base year back in the 1550s (Harris 2003, 225)--was too flat to account alone for the observed gain in rates of extramarital fertility. Combined with noted alterations in the conditions of agricultural work, however, the two tendencies probably explain most of the calculated increases in extramarital fertility and illegitimacy.

During the next period, from the middle 1700s into the early 1800s, overall fertility continued to follow nuptuality. Each now, however, moved upward in accelerating E fashion with zero years of 1860 and 1855 respectively (Figure 1.4) while the accompanying E trends of the CBR and the GRR targeted 1862 and 1851 (Figure 1.1). The linkages among these variables remained the same, though all now took the distinctive E shape. The crude marriage rate, however, shrank in C fashion from 1761 through 1841 with target year at 1895. The CMR could depart from I_m this way if, as fewer marriages occurred, women stayed married longer. That could happen by means of earlier nuptuals or through maintaining the reproductive partnership across more of the fertile span of females (by reducing the chance a partner would die or the couple would be separated). The data of Razzell show, for example, how mortality rates for men 31 through 45 and, perhaps, the fathers of Kent brides probably declined across the later 18th century in C form with target year in the vicinity of 1840, presumably lengthening their marriages (Fig. A.1a in App. A). Also, life expectancy improved between 1735 and 1805 for M.P.'s in their 30s in E fashion with zero year at 1871 while all English males of 25 saw their life expectancy rise in E shape (Figure A.1b and Table A.1). Was comparable improvement happening for women of fertile age?

Toward the end of the long historical span studied by the Cambridge Group, between the 1820s and about 1860, nuptuality and total fertility dipped then rose back together in 1/G' shape. The bottom for these sags arrived close to each other in the 1840s. Meanwhile extramarital fertility, which had pushed upward in two G' surges rather than a more gradual E-shape acceleration across the later 1700s, dropped in the 1830s before making a third but lower G' expansion that peaked at 1858. In all, as far as the 1860s overall fertility in England continued consistently to reflect movements in nuptuality, as the international literature on pre-modern demographic dynamics would have expected.

Continuing research, in particular the extensive findings from family reconstitution that are provided in the *English Population History* of 1997, has still further enriched understanding of nuptuality, fertility, and mortality, and their relationships to each other in England between the middle of the 1500s and the middle of the 1800s.

A marked expansion of *celibacy* lasting into their early 40s (roughly the end of their fertile years) among women of average age to marry during the 17th century (Fig. 1.5, bottom plot), on the other hand, helped pressed down I_m and also I_f across much of the 17th century without affecting I_g. As a determinant of nuptuality, celibacy accompanies the age of marriage, the degree to which women stay married until the end of their fertile period (without the loss of husbands or their own deaths), and the amount of permanent or temporary separation that is experienced for one reason or another. During the 17th century, among English women aged 25 two successive G' surges peaking in the vicinity of 1628 and 1673 created an upward-sloping plateau of high and rising celibacy that reached over 20 percent, more than twice the level observed in the early 1700s and three or four times the level of the late 1500s (Fig. 1.5; Wrigley and Schofield 1981, 260).

Looking at movements of female age at first marriage and celibacy among women, R. H. Smith (1999, 31-32) argued that in England during the late 1500s and the 1600s "changes in the proportion ever marrying had much greater impact upon fertility than did changes in the age of marriage." The evidence of Figure 1.5 and the quite constant average age of English women at first marriage from 1610 to 1770 (Wrigley et al. 1997, 134) seems to support that conclusion.

The availability of marriage for females was mostly reduced by the extent of emigration during this era. Except for the focused exodus of Puritans in the 1630s, the large majority of 17th-century English people who went to the New World, at least (did more families go to Ireland?), were young single men or boys. The first G' surge of servants and other English people to the colonies of the New World crested about 1640; and a roughly contemporary wave to Ireland before the Civil War is likely (Harris 2003, 67, 70). A second peak to the North American mainland and probably to a re-pacified post-Cromwellian Ireland (52-53, 67, 70) arrived about 1670--compared with potential G' highs for celibacy in England around 1628 then 1673. Lesser G' movements in female celibacy may have peaked across subsequent, lower long-term trends, even those involving significant decline, about 1707, 1803, and 1841.[21] The first and third of these accompany contemporary G' rises in estimated emigration numbers, the second does not (Harris 2003, 67).

The depressed levels for the late 1500s may seem extreme in comparison with what followed, but they reached no lower than those for English women in the third quarter of the 18th century--and on average approximate the 6 percent for French women where their records begin in the late 1600s. It seems appropriate to focus upon how the English rate of female celibacy became so elevated for the 17th century, not why it was so low toward the end of the 1500s. While the emigration rate for England was already high by the 1540s (Fig. 1.3), much of the outflow involved *families* leaving for religious reasons, Protestants then Catholics. Obscured in estimations for emigration rates, furthermore, are outflows to neighboring territories where more normal sex ratios might have been welcome as a new national 16th-century England brought "dark corners of the land" under centralized sway. What happened in the vicinity of 1600 was that, thanks to well-known international inflation, a roughly 50 percent collapse in real wages into the 1590s--the second decline of such proportion since about 1510 (Wrigley and Schofield 1981, 642)--squeezed the prospects of young English male workers just as the nation's adventurers opened up possibilities for expansion in Ireland and overseas while growing population continued pressure upon domestic opportunity in an essentially agricultural society. Their willingness to relocate drastically raised the proportion of women who never married, with major consequences for the demographic system.

The repeated parallelism of underlying, *long-term* trends for female celibacy, emigration, and related aspects of domestic change further clarifies how non-marriage among women (plotted with larger dashes in Fig. 1.5) waxed and waned between the 1590s and the 1840s:

Female Celibacy	1599-1694 H 1460	Population	1561-1656 H 1461
		"	1686-1726 H 1492
		Urbanization	1520,1600 ?H 1477
			1600-1670 ?H 1497
		Emigration	1541-1661 H 1480s
Female Celibacy	1684-1739 D 1690	Emigration	1656-1736 H 1688
Female Celibacy	1704-1754 C 1756	Labs./Agr. W.'s	1705,1754 ?C 1788
		Mfr.-Con./MWF	1700,1760 ?E 1800
Female Celibacy	1759-1844 H 1711	Labs./Agr. W.'s	1752-1831 H 1710
		Emigration	1726-1926 H 1693
		Ind./W.Dev. C.'s	1800-1880 H 1700

Following the great upward shift in the level of celibacy around 1600 from economic hardship and the way that made (mostly male) emigration to England's newly developing frontiers in Ireland and the New World attractive (replacing relocations during the second half of the 1500s for more religious reasons), the proportion of women of typical age to marry from

1599 through 1694 who never did wed before their fertile years were past, across the marked successive G’ swings that have been noted, gradually increased in H form reflecting the emigration rate (Fig. 1.3). This, in turn, was shaped by the H-type pressure that population growth put upon an essentially agricultural society, also promoting urbanization (Harris 2001, 150-51; 2003, 225; movements between 1520 and 1600 and 1600 and 1670 are both hypothesized to have had H rather than other forms of increase).

A quadrupling of female celibacy to a level of 20 percent or more for almost all of the 17th century provided a much larger supply of women without the impediment of families to work in agriculture as English farming from the 1500s forward diversified to include more female-friendly activities like dairying. It also increased the labor force in household service for the rising middle class in expanding towns and cities (the people who wanted more meat, milk products, and other improvements in their diets and lives) and in crafts and trades--in which women played a profitable part, even if their earnings in protoindustrialization were often low relative to those for men, unlike surprisingly equal wages for agricultural servants during this era (R. M. Smith 1999, 39-41). The high 17th-century “plateau” for rates of female celibacy, in other words, contributed significantly to the agricultural improvement, the development of crafts in rural as well as urban areas, and the urbanization that supported a larger population (through the 1650s) in this phase of English history (Harris 2003, 236-37, 225; 2001, 150-51).

Then, because death rates surged during the third quarter of the 17th century (Fig. 1.1), powered by urban-focused mortality (especially in London) thanks in part to deteriorating opportunity for those who emigrated overseas (formerly more of an alternative for the displaced, the population of England contracted somewhat in D fashion between 1656 and 1686, raising wages (Wrigley and Schofield 1981, 642-43) and reducing pressure on sustenance and the quality of life. This, significantly aggravated by less favorable opportunities for new arrivals overseas thanks to the normalization of colonial populations (Harris 2003, 410-19), triggered much steeper D-shape collapse of emigration starting in the 1650s. In response to such a lessening outflow of young males in particular, celibacy rates between about 1684 and 1739 fell in parallel D manner (zero year at 1690 compared with 1688).

The further decrease of celibacy, via C, from about 1704 to 1754 lacks apparent connection to either rate of emigration or changing population size (which both *increased*, as did urbanization). Between 1705 and 1752, however, the proportion of laborers (as opposed to live-in servants) in the agricultural work force declined enough to suit a C trend targeting 1788, though evidence for no intervening point is known (Harris 2003, 241). Comparably, between 1700 and 1760 the percentage of English men who were employed in manufacture or construction increased such as to fit an hypothesized opposing E curve with zero year about 1800 (Harris 1997, Fig. 12.11, 40, from Crafts 1984, 440).

Richard Smith (1999, 38) has stressed that during the first few decades of the 18th century “farmers strove to employ live-in labor” in response to shortages. Falling prices squeezed their liquidity, making it economical to pay workers annually. These workers were generally more equal in sex ratio than wage laborers, especially as relative price trends encouraged a shift to animal husbandry, where women and girls were useful--especially in dairying (32). The shift of labor toward industry during the first half of the 18th century, meanwhile, as yet involved mostly thickening protoindustrialization rather than outright factory work. In this context, the efforts of wives and children were directly important to potential husbands, not landlords, fostering family formation. Domestic structural change during this era both in agriculture and in manufacture worked to make marriage easier regardless of what happened to emigration.

H-type increase in female celibacy for the period between the 1750s and the 1840s, on the other hand, returned to resemble gains of that shape in net emigration from England that ran from the 1720s into the 1920s. The new trend even more closely paralleled the H path for now *rising* (and more frequently documented) proportions of agricultural workers who were employed as laborers--with t_0’s at 1711 and 1710 respectively (Harris 2003, 241). Population and urbanization, meanwhile, each increased via E--then in H form after 1800--and real wages fell in C fashion followed by G-type gain. Given the known growth of factories between 1750 and 1850, the nationwide proletarianization of labor, in country and in town, seems to have driven female celibacy and emigration.

Figure 1.5 also plots some changes in the ages at which women who *did* marry wed, and estimated consequences of such shifts for how many fertile years women were in regular sexual unions.

While the data are provided only in quarter-century segments (Wrigley et al. 1997, 141), it seems as if the percentage ever wed who married only at age 35 or older rose across the 17th century roughly along with the percentage who remained celibate. The tentative E then G paths for earlier then later decades differ markedly in detail from the two successive G’ surges for celibacy; but the overall increase from 1612 through 1687 closely resembles the underlying H pattern for proportion who did not marry. There is a large gap of information for the age distribution of brides in the 18th century; and spinsters who married widowers are not included. Nonetheless, from the last quarter of the 1600s into the last quarter of the 1700s, the available information suggests much the same kind of C-type decline (though later and weaker) as found for celibacy from 1704 through 1759. From about 1685 through 1715 late marriage contracted less sharply than female celibacy, but--as one might easily expect--the two seem here, too, to have responded together to whatever pressures limited nuptuality. The break came after the 1760s, when late marriage contracted further via D while never marrying increased (roughly inversely to about 1815, more strongly thereafter).

This was a period during which marrying under 20 or under 25 became more frequent for English women in upwardly accelerating E fashion, imprinting this shape of gain on both nuptuality and overall fertility (Figs. 1.5, 1.4). Such movement toward more young marriage, however, only slightly increased the estimated number of years during which significantly fertile women were in wedlock (the top plot of Fig. 1.5; estimated by subtracting the average age of first marriage, which contracted only from 25.0 to 23.6 [Wrigley et al. 134]--from 40, where further reproduction historically becomes markedly limited), and raised marital fertility (I_g) via E.

More frequent young marriage primarily reflected the movement of workers out of agriculture as farming could support more and more people, partly through increase in the scale of enterprises (Harris 2003, 241, 236). While it might seem to workers that nominal wages were rising, the flow to employment in growing towns and cities (ibid., 286) aggravated increases in the cost of living (for example, getting food and fuel to city dwellers) that made wages actually fall in opposite C fashion, cheapening labor costs for urban employers even if urban wages rose in E form relative to rural ones, helping pull workers out of agriculture (Harris 1997, Tab. 12.1; Ch. X below). The expansion of young marriage for women (during their most fertile years), which the move from rural to urban life and work encouraged, increased reproduction which powered the growth of population.

% Fem. Marry < 20	1787-1831 E 1875
" " " < 25	1787-1831 E 1900
Urbanization	1700-1850 E 1854
Nuptuality (I_m)	1758-1818 E 1860
Overall Fertility (I_f)	1718-1808 E 1854
Workers per Farmer	1765-1831 E 1838
Pop. per Person in Agric.	1750-1801 ?E 1834
Population	1726-1806 E 1822
% Men in Agric. or Extract.	1700-1800 C 1830
Farmers per Rural Pop.	1777-1831 C 1814
Urban/Rural Wages	1715-1795 E 1851
Real Wages (PBH)	1731-1813 C 1849
" " (CM)	1750-1804 C 1849
Nominal Wages (PBH)	1736-1810 E 1819
" " (CM)	1750-1804 E 1823

Previously, during the second, third, and fourth quarters of the 18th century, the proportion of English wives who married young had increased even more, recovering from a low point around 1712. The average age at first marriage for females dropped 2.3 years between 1715 and 1785, compared with 0.9 from there to 1834, just 0.2 by 1825 (Wrigley et al. 1997, 134). Yet most of the gain in the long E trends for nuptuality and fertility from the early 1700s to about 1820 took place following 1780 (Fig. 1.4). However, the advance in young marriage between about 1712 and 1787, though greater, had less impact upon overall nuptuality and fertility that thereafter. Strong proportional reduction in celibacy and the percentage of wives who married only at 35 or older, which both occurred during the first few decades of the 18th century, also failed to raise overall fertility robustly while marital fertility edged upward almost imperceptibly (Figs. 1.5 and 1.4). Something of a puzzle emerges in trying to understand increase in early marriage, its cause and effects, between about 1712 and 1787. The shift from one group of evidence to another during the long gap might be involved. So may effects of young adult mortality in disrupting unions and the frequency of remarriage.

Socioeconomic changes obviously related to trends in early marriage and less celibacy are less plentiful for this period. If the decline in the weight of farmers in the rural population from 1688 through 1793 took D form, however, it would have run opposite to the shift toward early marriage (t_0 around 1670 vs. 1677 for under 25 and 1704 for under 20 if the rises took G shape), while a temporary reversal of the shift from live-in servants to wage laborers in English agriculture might also have taken a D path based about 1680 during the gap of evidence between 1705 and 1752 (Harris 2003, 241). How would such developments have affected early marriage and fertility? In the Swiss canton of Zürich, movement from farming into protoindustrialization or multi-occupational combination of crafts with agriculture is known to have made wives and children useful sources of income, weakening forces that encouraged late marriage in rural areas (Braun 1978?).

Still earlier, the proportion of English wives who married young contracted in C fashion across the 17th century into the first decades of the 18th. The proportion wed only at 35 or older rose for most of the period in even steeper E form (Fig. 1.5). The basic explanation seems to be that the labor shortages generated by male emigration to about 1660 and population decline from there through 1686 significantly expanded opportunities for women as farm wages for men became more expensive in E fashion (with t_0 around 1789) closely opposite to the C-type decline in the percentage of women marrying young (R. M. Smith 1999, 38-40; Ch. X). A shift toward pastoral products simultaneously evened up wages for female servants in agriculture relative to men. Unmarried women contributed “disproportionately” to the flow of population to towns. The possibility of their employment for just the early adult phase of the life cycle needs careful scrutiny since overall nuptuality and fertility *rose* during this era (Fig. 1.4). Also, did income for females in towns and cities improve relative to their rural earnings as it did for men? More women entered more different kinds of trades as the weight of farmers in rural populations fell in something like C form between 1599 and 1705 (Harris 2003, 241). Female literacy rose relative to levels for males during the post-Civil War period. Marriage was delayed and female celibacy ran even higher than where it had jumped around 1600, before falling in the last years of the 17th century. The role of female age at marriage in the complexly interconnected demonomic system of England, like that of celibacy, altered significantly from era to era down into the early 1800s--not with unchanging cause or effect, but in various comprehensible ways.

During the remaining decades of the 19th century, the proportion of females age 20 through 24 who had ever been married swelled from the 1850s to the 1890s in G' fashion to a crest in the 1860s, then dropped back. This pattern for young marriage appears in communities with several distinct mixes of agricultural, industrial, and commercial activity. From the early 1900s into the 1950s, then, the percentage for the whole country rose in E form to a zero year about 1954. The nuptuality index I_m, meanwhile, first contracted comparably, but via a C path with zero year around 1962 (a C for 1865 through 1905 that targeted 1944 would fit the data for women married by their early 20s). It then also rose in something close to E shape toward t_0 in the later 1970s from the 1890s into the 1950s. Judging from the proportion of women age 45 through 49 who had never married, celibacy--after running quite constantly around 12.5 percent for those of average age to wed from about 1830 through 1870--increased in G' manner to more like 17.0 percent for women who would typically have married in the vicinity of 1895, before returning to the level of the mid-19th century by about 1930 (Friedlander 1992, 25; compare Fig. C.3a, App. C).

In the 20th century, the trend for celibacy became fully disconnected from the paths of net nuptuality and fertility. The proportion of women in England and Wales who never married fell between 1910 and 1965 all the way from 18.0 percent to 3.5 percent (Schoen and Canudas-Romo 2005, 141). Arranged by successive cohorts born between 1881 and 1971, this trend took smooth C form with t_0 around 1980 (subjects in 2009, by period of marriage; estimated from graphing). This C movement occurred as between 1891 and 1931 nuptuality (I_m) climbed gradually in E shape and then surged after World War II to a G' crest in the 1970s (Ch. 4, Fig. 4.2a) and overall fertility *fell* markedly in C fashion between 1871 and 1931, then--after the 'baby boom' of the 1940s and 1950s--again from 1961 through 1981 (Fig. 4.1b) rather than rising via E. Average age at marriage for these women (Schoen and Canudas-Romo 2005, 141), meanwhile, declined in C fashion from 1910 through 1970 (women born from 1881 through 1941). While such movement, as one would expect, elevated nuptuality, it ran *opposite to* a path that would have helped drive down fertility over these years, the actual trend for reproduction, which was determined now by conscious family limitation.

Though the trendings can at times be only tentative and approximate, G-based patterns help summarize English movements in fertility, nuptuality, celibacy, and age of marriage, and their relationships to each other from the 1500s through the 1900s.

AGE-SPECIFIC CHANGES IN FERTILITY, FAMILY LIMITATION, ILLEGITIMACY, AND CONCEPTION BEFORE MARRIAGE

Whereas the calculations of Wilson and Woods in Figure 1.4 indicate hardly any change in English marital fertility overall (I_g) between 1544 and 1868, the reconstitution analysis of 1997 (Wrigley et al. 1997, 355) displays rather more movement for total marital fertility--especially for the fertility of certain age groups among married women. Though some randomness is likely to affect these more specific findings through time, apparent trends displayed in Figure 1.6 and compared in Table 1.3 complement the evidence on nuptuality in elucidating how reproduction, viewed in 25-year units of time, waned then waxed across English history between 1600 and 1825.

The total marital fertility rate, first of all, from the first quarter of the 17th century into the third (mid-points from 1612 to 1662) shrank in C fashion with zero year at 1730. Then from 1687 through 1737 it rose in G form from a base year of 1607. Finally, between 1762 and 1812 it increased gradually in accelerating E manner toward a target year at 1922. As Table 1.3 indicates, these movements largely resemble trends of the same C, G, and E shapes for somewhat comparable successive periods of movement in I_f, though variations in span and the use of 25-year blocks of time for total marital fertility contribute to producing some differences in when the t_0's for the fitted curves arrive, especially for the last pair of trends (1855 vs. 1922).

Through the first three-quarters of the 17th century, total marital fertility declined in C form because decrease of this shape and approximate timing occurred for every potentially fertile age group of women except those 45 through 49, whose scant reproduction expanded in something like G fashion. In the next era, from the third or fourth quarter of the 1600s through the second quarter of the 1700s or rather later, G-shape gains in fertility for most age groups supported increase of G form in total martial fertility, though these patterns of increase were stronger (had later t_0's) among those in their 40s than for younger women with such trends. Such fertility gains within marriage preceded by several decades the G trends toward more young marriage after 1700 (Fig. 1.5). Exceptions in the form of delayed increase via E rather than G occurred among those 15 through 19 and 25 through 29, Table 1.3 summarizes. These tended to run opposite to the C-type decline in celibacy from about 1700 to 1760. Between 1750 and 1825 (mid-points at 1762 and 1812), finally, fresh E-type gains for these two groups of wives helped push up total marital fertility in gentler movement of this form, because their high levels of reproduction more than offset the impact of C-shape decline for most women 30 and over (though, as the second panel of Figure 1.6 indicates, in the first quarter of the 19th century some type of new increase for women in their 30s also assisted in elevating total marital fertility). For some reason, among those 20 through 24 and also 40 through 44 the now-flattening G-type increase of the previous epoch largely tended to be continued instead, while for wives in their later 40s fertility contracted gently in C form.

The tendency for most groups of married women over the age of 30 (excepting those 40 through 44) to have lower fertility in gradually accelerating C fashion during the first three quarters of the 18th century, on the one hand, hints that at least some family limitation may have been coming into play among older fertile females. One did not have to have the modern contraception associated with the ubiquitous international C-shape fertility declines of the 19th and 20th centuries (Ch.'s 2 and 4) to cut back on the number of children one had if the desire was there. That raises the question, however, of just what mechanisms drove the even more general C-shape reductions of marital fertility of the 17th century that appear in Figure 1.6, which involve wives of all age groups under 45. Were married couples in England significantly employing pre-modern techniques to limit family size already in the 1600s? Chapter 5 reviews the evidence that quite a few European population groups of the era in fact did that. Or, more likely, did the way that the CDR in England rose in opposite E fashion into the 1680s (Fig. 1.1) reflect increase in the death rates and illness of women of fertile age and their spouses (Tab. 1.5) and in maternal deaths with childbirth (Fig. 1.8b)? Was it was primarily effects of morbidity and mortality that cut back reproduction in this period--dynamics worth considering for other European populations as well? Did improvement in socio-economic conditions, starting about 1675 when the population had shrunk somewhat for a generation, subsequently (after about 1725) relieve pressure on collective marital fertility--whatever its cause--for younger English women during the 1700s, though not for those over 30 while it allowed more marriage (falling celibacy) and more younger marriage (Fig. 1.5)?

Changes in the average interval between births can significantly affect how fertility expands or contracts for a population. Longer spacings are an indicator of family limitation. The family reconstitutions of the Cambridge Group show that average birth intervals after the first child, when the preceding baby survived infancy, experienced a "not trivial" rise from the late 1500s to the 1660s before they fell off, more substantially, across the late 1600s and the 1700s

(Wrigley et al. 1997, 448-49). Yet, over the longer term, a proportional graphing of the average interval, decade by decade, between all births after the first generally shows gentle C-type contraction, first from 1585 through 1715 with zero year in the 1820s, then anew from 1715 through 1815 (ibid. 447; Fig. A.2 in App. A). For bachelor-spinster marriages such C-shape shortening of spacing was most notable to about 1650 between the first and second child, if the first survived infancy ("B-S Parity 1, Live"), followed by G-type extension through about 1740 then contraction in D form into the early 19th century. If the preceding baby survived, very slight C-form reduction in spacing appears in the average for all later intervals ("B-S Parity 2+, Live").

If the preceding child died, however, the birth gap for all parities greater than 1 ("B-S Parity 2+ Die") increased in some form between the late 1500s and early 1700s (perhaps including the G path suggested for 1662 to 1712), dropped back briefly, then rose again during the 18th--seemingly in E form. These G and E movements resemble trends in nuptuality, overall fertility, and total marital fertility during each epoch (Figs.1.4, 1.6), possibly representing during most of the 18th century reaction to falling real wages as the population expanded and urbanized (in comparable C and E paths respectively). In contrast, birth intervals following the death of the first child ("B-S Parity 1, Die") tended to fluctuate around a level underlying trend from the later 1500s into the third quarter of the 1600s. Then, the average seems to have surged in G' manner through a crest in the 1680s before expanding via G toward 1800. In the late 1600s there was less of a rush to replace a lost first child. If the G' movement is real, what in the experience of women at the time might generate this phenomenon? Early marriage for women was approaching its low point between 1600 and the 1830s and celibacy was at its maximum (Fig. 1.5). Did more women or couples than usual engineer pregnancy in order to achieve marriage, but under employment or living conditions that did not encourage more children (perhaps even keeping the first baby alive)? In the early 19th century birth intervals following the death of a child fell significantly at all parities, in contrast to spacing after a previous child survived. Some further probing seems desirable of just where and how in the birth sequences for women of what ages expansion and contraction of birth intervals occurred, and the way these made the national averages go up or down (reconciling what seem prima facie to be contradictions in Wrigley et al., 438-39 and 447-48).

In aggregate, the Cambridge Group estimate that between the middle 1600s and the early 1800s reduced spacing elevated the crude birth rate of England something like 10 percent (Wrigley et al. 1997, 449). The CBR rose about 48 percent from 1651-61 to 1806-21. Comparison of Figure A.2 with Fig. 1.5 indicates that increases in early marriage and, most of all, declining celibacy were considerably more significant.

Not all births, of course, occurred in wedlock; nor were all babies born to married couples conceived after the ceremony. Figure 1.7 presents trends in illegitimacy and premarital pregnancy in England from the late 1500s into the early 1800s.

The illegitimacy rate surged in G' shape from the 1580s or earlier to crest over 4 percent around 1600 before falling away in such a pattern to more like just 1 percent in the years of the Puritan Commonwealth (Wrigley et al. 1997, 224). At least its recording behaved this way. This movement, however, does parallel almost exactly the comparable G' trend for extramarital fertility (I_h) between 1568 and 1648 that appears in Figure 1.4. Both mirror, inversely, the fall of real wages to a low in the first years of the 1600s (Wrigley and Schofield 1981, 418, 642-44).

The proportion of all first births in the reconstitution study that occurred during the first 6 months after marriage, moreover, probably also rose and sank in slightly earlier G' form (zero year around 1588) between the later 1500s and the 1630s, though such a hypothesis rests upon only the midpoints of the broad year grouping of 1538-99, 1600-25, and 1625-49 (ibid., 421). From the first quarter of the 17th century into the third, then, the proportion of *prenuptually conceived* first births that arrived just within the first 6 months of marriage contracted in D fashion. After the crisis of the early 1600s, changing mores, reporting, or conditions under which women lived and made relationships with men made blatant evidence of fornication before marriage less common, more strongly encouraging nuptuals within only a few weeks of awareness of conception. This D-shape movement was accompanied by somewhat parallel decline in the proportion of *any* premarital pregnancies (up to 8 months after the wedding) among first births to couples between 1612 and 1662.

In subsequent years, across the later decades of the 17th century and the first of the 18th, the percentage of all births in the reconstituted families that were illegitimate climbed in H fashion. With base year at 1596, this trend--while noticeably flatter than the path with t_0 around 1640 for extramarital fertility (I_h in Fig. 1.4)--closely parallels the H trajectory for the percentage among all farm workers who were wage laborers between 1599 and 1705 or somewhat later (Harris 2003, 241). That proletarianization of the agricultural workforce and its residential shift out of the farmer's household, where servants tended to reside more than laborers, apparently contributed toward expanding illegitimacy in the countryside, where most English lived during this era, and to pushing up the national rate of extramarital fertility.[22]

After declining in D form through most of the 17th century, the percentage of first births that took place within 6 months of marriage likewise rose roughly from 1687 through 1737 back upwards in H fashion. With zero year at 1630, this trend closely resembles the H path of extramartial fertility in England from 1653 through 1758 (t_0 at 1641 in Fig. 1.4), while the *proportion* of all prenuptual pregnancies that produced babies within just the first 6 months after marriage climbed from 1687 through 1762 via H with base year around 1550--or parallel with possible H trends for the urbanization of England betwen 1670 and 1750 and the number of workers per farmer in the English countryside between 1599 and 1793 (Harris 2003, 225, 241). All early births (0 through 8 months), in contrast, increased as a proportion of total deliveries via a more rapidly decelerating G path from the late 1600s into the middle of the 1700s. What might have made prenuptual pregnancy between 6 and 8 months early less sensitive to changes taking place in English life, particularly country life, than more blatant violations of sexual norms? Pregnancy is of course more likely to be publically noticed after the first few months, while earlier the concern can be more private to the mother-to-be.

Thereafter, however, from the 1730s into the early 19th century, the illegitimacy rate and the percentage of births within both 8 and 6 months of marriage rose together in parallel G trends of comparable timing. The slight gain in the proportion of all prenuptual pregnancies that occurred within 6 months--in E form with target year as late as 1897--contributed to the appreciably steeper E-shape increase in overall fertility that occurred with the urbanization and industrialization of England from the later 1700s into the early 1800s (Fig. 1.4). It may reflect changes in economic, social, and sexual conditions for women as they went to cities and factories; or it may simply result by chance.

MOVEMENTS IN AGE-SPECIFIC MORTALITY AND LIFE EXPECTANCY

As has been the case for nuptuality and fertility, the 1997 reconstitutions of the Cambridge Group provide more detailed insight into the changing impact of *death* on the English demographic regime and its ongoing processes of renewal. Figures 1.8a and 1.8b begin by showing trends in infant and childhood mortality. Figures A.3a and A.3b provide other particulars.

Figure 1.8a plots decadal rates of mortality for certain groups of English children under 1 year of age and between their 1st and 5th birthdays that were developed by Schellekens (2001, 7-11) to include illegitimate births (unlike series from Wrigley et al. 1997 in Fig. 1.8b). To begin, infant mortality (all deaths before the first birthday) between 1580 and 1640 declined in C form with zero year at 1700. This movement closely parallels the decline of English fertility across that period as seen through crude birth rate and gross rate of reproduction and I_f (Tab. 1.2, Fig. 1.4; with t_0's at 1710, 1701 and 1707 respectively). As the loss rate among babies contracted, fewer births took place in parallel form. Couples are not thought to have been managing their reproduction in England during this early a portion of the historical record in spite of the upwardly accelerating 8 percent extension of birth intervals observed (Wrigley et al. 1997, 447-

48; contrast the stability of I_g in Fig. 1.4 and the average for all birth intervals as presented in Fig. A.2). More important in any nationwide adjustment to the fact that fewer infants died, according to conventional interpretation of pre-modern demographic dynamics, was contracting nuptuality (Fig. 1.4) fostered by a somewhat later age at marriage, which cut back the number of years through which women on average produced (Fig. 1.5; Wrigley et al. 1997, 134-35).

Neonatal (first month) fatalities, after rising slightly to about 1610, mimicked the C trend for all infants to about 1640 (Fig. 1.8a). Post-neonatal (months 2 through 11) fatalities, losses during the second year of life ($_1q_1$), deaths of mothers at birth (Fig. 1.8b), and estimated still births (Figs. 1.8a, A.3a, Tab. 1.4; Woods 2005, 149),[23] however, *rose* in opposite E form toward t_0's in the first years of the 1700s. Death during the first week of life (perinatal) and probably also endogenous infant mortality (from the process of giving birth itself, prematurity, or genetic defects that were soon fatal) increased together in G fashion from the last years of the 16th century into the first of the 17th, dropped downward about 1620, then resumed--from a lower level--very much the kinds of G paths they had been following before. From the late 1500s to about 1650 exogenous infant mortality (from infections originating outside the body) fell in approximately offsetting D fashion (Fig. 1.8b). Except for the relatively sudden improvement of endogenous mortality around 1620, when real wages finally turned upward after decades of dilution in purchasing power, changes as far as the middle of the 17th century tended to constitute a G-type shift from exogenous causes to endogenous ones. It should be rembered, though, that historically infanticide has often been passed off as endogenous death for infants.

The death rate for all children 1 through 4 years of age, meanwhile, displays C-shape decline that is comparable to the trend for infants to about 1610 or 1620, and then rises in similar G fashion--but only to 1680. Mortality between 5 and 10 ($_5q_5$) and all deaths under the age of 15 ($_{15}q_0$) tended to increase in this G fashion while loss rates between the 5th and 10th birthdays multiplied in somewhat flatter G form (based on average around 1563 rather than 1593) all the way from 1590 into the 1730s. So did mortality rates for the third year of life ($_1q_2$) and probably for all boys and girls 5 through 14 (10q5), though they first joined deaths during the 4th and 5th years in experiencing a 1/G' dip that bottomed out in the first decade of the 1600s (Figs. A.3b, A.3a, Tab. 1.4).

In all, the loss rate for all children before their own reproductive cycles began bulged in G' manner to a crest about 1597 (as the decline of real wages bottomed out and illegitimacy and premarital pregnancy under 6 months peaked). Then after falling back in that pattern, it increased more gradually in G fashion into the last quarter of the 17th century (Fig. A.3b). The latter was a path at first determined by mortality rates for children past their first birthday (age 1-4, 5-9, and 10-14; Tab. 1.4), since the death rate for infants contracted for two generations (1580 through 1640), in a C movement which somehow happens to be parallel with a contracting interval between the first and second births for bachelor-spinster couples if their earlier child survived (Fig. A.2).

Then (col. 3 in Tab. 1.4), from 1640 through 1730, infant mortality also worsened in G fashion. With base year around 1596, this trend was less steep than the G paths for English overall fertility and nuptuality for several decades following the Restoration (Fig. 1.4), though it did resemble the trend for the crude birth rate from about 1660 to 1750 (Tab. 1.2; Figs. 1.1, 1.2). Neonatal deaths and endogenous infant mortality both increased through the remainder of the 17th century in parallel G movements, accompanied to 1675 or later by continuing similar G patterns in losses for those age 1 through 4, 5 through 9, and 10 through 14 (begun in the col. 2 years of Tab. 1.4). Stillbirths and maternal deaths (Wilson 2005, 149; Fig. 1.8b), in contrast, fell off in C form, as did mortality rates for the third year of life. Deaths for all under 15, meanwhile, like rates for children 5 through 14 combined (${}_{10}q_5$), tended to dip in 1/G' form--as, for some reason, did perinatal mortality and losses during the third year of life. This is what the crude death rate for England did between 1681 and about 1730, with its low in the very first years of the 1700s (Tab. 1.4; Tabs. 1.1, 1.2).

Across the first half or more of the 18th century, and then again on into the beginning of the 19th (cols. 4 and 5 of Tab. 1.4), C-shape decline in young mortality was generally the norm. Trends of this pattern, mostly with t_0's near the turn of the century, began to appear by 1710 or so in neonatal deaths and still births, in all infant mortality, and in endogenous infants losses along with maternal death. Mortality for children 1 through 4 and 5 through 9, meanwhile, increased once more in G paths with base years at 1663 and 1680. Only perinatal mortality sagged as the CDR did to a low in the 1750s (Tab. 1.2). From about 1750 forward into the early 1800s, however, almost all categories of mortality under the age of 15 declined in C fashion as the crude death rate of England improved this way (zero year in the 1880s). Another 1/G' dip in perinatal losses and inverse G' movement in all mortality under 15 constitute the exceptions. For children 1 through 4 the pattern could be also G' between 1750 and 1790--but could equally take underlying C form over the longer term between 1715 and 1805 (if the 1730s and 1740s were averaged).

A more varied mix of trends reappeared after 1800 (col. 6) with some G' surges, another 1/G' perinatal dip, and some G-shape advance. Meanwhile, though, the CDR kept coming down parallel with the C movements of column 5.

These pervasive C contractions, it should be remembered, occurred as the birth rate, nuptuality, and overall fertility--and young marriage--all were rising in opposite E fashion to about 1820 (Tab. 1.2; Figs. 1.4, 1.5). Over most of the 18th century young mortality declined faster and faster even as rates for fertility and marriage accelerated upward (helped by C-shape contraction in celibacy between about 1700 and 1760 (Fig. 1.5). Instead of having the degree and direction of change in marriage and reproduction set inverse patterns for infant and childhood death through the pressure of numbers in what Malthus called a 'positive check,' by about a quarter of the way through the 18th century decreasing loss of infants on top of rising nuptuality actually helped the English population accelerate upward in size, starting to 'explode.' This quite different association between early death, on the one hand, and nuptuality and fertility, on the other, instead evokes another common demographic interpretation--that of modern ‘demographic transition,’ with improvement in mortality occurring in advance of control over fertility. In England, in short, such a shift of regime from Malthusian to transitional commenced as early as the second quarter of the 1700s.[24] Previously, across the later 16th century and the 17th, mortality for infants and for children under 5 tended to decrease along with nuptuality and fertility, which a relief of Malthusian pressure on resources would imply, though between 1585 and 1685 losses for older boys and girls from 5 through 14 ($_{10}q_5$) took E form *opposite* to these C paths--the contrary of Malthusian expectations.

Thus, for England at least, G-based trending reveals the opening phase of a historically familiar and crucial change of demonomic dynamics early in the 18th century, not the 19th. Such patterning simultaneously raises issues as to how, and with what consequences, a Mathusian ‘positive check’ might have operated before then, given opposite reactions among those over and under the age of 5 and the way the population grew in H form from the 1560s into the 1720s except for relatively flat decline briefly between 1656 and 1686. The differences and similarities revealed by the G-related movements observed in mortality for successive age-groups prior to maturity, meanwhile, should provide valuable insight into changing causes of death at certain ages, and their impact upon mortality later in the life cycle--whether the losses occurred through disease, the adequacy of diet and shelter, the health of mothers, patterns of nursing and child care, or abortion and infanticide.[25]

The analysis of early deaths in *English Population History* terminates in the 1830s. Rates of infant mortality, however, are known into modern times.

For England and Wales, by the 1980s these had fallen over 90 percent as part of ‘demographic transition’ that began in the middle of the 19th century. Broadly speaking, in spite of a spike in the later 1880s, this decline as far as the 1950s took a C-shape path with zero yeaar around 1933 (Fig. 4.3b in Ch. 4) that closely paralleled the trajectory of such shape for the crude death rate between 1831 and 1923 (t_0 at 1936, Fig. 1.1 and Tab. 1.1; Teitelbaum 1984, 31, for 1845 through 1885). Millward and Bell (2001, 701) have separated out for 1865 through 1915 trends for several different types of towns, and between 1875 and 1915 have distinguished deaths by various forms of diarrhoea from other cases. Some setback for long-term declining mortality, peaking in the 1890s, appears everywhere, though least in farming towns, textile centers, and suburban communities. For the reduction of diarrhoea in the latter ‘middle class’ towns no such hump appears and D-shape decline is evident between 1875 and 1915. Finer analysis of the trend for all infant mortality for 1908 through 1965 (Wrigley 1998, 447) or between 1848 and 1986 (Fig. 4.3c, from Chesnais 1992) can support either C or D patterns of decline across the later 1800s and the 1900s, a trending problem to which the findings of Millward and Bell about different environments and different causes may contribute some insight. Wrigley’s data for still births and death at various stages during the first year of life, furthermore, show D trends in months 2 and 3, and 4 through 6, and for exogenous infant mortality; but C patterns are indicated for still births, neonatal losses, months 7 through 12, and endogenous infant mortality. The data of Teitelbaum (1984, 31), on the other hand, display successive C movements for deaths of children under 5, first between 1865 and 1885 then, following a jump, between 1895 and 1915, but steeper (with earlier target years) than the similar pair of C paths for infant mortality, and beginning only after some G-shape increase between 1845 or sooner and 1865. These differences in path of decline in mortality by age (graphed but not shown) should assist in ascertaining what generated the risk at successive stages of early individual development. Chapter 4 further examines such distinctions of trend shape in infant mortality for England and Wales and for several other European countries (Tab. 4.4).

What, then, about trends of mortality for adults? Patterns for selected age groups over 25 (both sexes; Wrigley et al. 1997, 290) are illustrated in Figure 1.9. The characteristics of movements for these and for other ages are summarized or estimated in Table 1.5. While the decade-by-decade rates fluctuate substantially, certain familiar underlying patterns emerge from them.

Over the middle 1600s, loss patterns for those in their later 20's and later 30's fell in what Figure 1.9 represents as C paths that are rather steeper than the one for infant mortality. Across the later 1600s and into the early 1700s, from there to the 1750s, and a third time during the second half of the 18th century, for young adults 25 through 29, 30 through 34, and 35 through 39 successive G' surges in mortality appear in Table 1.5. These crested together in the vicinity of 1690, 1725, and 1775. Comparable movements occurred in deaths during the first 15 years of life (${}_{15}q_0$) between 1705 and 1755, 1755 and 1795, and 1805 and 1833, but an inverse 1/G' dip appeared between 1675 and 1715 (Tab. 1.4). For that period, temporarily improved survival to 15 was accompanied by a surge in mortality for young adults. Such G' movements for the young were evident in particular among children 1 through 4 (Fig. 1.8a). For some age groups over 45, on the other hand, slightly lagged 1/G' sags of mortality in turn reflect the recent culling of younger adults. During the second half of the 18th century as childhood and young adult mortality crested together, opposite 1/G' dips for some groups over 40 appear.

The relationships of these patterns for successive age groups should help identify what was killing or debilitating the English population during various periods, including the two puzzling sags of the death rate and surges of life expectancy between 1681 and 1761 (Fig. 1.1). Also, the G' bulges in mortality for adults still of fertile age, especially those 25 through 29,[26] tended to rise and peak across the second half of the 1600s like female celibacy (Fig. 1.5). This is the period in which uprooted young people who might have previously emigrated, backed up in urban centers largely because of normalization in colonial populations, especially in London, and died much faster than they reproduced (Fig. 1.3; Harris 2003, 186). The mortality of these persons of fertile age not only lifted celibacy at the time, but also pulled down fertility as unions were prevented, postponed, terminated, or disrupted by death and poor health--as a previous section has speculated in trying to understand .

Long-term, mortality for several adult age groups in England tended to decline from the middle of the 1600s into the middle of the 1700s in roughly C fashion. This pattern is most clear for those 45 through 59 (Fig. 1.9, Tab. 1.5), but also broadly characteristic of other cohorts before the G' lift of the second half of the 18th century.

As age cohorts grow older, they become smaller. Increasingly, the similarities and disparities may be products of chance. Still, the potential trendings offered in Figure 1.9 and Table 1.5 would seem to raise some insights as to how mortality rates in England for various adult phases across the lifecycle were related--in both parallel and contrast--to each other and to deaths among the young between the 1640s and the opening of the 19th century. These are worth further attention in exploring how historical impacts of mortality upon the English population were generated and what their effects were, especially where trends for males and females can be distinguished.

As mortality shifted for various age groups among children and adults, life expectancy--the probability of living through certain further stages of the life cycle--also altered in G-related patterns. Figure 1.10 trends some of these movements from family reconstitution (Wrigley et al. 1997, 295, 290).

Life expectancy at birth, e_0 for both sexes, declined in C shape across most of the 17th century towards a zero year at 1738. This 1605 through 1685 result via reconstitution compares with similar but longer C trends identified in the *Population History* between 1576 and 1681 and via GIP in the 1997 analysis between 1561 and 1681, with t_0's at 1729 and 1731 (Figs. 1.1, 1.2; Tab. 1.2). The G' surge then identified from 1685 through 1715 also closely resembles such movements during the later 1600s and early 1700s. The pair of E trends that follow in Figure 1.10, first from 1725 through 1755 and then from 1765 through 1805, however, then depart somewhat from patterns previously identified. While the upward acceleration after 1765 is just rather steeper than E movements of Table 1.2 between 1731 and 1811 or 1761 and 1831 (with zero year at 1858 rather than 1875 or 1892), the preceding E pattern contrasts with the extended single E from 1731 forward in the GIP analysis and a second G' surge that emerges between 1731 and 1761 in the original back projection of the *Population History*. Up-and-down movement between 1745 and 1765 where the two E trends meet in Figure 1.10, though, is not much inconsistent with such a G' trend cresting in the vicinity of 1755.

For young adults aged 25, change in the duration of further life expected (the second plot in Fig. 1.10) reflects both the G' movement of e_0 around the turn of the century and its E pattern of acceleration during the later 1700s. Across the middle of the 18th century, however, life expectancy for men and women at 25 expanded in G form rather than any of the movements appearing in e_0 for this period in Figures 1.10 or Table 1.2. The number of years lived on average between 25 and 45 ($_{20}e_{25}$) basically remained flat during this era. The broader improvement in adult life expectancy (e_{25}) derived from G-shape increases between 45 and 65 and, most steeply between 65 and 85 from the 1720s to the 1760s, not gains between 25 and 45. The G' bulge in e_{25} that culminated around 1700 likewise shows up most among men and women 65 and older, rather less among those 45 to 65, and not at all in the life-cycle segment between 25 and 45. In contrast, the E-shape increase of life expectancy at 25 during the last years of the 1700s and into the early 1800s occurred as partial life expectancy for those 65 *declined* in opposite C form. What curbed the survival for the elderly as those of middle age benefited from longer life? Across the middle of the 1600s, also, there are some differences in how prospects for living further altered among English adults at successive stages of life.

SETTING A COURSE FOR FURTHER ANALYSIS

Variations in where mortality occurred in the life cycle during centuries of recorded English experience, whether among the young or among adults, like previously discussed trends observed in nuptuality and fertility raise stimulating questions about how the observed movements might have taken place and what their consequences were. Debate and refinement of evidence must continue, not only with regard to the shapes of patterns that are offered here but also concerning the underlying evidence upon which any trending must be based. It is essential to keep in mind, furthermore, that much of the material that is ever going to be available consists of approximations, sometimes quite rough ones.

For all the lingering uncertainty and incompleteness involved, however, some insightful outlines of the English demographic experience since the 1500s are discerned through their G-related trends. These patterns and their relationships to each other should assist in understanding how other populations have evolved, whether or not those particular demographic histories resemble the English record.

First of all, in the exceptionally long-running English historical case, rates for births, deaths, natural increase, and migration--and also changes in reproduction, life expectancy, age structure (Harris 2003, 453-57), and nuptuality--all appear to have moved in G-based paths, like the patterns of growth or decline in population numbers that these underlying dynamics together produced. Improvements, additions, and refinements that have been advanced for the data and interpretation of the pathbeaking 1981 *Population History* make the argument for G-based trending stronger and clearer rather than weaker and less sure. While altering certain particulars somewhat, they produce the same *shapes* of change. One fundamental question, then, becomes whether such repeated patterning of demographic processes, via mostly just the simplest C, D, E, and G trends,[27] is characteristic of basic demographic trends found in *other* societies, perhaps *all* human populations.

Another important issue concerns the degree to which over time other populations have experienced not only similar paths in general but similar *sequences* of trends in these demographic variables, or how their successive patterns have instead departed from the English ones. Comparative considerations of both form and timing in all aspects of population change are necessary and fruitful even if just the same few shapes of movement in the variables keep appearing. Are G-based trends helpful in this process?

As part of such comparative analysis, there arise crucial issues about the *relationships among* G-based movements in the rates of births, deaths, and migration that jointly create expansion and atrophy in populations, and their connections with particular trends of growth and decline to which they contribute. How is the mix determined, and how do the participating demographic movements interact as populations size changes in various ways? Already clear in the well-documented demographic history of England, for example, is that a given form of change in population numbers did *not* always require identical combinations of G-based movements in fertility, mortality and net migration. Conversely, particular forms of change in the vital rates, in the natural increase that they produce, and in migration could contribute to more than one type of growth or decline during successive phases of the long history of the English population between 1541 and 1990.

Continuing, more refined work conducted over the past quarter of a century on fertility, mortality, nuptuality, and migration in England since the 16th century has significantly increased the power of the lens through which that country's demographic history can now be viewed. Details of death at various ages clarify the impact of mortality on the English population and certain of its sub-groups, help frame possible roles played by various types of disease or hardship for better identification and understanding, and point to likely sources of greater or lesser demographic loss or strain as economic and social change took place. Techniques for discerning movements in fertility--by marital status, age of mother, or spacing of children--have helped demonstrate how births trended through time as they did. The record of nuptuality--not just in terms of crude marriage rates, but through age at marriage, celibacy, illegitimacy, and the degree of participation in wedlock by women during their fertile years--elucidates more about how reproduction evolved between the later middle ages and the 20th century than the *Population History* of 1981 could. Better particulars on relocations to the colonies and to Ireland, and to towns and cities within England--though large unknowns still becloud the view--help identify probable rates of English migration (and related socioeconomic change), and verify implications for net movements out of the country that are crudely constructed from the difference between the growth rate of the population and the pace of natural increase or decrease that it experienced. In all of these particulars, G related patterns appear and assist analysis.

Some of the more precise perspectives may not be available for many other populations, or may offer little historical depth in their records. A few other types of insight, meanwhile, may well be available elsewhere if not for England by the 1830s or 1870s. In all, nonetheless, from the English example it seems possible to demonstrate that detailed dynamics of demographic change have unfolded historically along G-based paths just as much as the bare summary outlines of births, deaths, and migration. The fabric of English population history is not just decorated here and there with such patterns of change. It is woven full cloth of this limited set of G-based movements.

How, then, might so many different properties of a demographic regime alter across half a millenium over and over again in such fashion? How much, and in what ways, were the observed trends responses to exogenous forces? To what extent, by what means, and with what consequences, on the other hand, might the repeatedly G-based patterns have instead originated in the inherent nature of demographic systems themselves and their processes of continuous renewal? Answers must begin with some comparative perspective on historical patterns that transcends the social, cultural, economic, and environmental particulars in the experience of just one country. In the end, though, the English trending can be readdressed and related systematically to various aspects of its historical context in order to illustrate how grasping the G-based forms can improve current understanding of much-discussed interactions between demographic change and developments in economy and society.

NOTES

1\. . The crude birth and crude death rates to 1871 come from the *Population History* (Wrigley and Schofield 1981, 528-29, Table A3.1). For England 1961-1990, they are taken from Office of Population Census and Surveys, *Population Trends* 1991, 66: 63, Table 8. For the intervening period, rates for England and Wales are used. Both the CBR and the CDR come from O.P.C.S., *Birth Statistics* 1984, 13: Table 1.3. So do the gross and net rates of reproduction for England and Wales for all times after the era examined by the *Population History*. Life expectancy for the population of England *and* Wales 1881-1940 follows the Wrigley-Schofield series through 1871 (Table A3.1). These data are averages of the computations for males and for females by Preston, et al. 1972, 232-59. For 1951-1981, life expectancy at birth used here is for England only; the data come from averaging male and female calculations in O.P.C.S., *English Life Tables* 1984, 14: Table V. *Population Trends* 1991, 66: Table 12, supplies data for England and Wales in 1988. For percentage of the total population under 15, the sources after 1871 are: Keyfitz and Flieger 1971, 104, for England with Wales 1871-1946; *Population Trends* 1975, 1: 35, Table 16, for England and Wales 1951-1966; and ibid., 66: 60, Table 6, for England alone 1971-1990. Comparisons from the sources cited here for years in which both series are available indicate that the inclusion of much smaller Wales with England changes the rates only slightly.

2\. . The gross reproduction rate is the average number of girls that, at current fertility rates, would be born to women if all women survived to the end of their reproductive period.

3\. The decline of the CDR into the 1560s was probably the culmination of an improvement that had been gaining momentum across the later 1400s and early 1500s (R. D. Lee 1973, 581-607; discussed in Ch. “P”).

4\. For instance, Keyfitz 1985, 23-27; Cox 1970, 385.

5\. . The way some analysts still consider things to work is diagrammed in Chesnais 1992, 27, and Livi-Bacci 1992, 103.

6. Moore (1993, 285, 295) shows probate numbers for 1557, 1558, and 1559 that are more than triple their four-decade base trend. The original hypothesis appeared in Fisher 1965, 120-29.

In Moore's presentation, in critique by Michael Zell (1994, 354-58), and in rebuttal by Moore (1994, 359-61), it seems strange that no mention is made of how the attempt to reinstate Catholicism and the reestablishment of ecclesiastical courts under Mary (1553-1558) may have affected the timing of will-writing and/or will-probating. The impact not just of mortality but of the probate process itself in years of political as well as medical danger would seem to bear more upon the timing of these records than upon the parish registers of burials which form the foundation for the results of Wrigley and Schofield--and which swing up and down less than the evidence of probate. On the whole, the titles of the "'flu" contributions are more satisfying than their debate.

7. H is the path of growth followed typically followed by the populations of 'developing' countries (Harris 2001, 385, for 1955 to 2025 collectively; *passim* for individual populations).

8. A recent rebuttal to Razzell by Wrigley (2004, 431-38) discusses results for the gross rate of reproduction and life expectancy that are more different according the thinking of Razzell, though the consequences for population size, while lower via Razzell, run mostly parallel except for the second half of the 18th century.

9. In Lindert's suggested corrections for the CDR, the levels rise somewhat above what is shown in Figure 1.1 from the *Population History*; but the long-term E into the 1680s and the D that followed to 1700 or so remain very much the same. By both accounts, his and the original, mortality worsened faster and faster from the reign of Elizabeth to the accession of James II, then improved for a while. The main difference that Lindert's proposed revisions make is to soften the ups and downs of the CDR across the first half of the 18th century. The kind of C that the Wrigley-Schofield calculations indicates for 1761-1831 can for Lindert's corrections be pushed back more readily all the way from 1825 to about 1695, eliminating the need for movements like

the 1681-1731 and 1731-1761 1/G' sags that are plotted for the CDR of the *Population History* in Figure 1.1. The Lindert data, however, are grouped by decade, not quinquennium; that of itself will have some smoothing effect. Even then, errant points of evidence remain (notably, high values for the 1720s and 1730s) precisely where the Wrigley-Schofield calculations place an interrupting peak in the series.

In the end, given the kinds of dipping in mortality between 1681 and 1761 that Chapter 2 finds not just in England but in several other northern European countries, by saying that the CDR should instead be raised through the 1700s and lowered in the early 1800s via his proposed corrections, Lindert may have created an even greater artificiality than the allegedly spurious "mortality decline before the onset of modern medicine" that he attributed to "errors in the Wrigley-Schofield death series" rather than genuine improvements in sanitation, "exogenous decline in the virulence of infectious microorganisms," or better diet via the adoption of potatoes or more nutritious grains (148). The impact of such changes at various points in time, however, do need to be explored--for instance, as they bear upon to the 1/G' shifts in CDR between 1681 and 1761 that Lindert's analysis obscures.

10. Crude natural increase comes from O.P.C.S., *Birth Statistics* 1984, 13. Compound growth is taken from O.P.C.S., *Census 1971,* 1974), 1, "England and Wales."

11. Wrigley and Schofield (1981, 219-20) likewise show some decline via their technique of back projection, as the accompanying dotted line in Figure 1.3 indicates.

12. See Menard 1988, 105, 113, 124, for a summary of much of the American evidence.

13. Dunn 1972 demonstrates these tendencies during the 17th century in the British West Indies. Harris 1992, brings together evidence on the Chesapeake.

14. For example, Wrigley and Schofield 1981, 425, 642-644. Scholars of colonial American immigration have generally misused this series, trying to explain the contraction of emigration after about 1660 by saying that its upturn was five decades later--in the middle of the 17th century, not at its beginning.

15. Wrigley and Schofield, too, identified decline into the 1770s in the absolute number of English emigrants, a number approximately confirmed by Bailyn's rather lower totals of English coming to North America in the registers of 1773-1776 (1986, 92) plotted in Harris 2003, 67). Gemery's estimates comparably indicate decrease into the 1770s for the number of Europeans coming to the British colonies of North America and the Caribbean (Harris 2003, 57).

16. Again, it should be remembered that migration estimated quinquennially from growth minus natural increase has great variation.

17. Ibid. The two data points that are available would support a zero year for an H around 1477.

18. As not only 16th- and 17th- and 18th-century data from England indicate, but growth in China from the 1740s to the 1840s suggests, Harris 2001, 243).

19. To select the movements of Figure 1.3 for representing total English net emigration, however, calls for some changes in the English contribution to immigration to the Thirteen Colonies of mainland North America as estimated in Volume II (Harris 2003, 65-71). There, this flow was thought to be approximately half of the Wrigley-Schofield calculations of total net emigration from back projection because the numbers generated by such an assumption fitted independent findings of Gemery in the later 1600s, Bailyn in the 1770s, and Erickson at 1831. To employ the movements of Figure 1.3 instead requires some adjustments in the conclusions of Volume II if one continues to hypothesize that about half of English emigration came to North America:

For Figure 1.20a (Harris 2003, 67), rather than experiencing a second G' surge between 1695 and 1725, English arrivals in the Thirteen Colonies would have continued to shrink down the declining slope of 1635-to-1695 G' movement all the way to 1725 (with just a few years' delay in the date of cresting). Taking half of Figure 1.3's implied net emigration from the 1730s through the 1760s and the English rate implied by Bailyn's numbers for the early 1770s then generates a new G' surge, timed perhaps a decade later than that fitted for 1735-1765 in Figure 1.20a of Volume II and reaching a crest about a third lower than calculations made from half of the Wrigley-Schofield back-projection emigration numbers.

These changes for English arrivals in turn alter totals in Figure 1.20b of Volume II for all Europeans coming to the Thirteen Colonies, first by creating G' movement between the 1690s and the 1720s that is about a third lower than computations based upon English estimates from the *Population History* and peaks more like 1726 than 1732. Then from 1725 through 1786 (Grabbe's estimate) another G' bulge follows, now with its peak just 9 percent below the movement calculated in Volume II and coming some 5 years later.

Relative to estimates based this way upon growth rate less rate of natural increase in Figure 1.3 rather than the migration numbers offered by Wrigley and Schofield, Fogelman's calculations (Harris 2003, 59) for the flow of English to the Thirteen Colonies improve somewhat, but remain decidedly low for most of the 18th century: now 3, 7, 21, 52, 60, 29, and 75 percent of half of total estimated net English emigration across the decades from the 1700s through the 1760s. His figures, meanwhile, repesent 12, 32, 43, 75, 69, 60, and 89 percent of this study's calculations for all Europeans over the same 70-year span.

The impact of working with Figure 1.3 for generating estimates of English coming to the New World as a whole (both the mainland and the West Indies) is to push D-shape decline later and deeper (1655 to 1775 with zero year around 1652 rather than 1615) than was shown in Figure 1.20a of Volume II. Contraction between 1635 and 1735, furthermore, might also be captured by a C trend with t_0 in the vicinity of 1728.

Finally, the D-type decrease in the size of current European immigration relative to the existing white population in the Thirteen Colonies (Harris 2003, 72, Figure 1.20b) would just run a little lower with virtually no change in timing while the second trend of this shape, from 1745 through 1815 would be about a decade earlier with little change in level.

Again, both the computations of Volume II based upon English emigration numbers that were calculated from back projection by Wrigley and Schofield and quantification from the difference between rates of growth and of natural increase preferred in Figure 1.3 both generate just *estimates* across a span of time through which there is little independent help to guide the construction of trends. Concordance of the newly calculated movements based upon half of the emigration totals in Figure 1.3 with what is known directly about some of the flows involved, however, seem to make them preferable for conceptualizing English and all European migration to America.

20. The crude marriage rate came down a little earlier, with t_0 in the 1680s (Wrigley and Schofield 1981, 528-29).

21. Only the first of these is fitted in Fig. 1.5. The last, cresting in the 1840s, is closely inverse to, and should help explain, the 1/G' contractions in English nuptuality and overall fertility observed between the 1820s and the 1860s (Fig. 1.4).

22. Reconstituted families, from which the proportion of illegitimate births in Fig. 1.7 is derived, may include fewer births out of wedlock than the larger reconstructed population used to calculate extramarital fertility in Fig. 1.4 (Wilson and Woods 1991, 401-02).

23. Both his SBR4 (based on the maternal mortality rate plus a constant) and his SBR3 (based upon perinatal mortality plus another constant). The time blocks for these series are broad (a quarter of a century), which, with the addition of a constant, in each case makes the apparent trends in these calculations somewhat different from the series of maternal or perinatal mortality from which they are projected.

24. In the period of accelerating 'population explosion' during the 18th century, Wrigley (1998, 459-61) argued that a "large fall" in the frequency of still births occurred and that this did much to reduce spacing intervals between children, thereby pushing up marital fertility. In his view, still birth and perinatal mortality (during the first week) improved (declined) because of better nutrition in England, brought about by better economic conditions. Subsequent probing (Ch. X) of what actually happened to wages and living conditions from the early 1700s to about 1815, however, tells a rather different story from what Wrigley generally implies. The two successive C-shape contractions of still births indicated by the data of Woods (2005, 149) between 1712 and

1831, meanwhile, are actually slightly flatter (have later target years) than contemporary declines of that shape in infant mortality as a whole, though the three 1/G’ sags in perinatal death shown in Fig. 1.8b do lower those losses more significantly.

Woods (2005, 160) perhaps correctly questions the proportion of fertility gain that in fact resulted from having fewer still births. His conclusion that stillbirth rates show no “sustained decline during the eighteenth” century (after worsening in the seventeenth), however, seems overstated.

His trends of SBR4 and SBR3 paralleled downward C paths those for neonatal deaths, endogenous and total infant mortality, and maternal losses across the first half of the 18th century, then followed further C decreases in these same variables, now along with post-neonatal rates and exogenous infant deaths between about 1750 and the early 1800s. The widely common character of these movements--particularly between endogenous infant mortality and maternal deaths, on the one hand, and exogenous infant mortality, on the other, after about 1750--suggests that Woods is correct in proposiing an improving disease environment, rather than the maternal nutrition advanced by Wrigley, as the principal dynamic generating these changes--especially since there is some evidence from real wages and from stature that the English standard of living in fact deteriorated in the later 18th century before improving in the 19th (Ch. X).

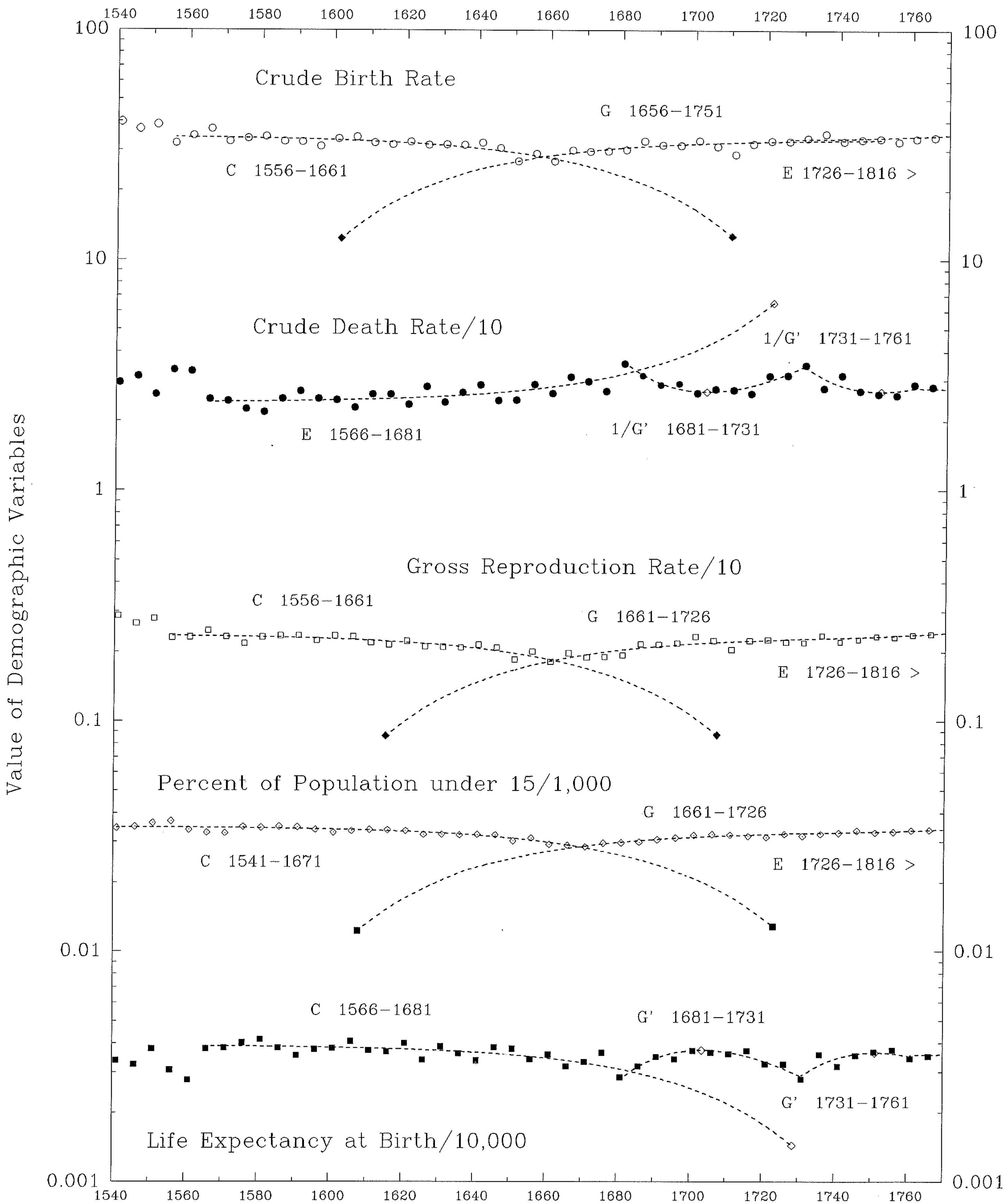
25. Including the extent of care given to ill or handicapped children.

26. Mortality patterns for those 15 through 24 unfortunately seem to be unknown.

27. Also some G’ and 1/G’ movement, as first discovered by Vol. II for migrations.

Figure 1.1

G-Based Patterns of Some English Demographic Trends 1541-1990
According to the *Population History* and the Census



Sources: See note 1.

Figure 1.1 (cont.)

G-Based Patterns of Some English Demographic Trends 1541-1990
According to the *Population History* and the Census

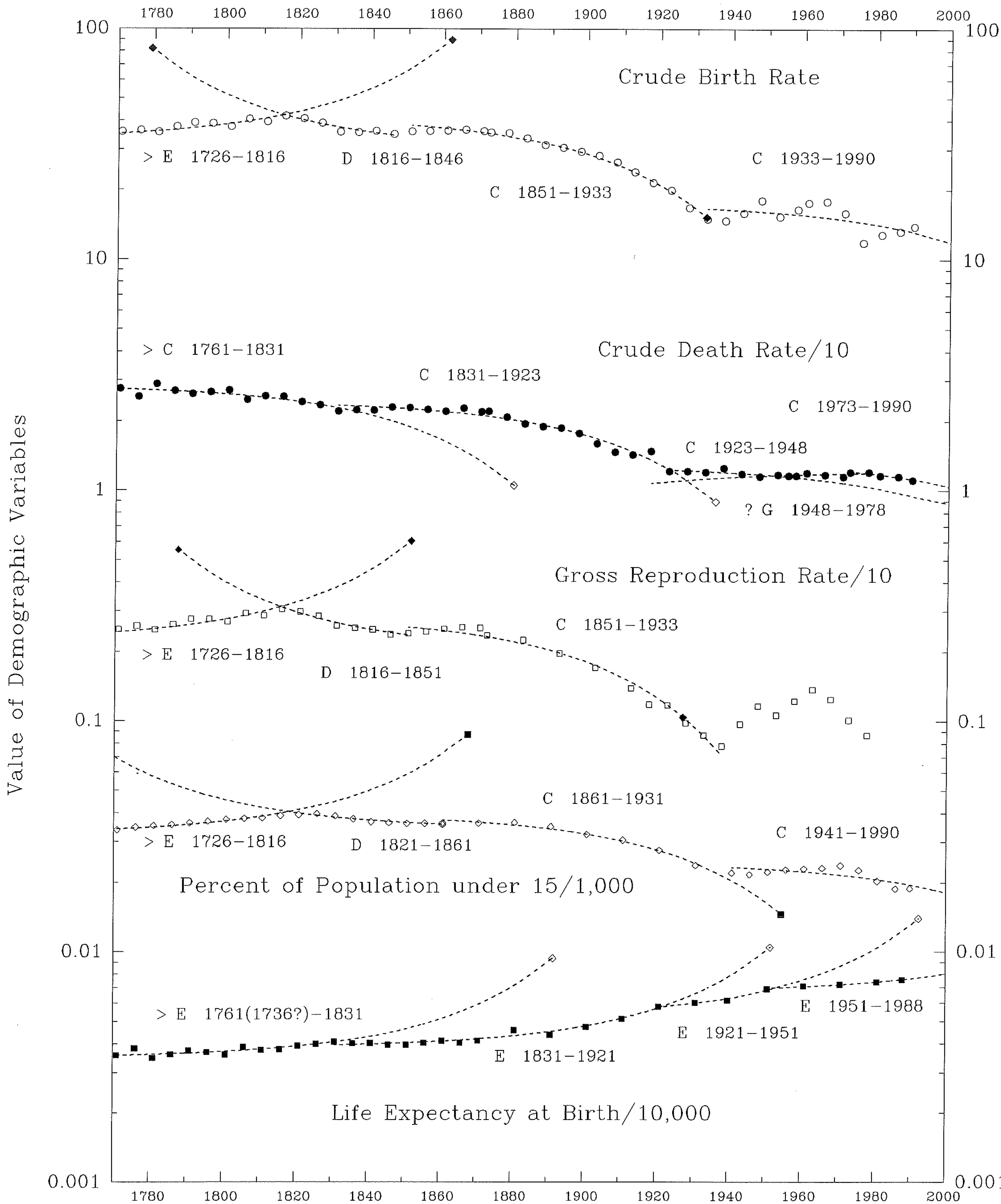
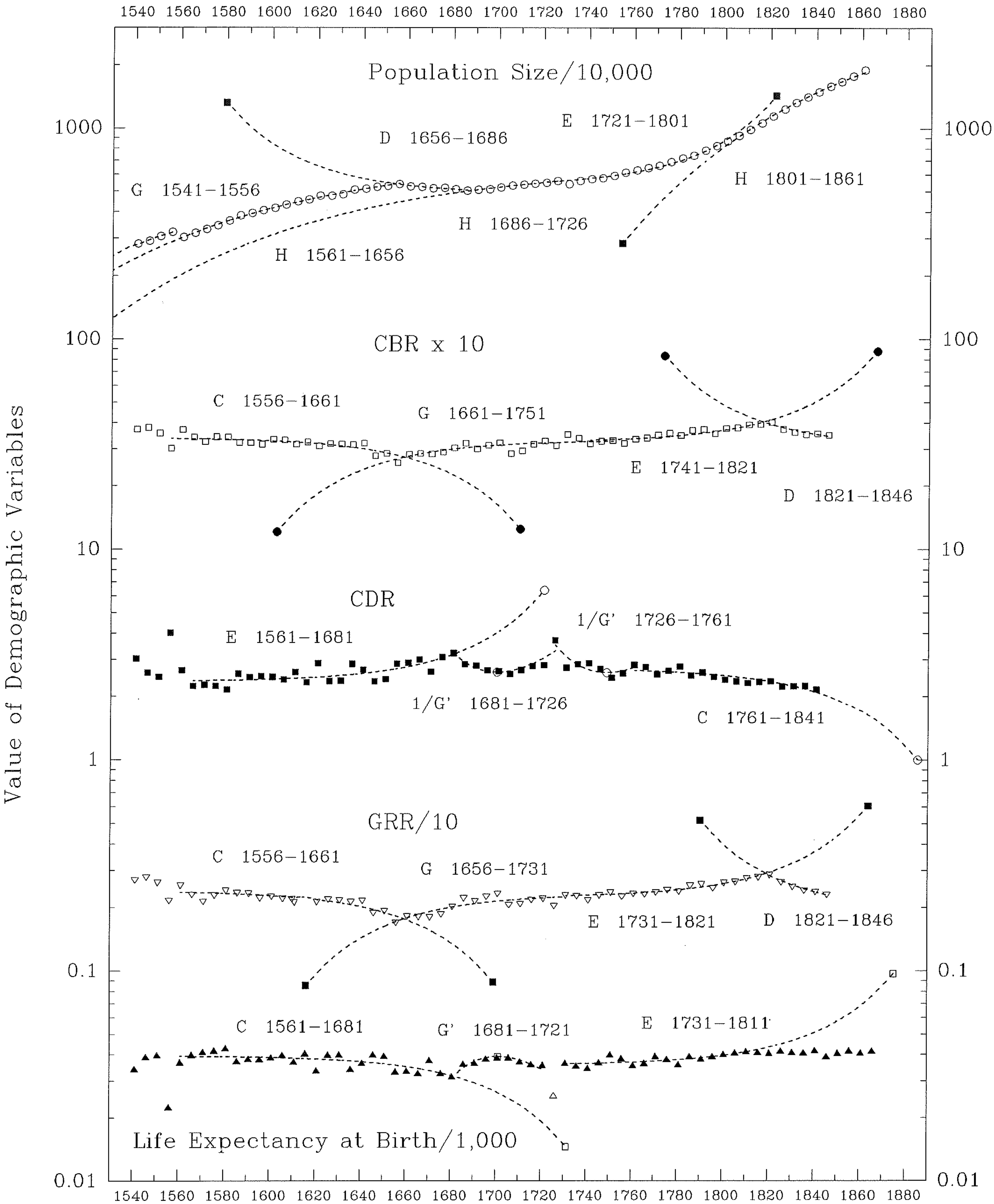


Figure 1.2

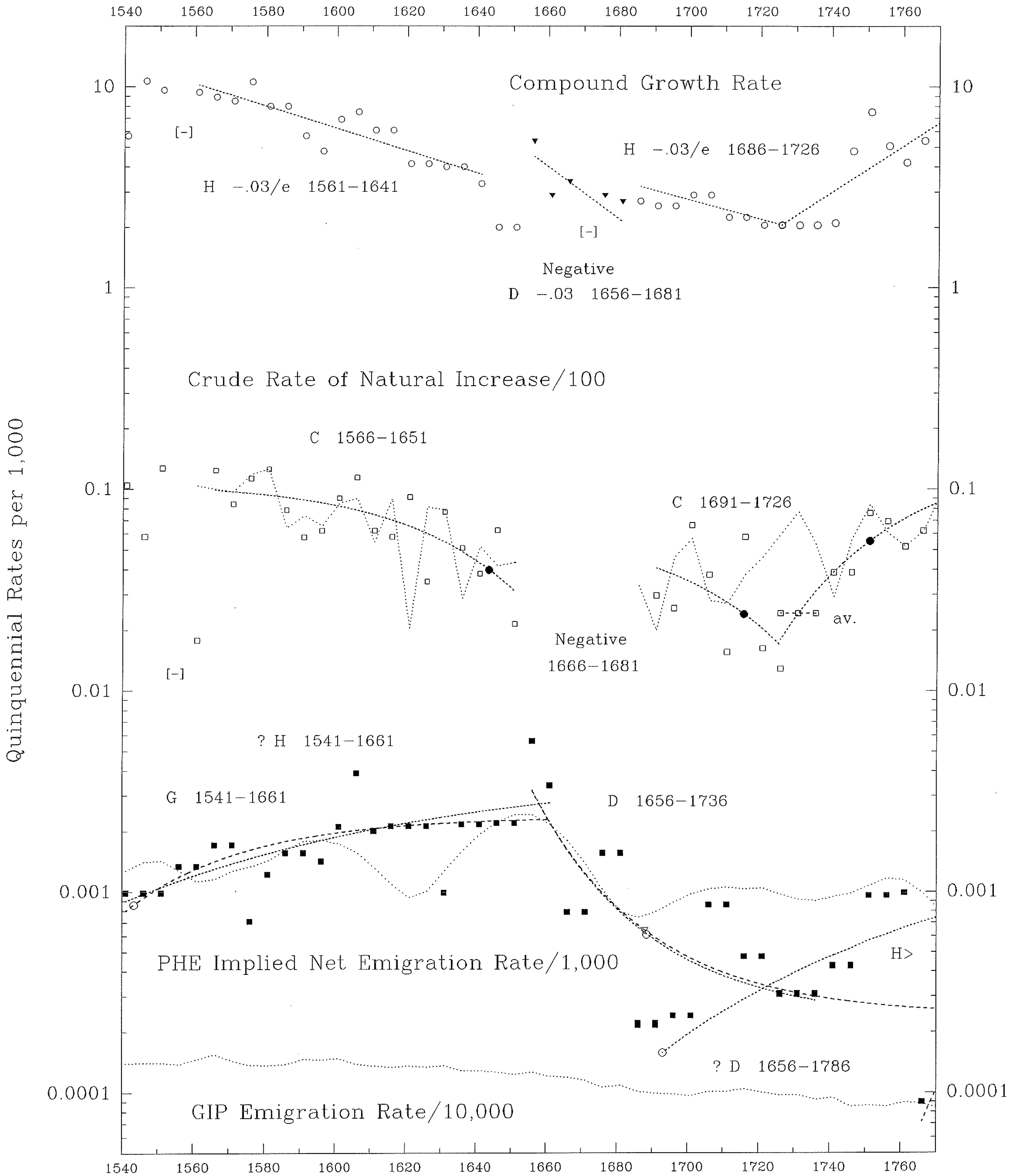
Patterns of Growth, Birth and Death Rates, GRR, and Life Expectancy in England according to GIP Method



Source: Wrigley at al. 1997, 614.

Figure 1.3

English Rates of Population Growth, Natural Increase, and Estimated Net Emigration 1541–1990



Sources: Wrigley and Schofield 1981, 528-29, 219; Wrigley et al. 1997, 614.

Figure 1.3 (cont.)

English Rates of Population Growth, Natural Increase, and Estimated Net Emigration, 1541–1990

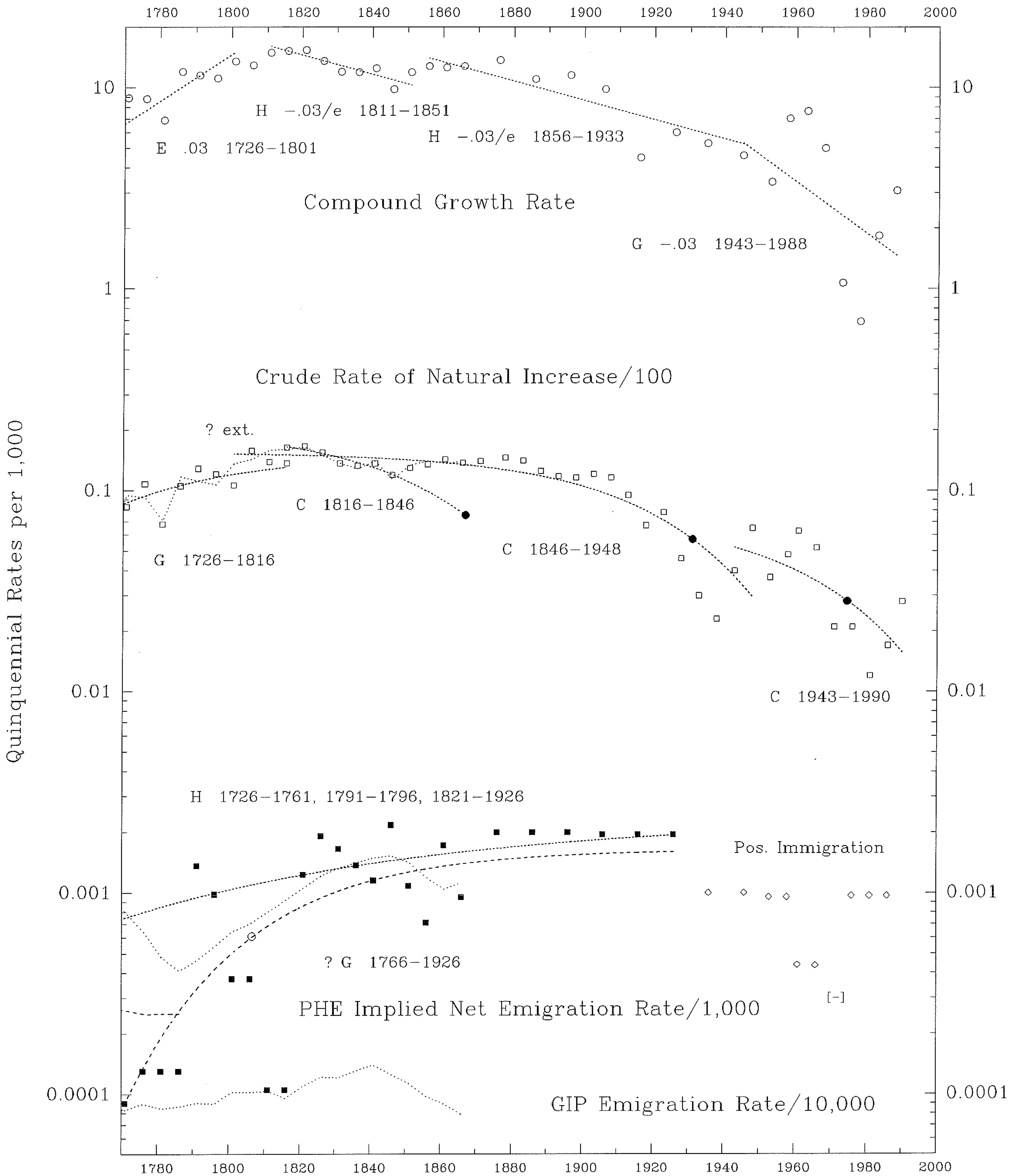
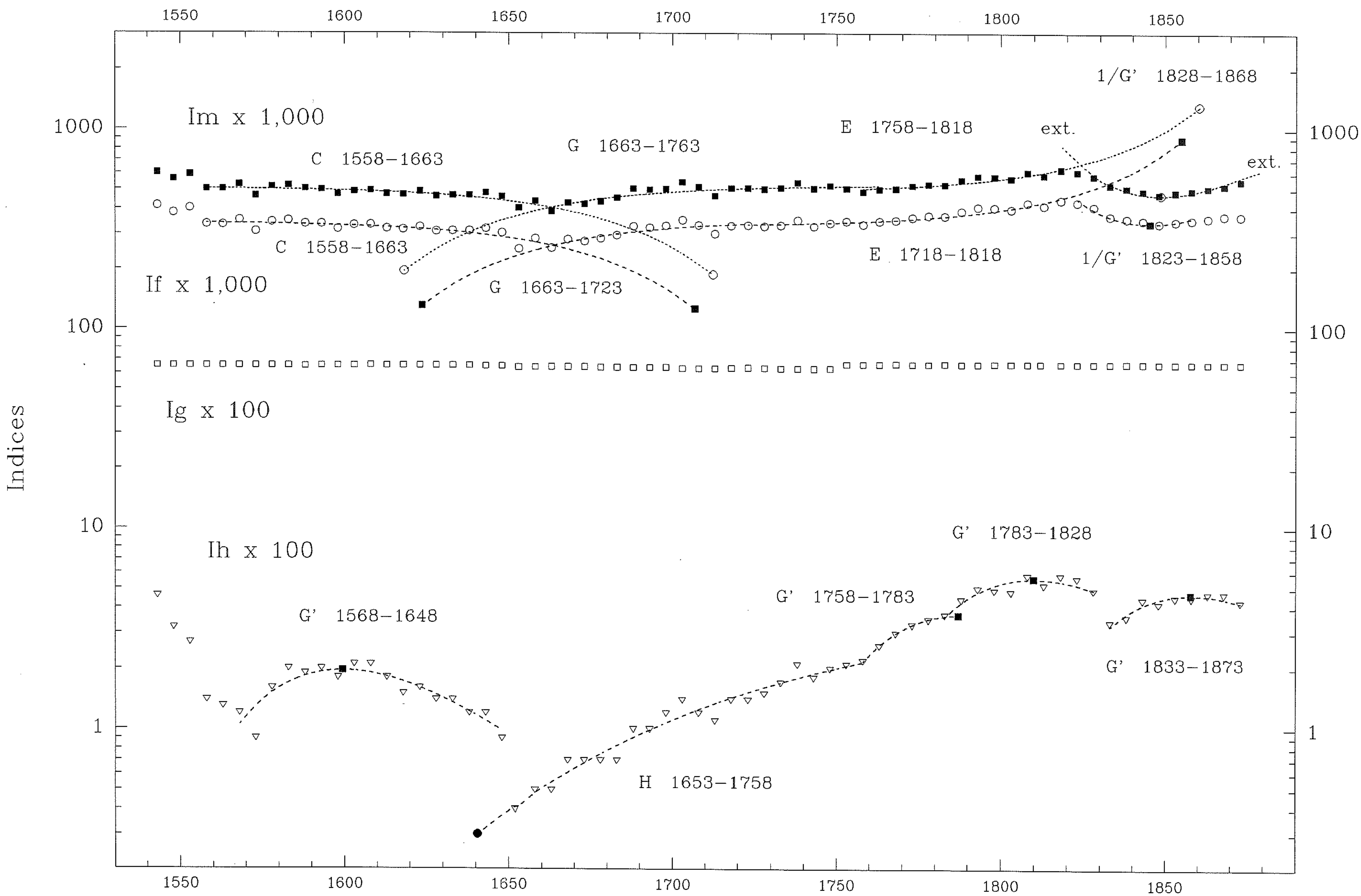


Figure 1.4

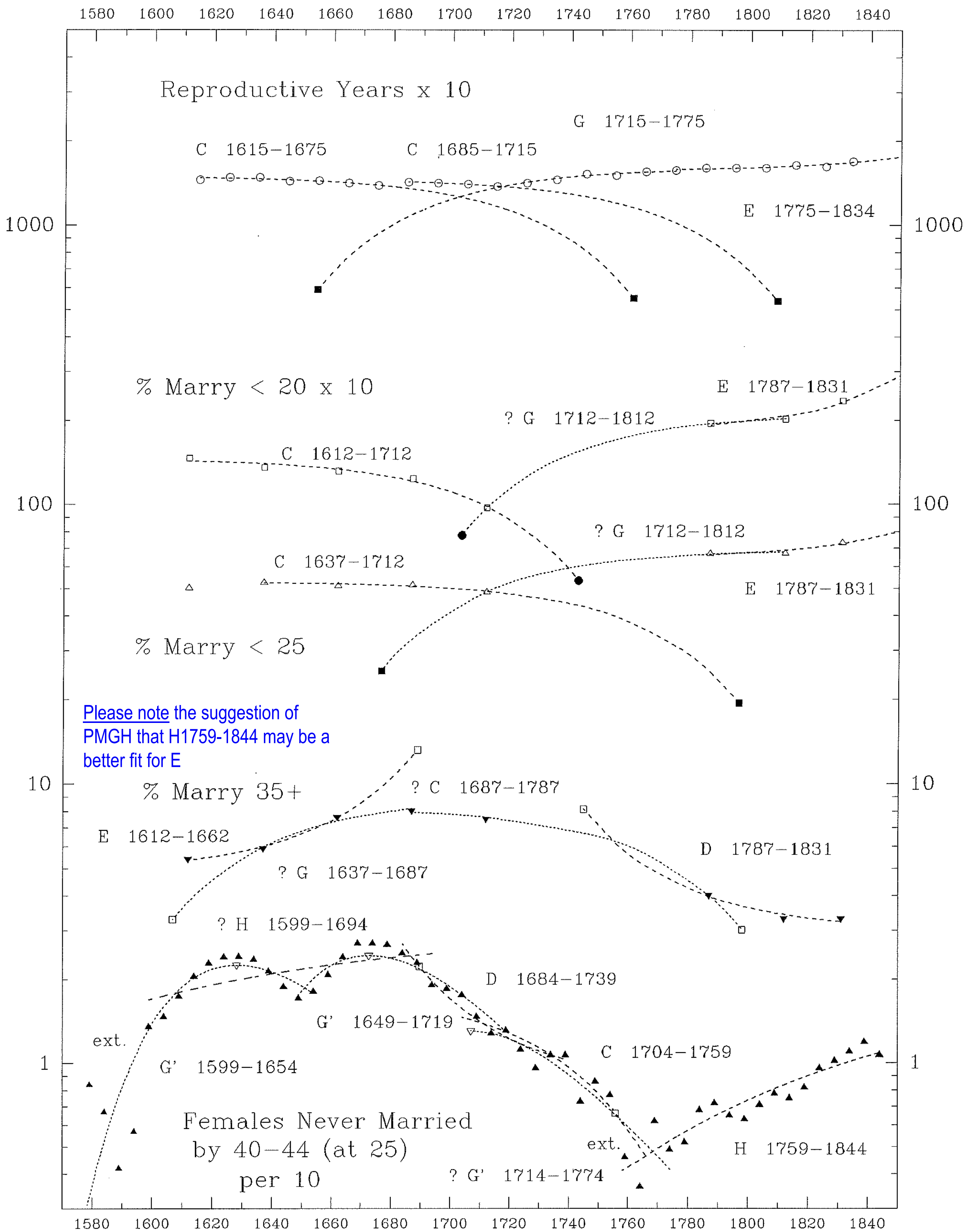
Indices of Fertility and Nuptuality in England between 1543 and 1873



Source: Wilson and Woods 1991, 414–15.

Figure 1.5

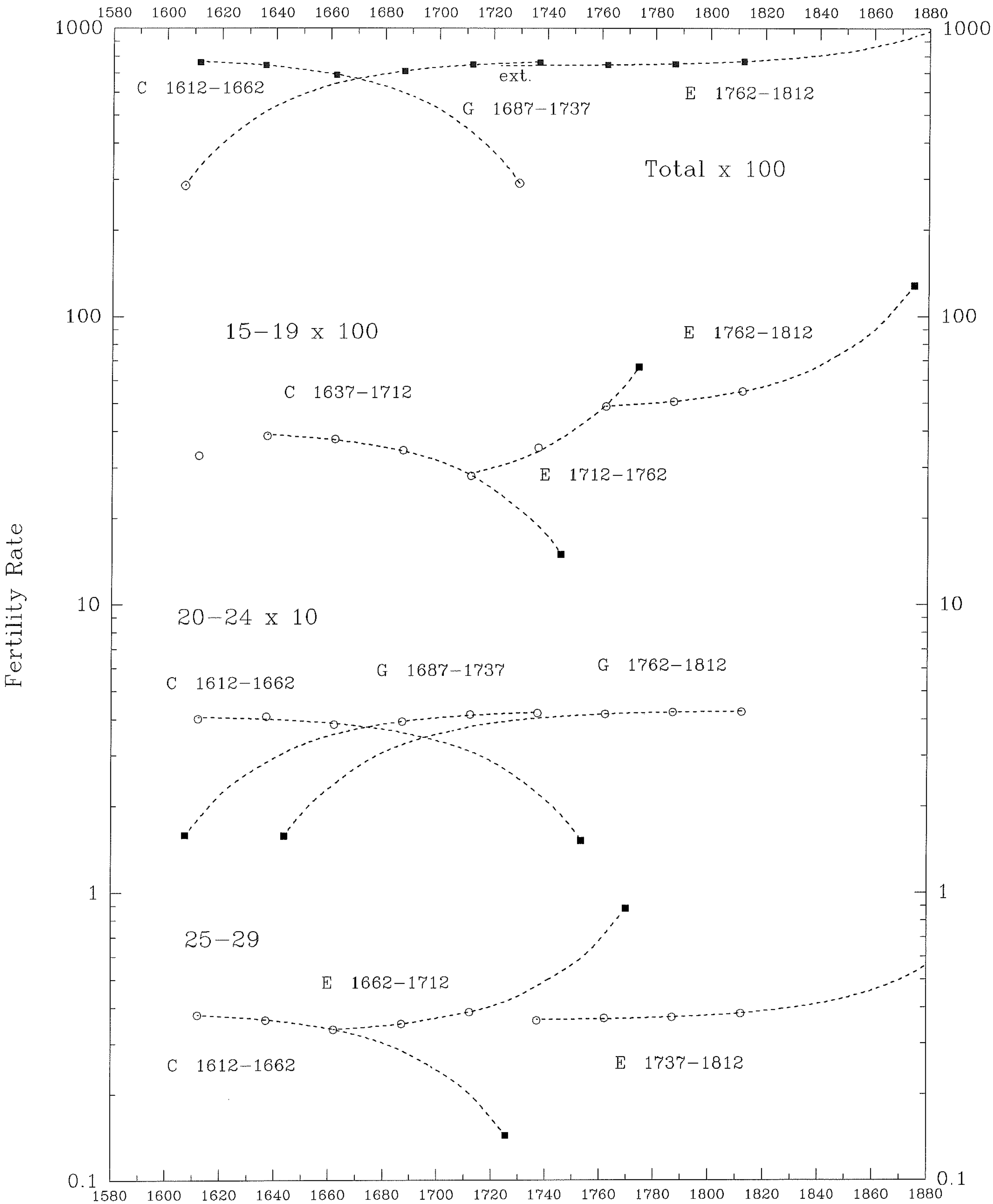
Reproductive Span, Age of Marriage, and Celibacy



Sources: Wrigley et al. 1997, 134, 141; Wrigley and Schofield 1981, 260.

Figure 1.6

Age-Specific Marital Fertility in England 1612 to 1812



Source: Wrigley et al. 1997, 355.

Figure 1.6 (cont.)

Age-Specific Marital Fertility in England 1612 to 1812

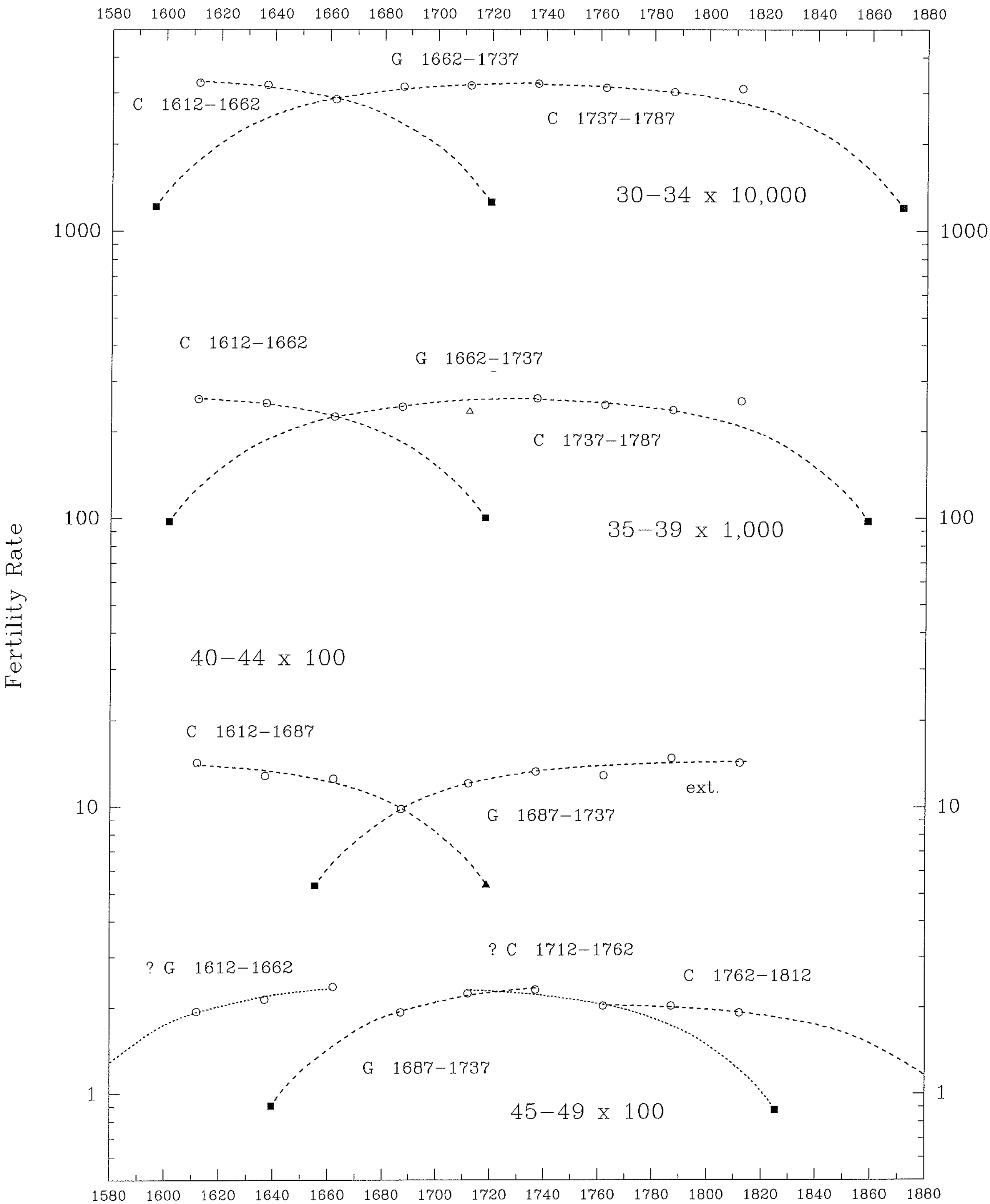
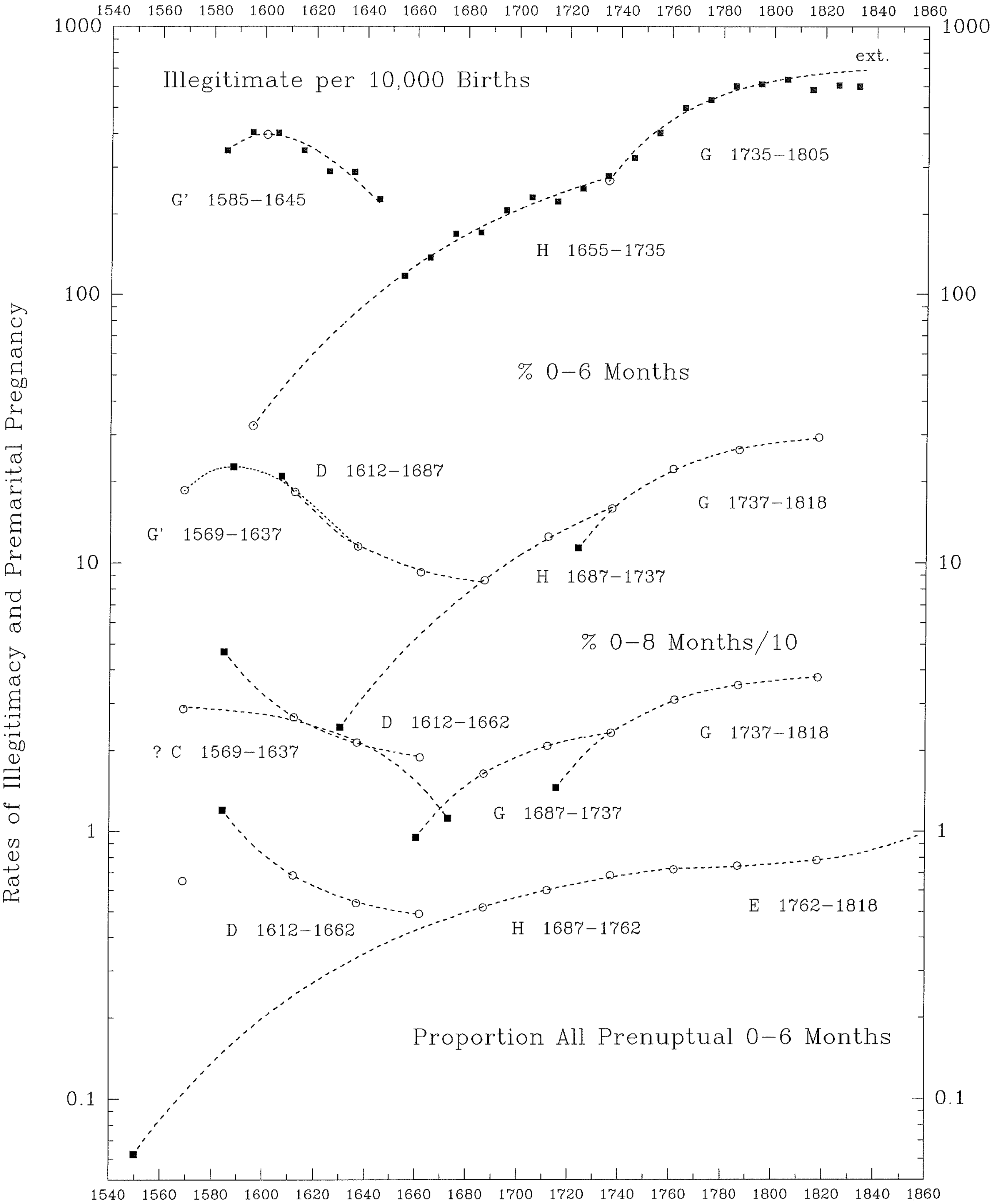


Figure 1.7

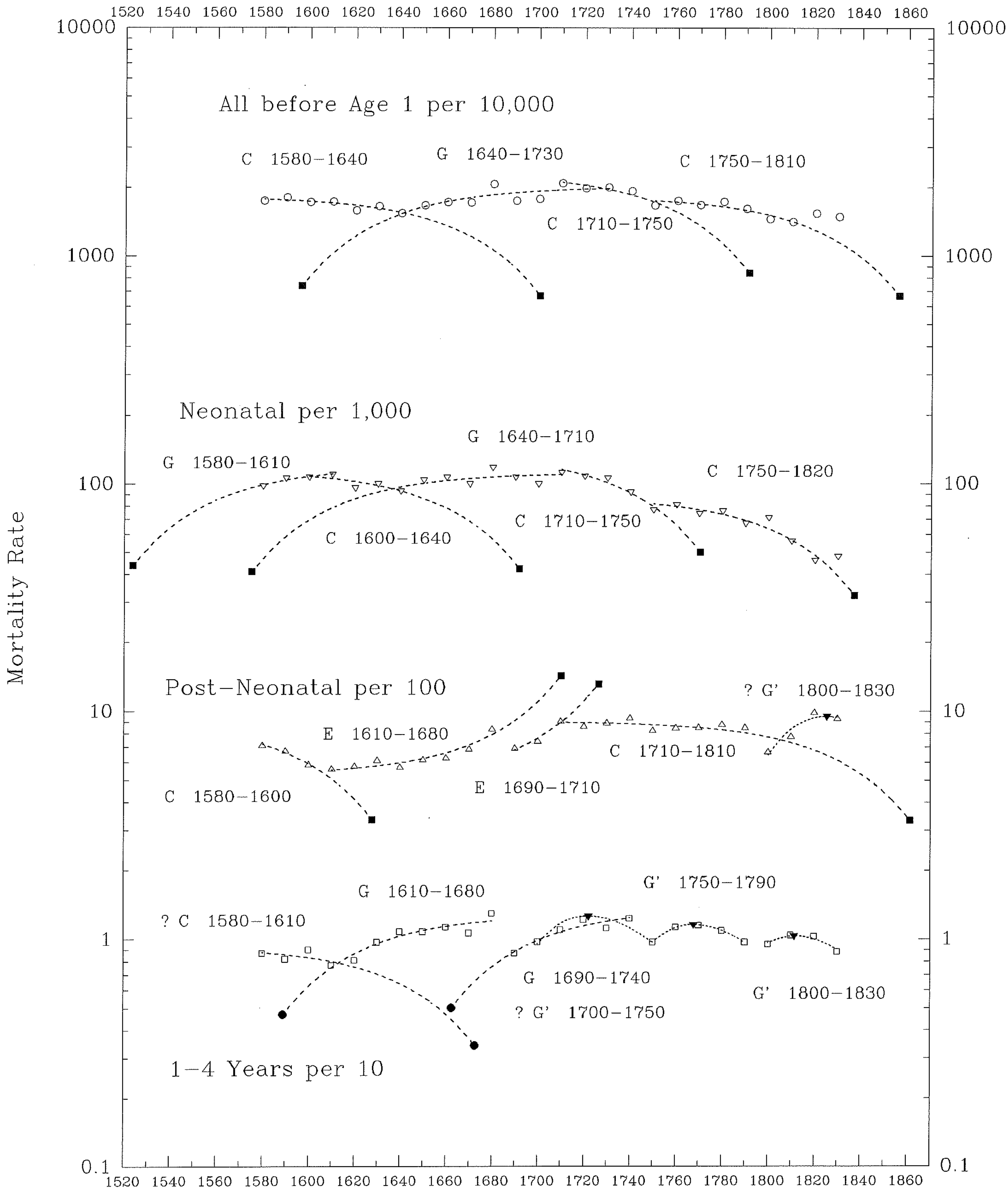
Patterns of Illegitimacy and Prenuptual Pregnancy



Sources: Wrigley et al. 1997, 224, 421.

Figure 1.8a

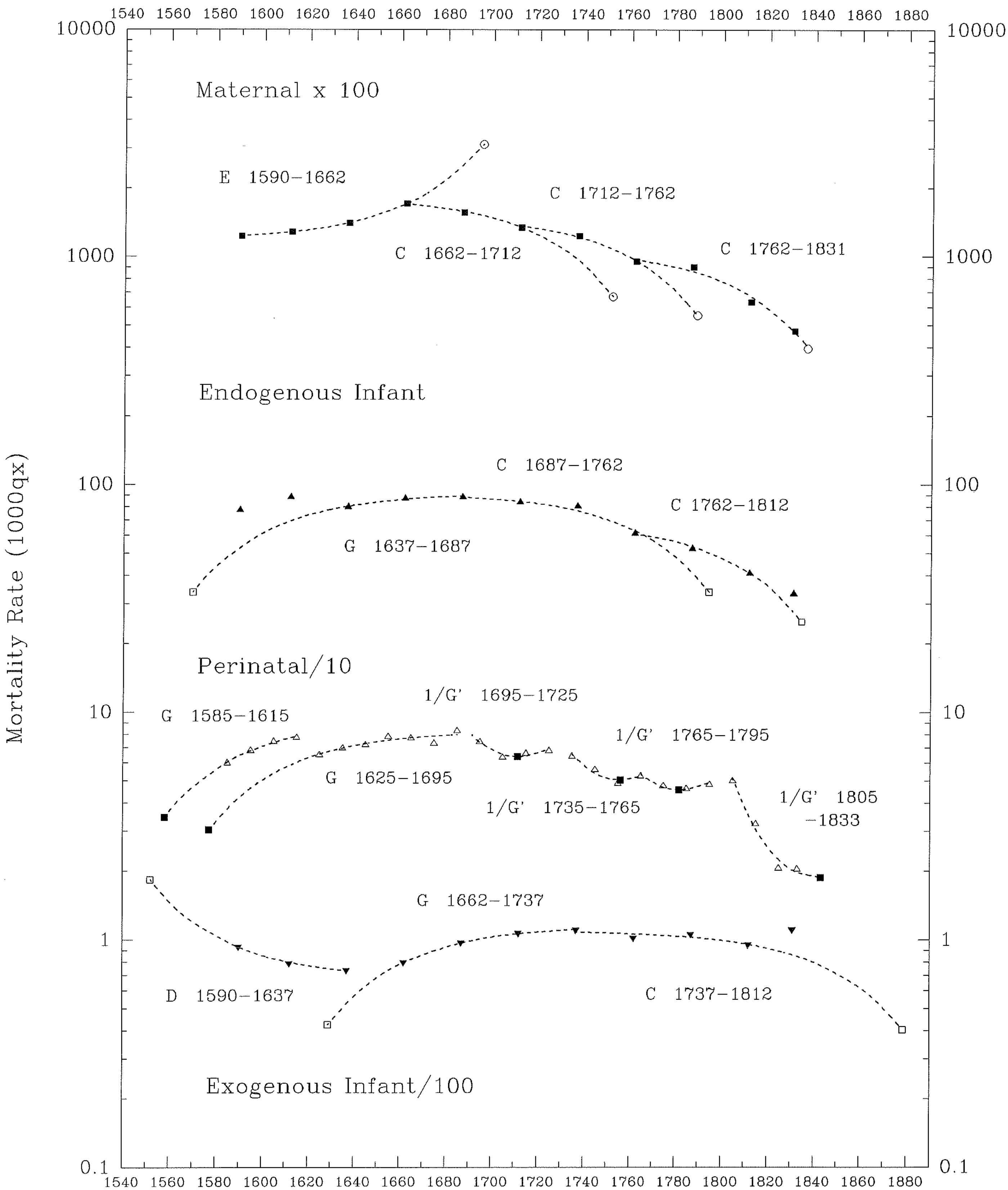
Trends of Infant and Childhood Death in England: Infant, Neonatal, Post–Neonatal, and Age 1 through 4



Source: Schellekens 2001, 7–11..

Figure 1.8b

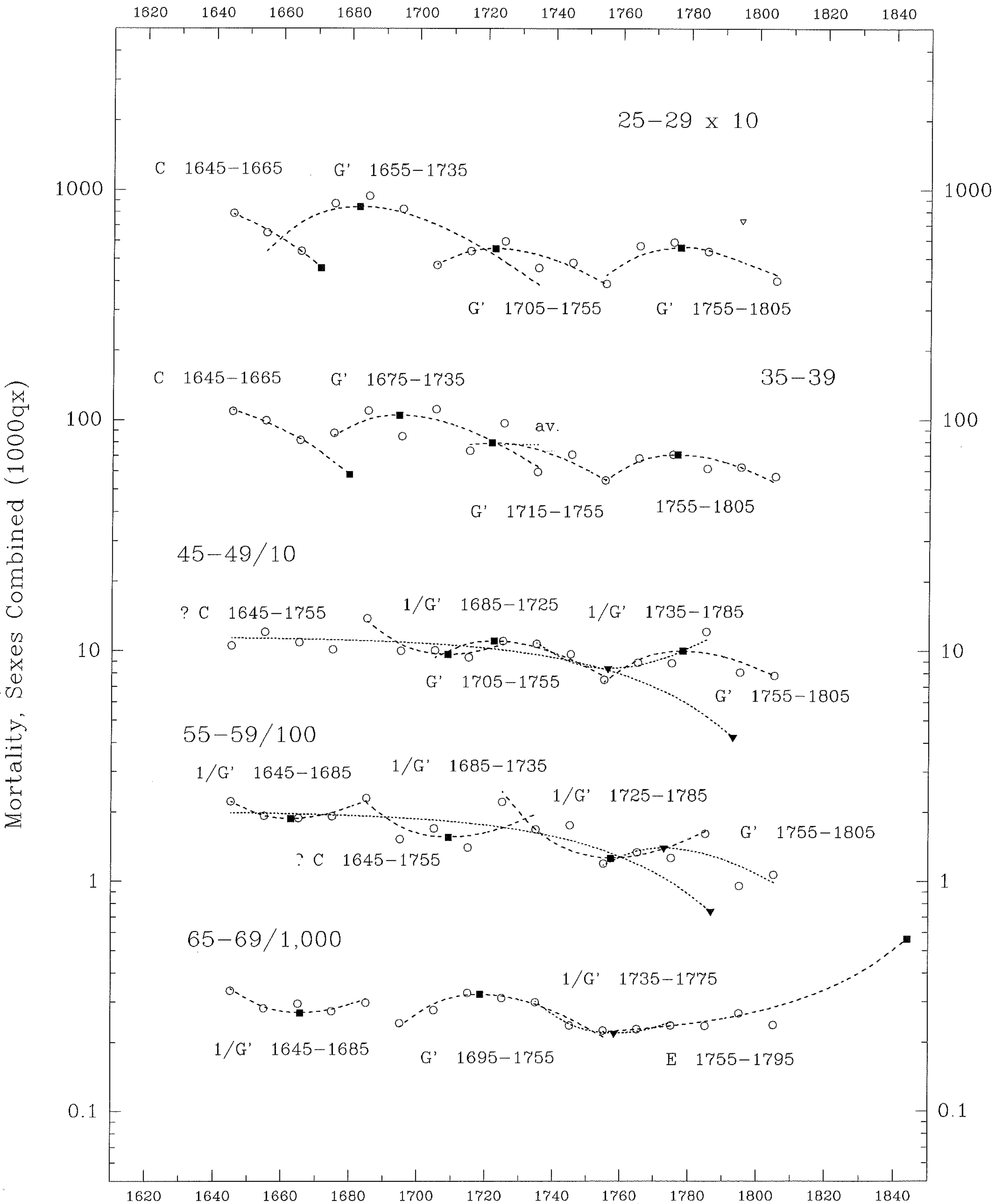
Trends of Infant and Childhood Death in England: Maternal, Perinatal, and Endogenous and Exogenous Infant



Sources: Wrigley et al. 1997, 226, 236, 239.

Figure 1.9

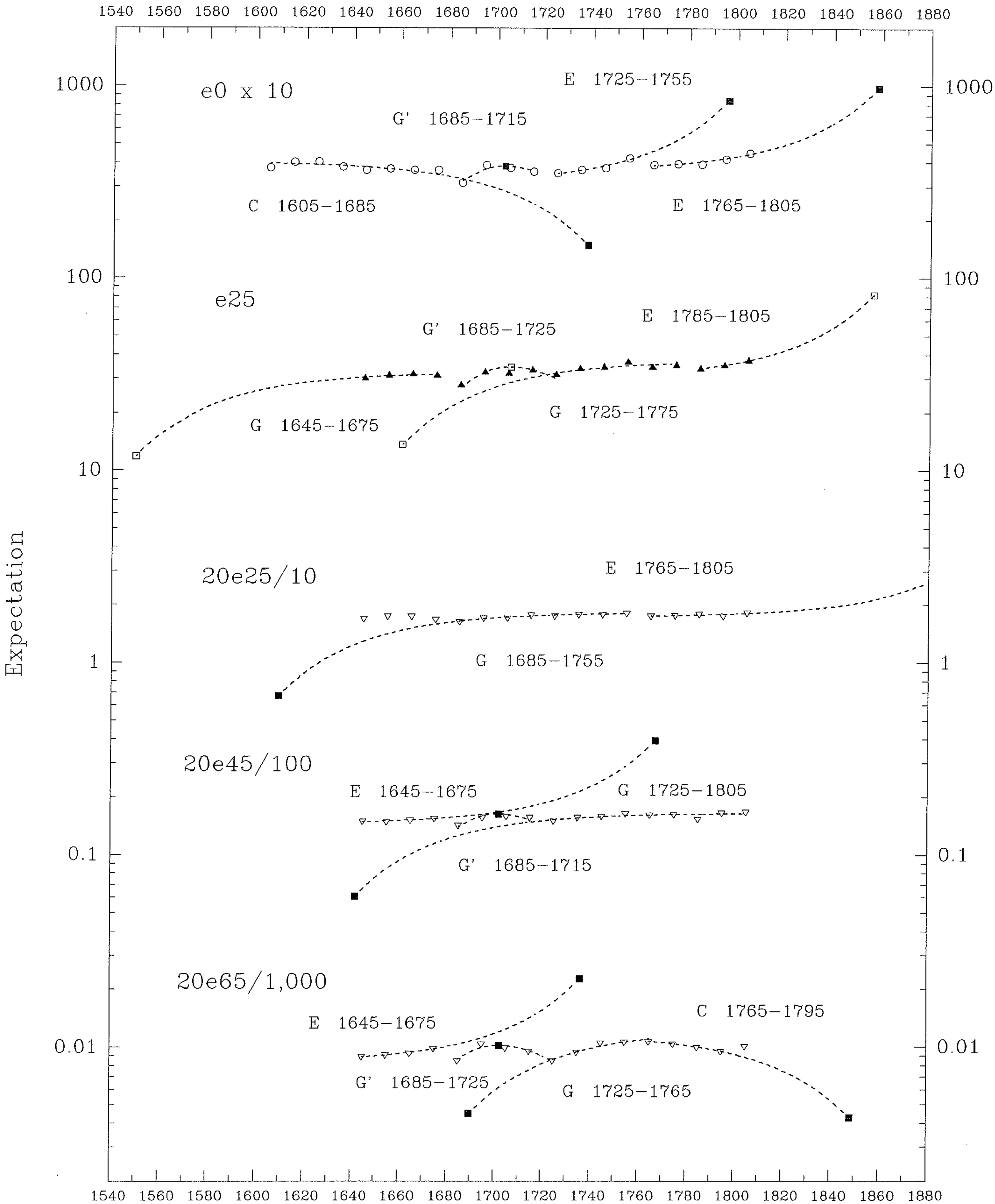
Trends of Mortality during Selected Adult Age Spans



Source: Wrigley et al. 1997, 290.

Figure 1.10

Life Expectancy at Birth and for Adults across Certain Segments of Life



Sources: Wrigley et al. 1997, 295, 290.

Table 1.1

Relating English Population Movements

(according to Wrigley and Schofield, Lindert, and Razzell)

Population	Crude Birth Rate	Gross Rep. Rate	Percent under 15	Crude Death Rate	Life Expectancy
	L 1545-1585 D 1485				
	L 1575-1665 C 1731				
1561-1656 H 1461	1556-1661 C 1710	1556-1661 C 1701	1541-1671 C 1723	1556-1681 E 1722	1576-1681 C 1729
1656-1686 D 1587	L 1665-1755 G 1608				
1686-1726 H 1492	1656-1751 G 1602	1661-1726 G 1615	1671-1726 G 1608	1681-1731 /G' 1704	1681-1731 G' 1704
	R 1750-1795 E 1861				
	L 1725-1795 E 1867				
1726-1806 E 1822	1726-1816 E 1862	1726-1816 E 1851	1726-1816 E 1868	1731-1761 /G' 1752	1731-1761 G' 1751
				1761-1831 C 1880	1761-1831 E 1892
	R 1795-1845 D 1750				
	L 1795-1845 C 1901				
1816-1861 H 1758	1816-1846 D 1779	1816-1851 D 1787	1821-1861 D 1759		
1861-1939 H 1794	1851-1933 C 1933	1851-1933 C 1926	1866-1931 C 1955	1831-1923 C 1936	1831-1921 E 1952
				1923-1948 C 2030	1921-1948 E 1993
1951-1991 G 1899	1933-1990 C 2032	"baby boom"	1941-1990 C 2040	1948-1978 G 1848	1951-1988 C 2057
				1973-1990 C 2044	

L = Lindert; R = Razzell.

Sources: Harris 2001, 148, 150-51; Wrigley and Schofield 1981, 528-29; Lindert 1983; Razzell 1993.

Table 1.2

Comparing Cambridge Group Demographic Trends for England from Back Projection (1981) and from Generalised Inverse Projection (1997)

	Back Projection			*Generalised Inverse Projection*		
<u>Population Size</u>:						
	1541-1556	G	1507	1541-1556	G	1506
	1561-1656	H	1461	1561-1656	H	1460
	1656-1686	D	1587	1656-1686	D	1580
	1686-1726	H	1492	1686-1726	H	1487
	1726-1806	E	1822	1721-1801	E	1822
	1816-1861	H	1758	1801-1861	H	1755
<u>Crude Birth Rate</u>:						
	1556-1661	C	1710	1556-1661	C	1710
	1656-1751	G	1602	1661-1751	G	1603
	1726-1816	E	1862	1741-1821	E	1867
	1816-1846	D	1779	1821-1846	D	1774
<u>Crude Death Rate</u>:						
	1556-1681	E	1722	1561-1681	E	1721
	1681-1731	1/G'	1704	1681-1726	1/G'	1700
	1731-1761	1/G'	1752	1726-1761	1/G'	1749
	1761-1831	C	1880	1761-1841	C	1886
<u>Gross Reproduction Rate</u>:						
	1556-1661	C	1701	1561-1656	C	1699
	1661-1726	G	1615	1656-1731	G	1616
	1726-1816	E	1851	1731-1821	E	1864
	1816-1851	D	1787	1821-1846	D	1790
<u>Life Expectancy</u>:						
	1576-1681	C	1729	1561-1681	C	1731
	1681-1731	G'	1704	1681-1721	G'	1701
	1731-1761	G'	1751			
	1761-1831	E	1892	1731-1811	E	1875
	1831-1921	E	1952	1811-1866	flat	
<u>Crude Rate of Natural Increase</u>:						
	1566-1651	C	1643	1546-1651	C	1647*
	1661-1686	negative		1656-1681	negative	
	1691-1726	C	1716	1686-1761	G	1676*
	1726-1816	G	1751	1761-1821	G	1768*
	1816-1846	C	1866	1821-1846	C	1869*
	1846-1948	C	1928	1846-1866	flat	

* = estimated rather than fitted.

Sources: Figures 1.1, 1.2, and 1.3; Wrigley and Schofield 1981, 528-29; Wrigley et al. 1997, 614.

Table 1.3

Trends of General and Age-Specific Marital Fertility in England

I_f	1558-1663	C	1707	1663-1723	G	1624	1718-1808	E	1855			
TMFR	1612-1662	C	1730	1687-1737	G	1607	1762-1812	E	1922			
15-19	1637-1712	C	1746	1712-1762	E	1774	1762-1812	E	1875			
20-24	1612-1662	C	1753	1687-1737	G	1607	1762-1812	G	1644			
25-29	1612-1662	C	1725	1662-1712	E	1770	1737-1812	E	1908			
30-34	1612-1662	C	1720	1662-1737	G	1596	1737-1787	C	1871			
35-39	1612-1662	C	1718	1662-1737	G	1602	1737-1787	C	1859			
40-44	1612-1687	C	1719	1687-1812	G	1655						
45-49	1612-1662	G	1565	1687-1737	G	1640	1712-1762	C	1825	1762-1812	C	1898

Sources: Figures 1.4, 1.6; Wrigley et al. 1997, 355.

Table 1.4

Trends of Infant and Childhood Mortality by Age

Period:	1	2	3
Perinatal (0-6 days)	1585-1615 G 1558	1625-1695 G 1577	1695-1725 /G' 1711
Neonatal (1st month)	1580-1610 G 1524	1600-1640 C 1692	1640-1710 G 1575
Post-Neo. (1 mo.-1 yr.)	1580-1600 C 1628	1610-1680 E 1710	1690-1710 E 1726
Stillbirth*		1590-1662 E 1708	1662-1712 C 1762
All Infant (1st year)		1580-1640 C 1700	1640-1730 G 1596
Endogenous Infant		1637-1687 G 1570	
Maternal		1590-1662 E 1696	1662-1712 C 1752
Exogenous Infant	1590-1637 D 1552		1662-1737 G 1629
$_1q_1$		1585-1685 E 1710	1695-1715 E 1717
$_1q_2$	1585-1635 /G' 1609	1615-1685 G 1606	1685-1745 /G' 1710
$_1q_3$	1585-1645 /G' 1603		1655-1695 C 1742
$_1q_4$	1585-1645 /G' 1605	1645-1715 /G' 1676	
All 1 through 4	1580-1610 C 1673	1610-1680 G 1589	
" " " "			
$_5q_5$		1615-1685 G 1600	
$_5q_{10}$		1590-1737 G 1559	
$_{10}q_5$		1585-1685 E 1716	1695-1755 /G' 1724
All under 15 ($_{15}q_0$)	1585-1615 G' 1597	1615-1675 G 1568	1675-1715 /G' 1692
$_1q_0/_{15}q_0$	1585-1605 C 1665	1615-1635 C 1671	1645-1695 E 1745
$_4q_1/_{15}q_0$	1595-1645 E 1681?	1645-1675 C 1729?	

* Estimated from Woods, SBR4.

Sources: Figures 1.8a, 1.8b, A.2a, and A.2b; Schellekens 2001, 7-11; Wrigley et al. 1997, 226, 236, 239, 250-51, 215; Woods 2005, 149.

Table 1.4 (cont.)

Trends of Infant and Childhood Mortality by Age

4	5	6	Period
1735-1765 /G' 1756	1765-1795 /G' 1782	1805-1833 /G' 1843	Perinatal
1710-1750 C 1770	1750-1820 C 1837		Neonatal
	1710-1810 C 1861	1800-1830 ?G' 1826	Post-Neonatal
1712-1762 C 1808	1762-1831 C 1872		Stillbirth*
1710-1750 C 1791	1750-1810 C 1856		All Infant
	1745-1837 ?D 1712		
1687-1762 C 1794	1762-1812 C 1834		Endogenous Infant
1712-1762 C 1789	1762-1831 C 1837		Maternal
	1737-1812 C 1879		Exogenous Infant
	1725-1815 C 1878		$_1q_1$
1695-1785 G 1656	1765-1825 C 1872		$_1q_2$
	1705-1805 C 1827		$_1q_3$
	1725-1795 C 1819	1815-1833 C 1832	$_1q_4$
1690-1740 G 1663	1750-1790 G' 1768	1800-1830 G' 1812	All 1 through 4
	1715-1805 ?C 1816		" " " "
1695-1745 G 1680	1735-1805 C 1808	1805-1833 G 1801	$_5q_5$
	1737-1787 C 1829		$_5q_{10}$
	1715-1805 C 1816	1805-1833 G 1804	$_{10}q_5$
1705-1755 G' 1726	1755-1795 G' 1771	1805-1833 G' 1821	All under 15
	1695-1775 C 1838	1785-1815 G' 1797	$_1q_0/_{15}q_0$
1695-1825 G 1652?			$_4q_1/_{15}q_0$

Table 1.5

Patterns of Adult Mortality across Successive Ages

Ages:				
25-29	1645-1665 C 1671	1655-1735 G' 1682	1705-1755 G' 1722	1755-1805 G' 1777
30-34*		1655-1755 G' 1690	1715-1755 G' 1728	1755-1805 G' 1773
35-39	1645-1665 C 1680	1675-1735 G' 1694	1715-1755 G' 1722	1755-1805 G' 1776
40-44*		1655-1715 G 1596	1715-1765 /G' 1739	1745-1805 G' 1762
" "				1725-1805 C 1824
45-49	1645-1755 C 1793	1685-1725 /G' 1709	1705-1755 G' 1723	1755-1805 G' 1778
" "			1735-1785 /G' 1756	
50-54*	1645-1745 C 1780			1755-1805 G' 1770
55-59	1645-1755 ?C 1787	1685-1735 /G' 1709	1725-1785 /G' 1757	1755-1805 G' 1774
" "	1645-1685 /G' 1663			
60-64*		1645-1705 G' 1674	1705-1755 G' 1725	1765-1805 ?G' 1778
65-69		1645-1685 /G' 1666	1695-1755 G' 1719	1755-1795 E 1844
" "			1735-1775 /G' 1758	
70-74*		1645-1695 ?G' 1664	1725-1775 /G' 1753	1745-1795 E 1824

* = Estimated; others fitted.

Sources: Figure 1.9; Wrigley et al. 1997, 290.

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Chapter 2

Universal Patterns of Demographic Change?

International Trends in Death Rates and Birth Rates

Evidence for England is exceptional in detail and in historical span. Are the types of patterns found in those demographic trends also exceptional, or have such movements been general in the experience of other populations?

Since usually not as much is known elsewhere historically, extensive international comparison is limited. Birth rates and death rates, and the rates of natural increase that their difference indicates, nonetheless, can be followed from the early 1700s forward for several European countries;[1] and by the early 1900s similarities and differences of trend can be outlined for at least a few dozen diverse populations around the world, though certain parts of the globe remain seriously under-represented, and even today offer little in the way of reliable time series.

To what extent have the kinds of G-related trends in birth rates and death rates established for England in Figures 1.1 and 1.2 also characterized the history of other populations? What countries, and what kinds of countries, have or have not shared certain of these movements? Does G-based trending assist in making comparative classification clearer, providing a better basis for understanding the way that populations have changed in certain observed fashions?

{Please note that the Figures and Tables referenced in Chapter 2 are not interleafed in the text but appear at the end of the chapter. MSW 31 July 2015}

SHARED AND CONTRASTING TRENDS IN CRUDE DEATH RATES

Death rates are examined before birth rates because the international distribution of their trend patterns in known populations has on the whole been simpler than the variation found among birth rates. European countries are discussed first because the bulk of evidence before the 20th century, and the earliest evidence, comes from them. Most of the data come from a collation by Jean-Claude Chesnais (1992, 555-78 and 515-41). Certain regional or local particulars are employed in order to tentatively extend national series backward somewhat.[2]

In spite of the difficulties, it is possible to identify trends in several national and regional death rates back as far as the 1700s, and to plot out about sixty such cases in all since the early 1900s. While over half of the populations whose death rates can be so followed are European (or overseas, still predominantly European demographic colonizations in North America and the Southern Hemisphere), a dozen examples of more indigenous and African origin from the Caribbean and from Central and South America are also available. Another thirteen cases from Asia include at least some insight on key populations like those of India, Japan, and China as well as ten smaller nations. Even four African examples can be employed--Tunisia and Egypt from the North, and the Indian Ocean islands of Mauritius and Reunion. The weakest coverage persists for sub-Saharan Africa, from where no usable chronologically extended series is presently available, and for the populations of the Middle East.

This information serves, first of all, to determine whether the types of G-based trends that have been observed in the English death rate (Fig. 1.1) also have characterized the experience of other populations. Do such movements tend to be general? Beyond that, do G-related patterns help distinguish and categorize how mortality has changed internationally, across various types of societies and different time periods, better than previous efforts of classification? If a few shapes of trend keep recurring, finally, what in the nature of populations might produce such general patterns among paths of CDR?

Figures 2.1a through 2.1i delineate trends of the crude death rate in five dozen populations for which reasonably extensive and largely reliable estimates exist: Figures 2.1a through 2.1e for European countries, Figures 2.1f through 2.1i for other parts of the world.[3] While experts on particular populations can doubtless in some cases extend the data backwards and forwards in time and improve them (including the necessary splicing for certain series), the trends outlined should provide at least a working sense of what kinds of movements in crude death rates were taking place, and when and where these occurred. Tables 2.1a and 2.1b summarize the patterns identified, in Europe and elsewhere, for comparison and contrast.

The first thing to stand out from these tables and figures is that over and over again changes in death rates have indeed tended to follow G-based forms.[4] There are some obvious wanderings of data around the underlying paths proposed (the history of death rates, after all, has laid much stress upon recurrent mortality crises); but, on the whole, trends related to G seem to capture the long-term movement of the evidence through time quite effectively.

More specifically, from the middle of the 18th century up until the aging of many European populations after World War II (and comparable recent G-shape increase in the CDR for a few others,)[5] downwardly accelerating C--G reversed with respect to time--was *the* path taken by national crude death rates in the vast majority of historical cases that can be established.[6] The C curve in arithmetic scale has a backwards ‘S’ shape: starting slowly, dropping off rapidly for a while, then leveling out. This is very much the form attributed to the decline of the death rate in discussions of ‘demographic transition.’ What is added here, though, is how generally this type of change conforms to the one C “relative” of the G curve.

The few exceptions are informative. Besides G-type increases in CDR from populations that aged significantly during the later 20th century, certain others should be noted:

In Palestine/Israel, Taiwan (twice), Malaysia, Mauritius, and Reunion, rather than via accelerating C-shape decline the crude death rate fell during the much of the 1900s first fast then ever slower via D. What might have made the modern reduction of mortality in these few populations take D rather than C paths? As 21st-century experience unfolds, will more D-type cases emerge elsewhere, and in what kinds of countries?

Four rising but decelerating G trends in the crude death rate appeared as northern Italy (1770-1815), Japan (1872-1922), Chile (1880-1907), and Costa Rica (1887-1917) edged into modern economic development and increased world contact and trade. Though such a pattern in CDR did not occur in England between where the data begin in the 16th century the aging that followed World War II (Fig. 1.1), was this one way that populations paid a price for linking up to an industrial global economy? Would, furthermore, earlier data than is presently available from certain parts of Europe, or very recent evidence from other developing countries, produce more instances of this trend?

Four *accelerating* E-type increases occurred as England (1566-1681 in Figure 1.1), Ireland (1864 or sooner to 1877), Cyprus (1902-1922), and Jamaica (1885-1912) apparently coped with harsh times. In the Irish case, the momentum of mortality from the famine of the 1840s and the aging that emigration produced were probably still at work into the 1870s. Deerr (1950, 2: 376-78) commented on the decay of Jamaican sugar culture, problems with migration, and other difficulties around 1900, in contrast to the contemporary situation on Trinidad. In England (Ch. 1) the death rate climbed into the third quarter of the 17th century as emigration backed up in conduit cities, and was carried toward a climax by civil war and plague. What happened to Cyprus in the early 20th century is unclear. Once again, would further series from populations under stress produce other instances of CDR rising in this form?

Composing a final category of exceptions in the figures and in the overview of Tables 2.1a and 2.1b, for some reason a temporary *dip* in death rates appeared in England (1681-1731 then again 1731-1761), Sweden (1693-1743), Finland (1723-1763), Denmark (1737-1762), Germany (1755-1795), the Czech lands of Bohemia and Moravia (1787-1812), and perhaps Norway (1743-1773). What diffused across northern and central Europe in a way that would give such temporary relief from mortality in the 18th century? The potato, or other new ways of producing food? Medical advances? Better weather is a unlikely cause given the considerable time lag from country to country.

In all, these findings seem to undermine some conventional conclusions but to be compatible with others of 1) *Accelerating*, not decelerating, decline has been the predominant modern form in crude death rates.[7] 2) National *sequences* of such accelerating declines, in which one steepening, downward-bending curve stops and is replaced by the earlier, flatter stages of another, have been overlooked by most observers, whose expectations have been overly influenced by simplistic theory that depicts essentially one-step modern mortality decline as part of a general pattern of 'demographic transition.'[8] 3) These repeated accelerations in the fall of CDR's have taken *neither* linear *nor* logistic shape but the G-based double exponential form of the C curve. 4) Scattered reversals towards higher crude death rates have been quite *systematically* distributed across certain types of populations in G (less often, E) trajectories and should therefore not be so "unexpected." There exist very good clues as to why they appeared.

Table 2.2 presents--based upon the Tables 2.1a and 2.1b and Figures 2.1a through 2.1i--what seems to emerge as an insightful preliminary categorization of five dozen documented populations according to the phases or stages of movement in crude death rates which they have experienced since suitable contemporary records or reasonable modern back-projections begin. It is based 1) upon the *sequences* of trend shapes that CDR's in reported countries have taken, and 2) upon *how early* the determinative modern feature in these population histories--C-type decline in mortality through the 19th and early 20th centuries--occurred and how long it *lasted*. The classifications transcend the division between Europe and other places with which the figures and tables began. In order to keep in mind the geography of the categories that emerge and introduce its implications, however, populations are still grouped by part of the world according to the columns in which they appear (Europe, the Americas, Asia and Oceania, Africa) .

Armed with better perception of the shapes of change that have been followed, Table 2.2 avoids the oversimplification that has been common in the ‘transition’ literature but nonetheless usefully classifies national histories of crude death rate into three basic clusters according to the forms of trends that populations have experienced in modern times. The largest group, labelled ‘B’, comprises just over half of all the surveyed historical sequences of trends. It includes 10 countries of 27 in Europe and 22 of 33 elsewhere.[9] In these 32 of the 60 analyzed populations, the death rate as of about 1990 had so far never *yet* increased over a substantial span of years since modern reduction began. In Japan and Italy, and Cyprus and Jamaica, that means since just after World War I, following G and E patterns up to that point respectively. In Ireland, E-type increase lasted only to 1877. But since these times in those particular countries, the death rate has just gone down in one successive C trend after another. Examples from France, Belgium, Luxemburg, Italy, Ireland, Austria, and Spain, whose data series reach back into the middle of the 19th century or sooner, appear in Figure 2.1.b. Similar long-running cases of this type are found outside Europe (Fig. 2.1f) in Canada, the U.S.A. (Massachusetts earlier on), New Zealand, and probably Australia (just New South Wales in the middle 1800s).

Most other national histories of death rates, 22 in all, have--after recurring C declines--seen death rates *rise* somewhat in G form in recent years. Figure 2.1.a presents cases of this behavior from Sweden, Finland, Norway, Denmark, and Germany. Figure 1.1 has graphed England and Wales. Most of these ‘A’ populations are European (17 of the 27 demographic histories documented for that continent, compared with just 5 of 33 countries elsewhere).[10] Recent particulars in the figures, however, show that several other nations may just now be beginning to follow this European lead. In the 1980s their death rates probably turned upward, though no G pattern can be established until further data are examined.[11]

An inspection of the left column of Table 2.2 to determine how various European populations have been distributed across this ‘A’ vs. ‘B’ divide begins to throw some light on why the two groups may have behaved as they did. To date, Europe splits very neatly into two parts with respect to modern crude death rate patterns: 1) From Scotland and England to the Netherlands, Germany, and Switzerland, and thence to the present-day Czech Republic, erstwhile Yugoslavia, and Greece, and in all recorded countries north and east of this diagonal, including Scandinavia, Poland, Hungary, Russia, and the rest of the Balkans except Albania (entries 1 through 18 in Table 2.1a), death rates have recently *risen* in G form following decades, if not generations, of substantial successive phases of C-shape decline. In Table 2.1.a certain phases of change in trends are distinguished by lines for emphasis, and to facilitate comparison of their timings. 2) In both parts of divided Ireland, in Belgium, Luxemburg, France, Italy, Austria, and Albania and southwestward into Iberia (the third layer of entries in Tab. 2.1a--numbers 19 through 28), no such sustained increase has yet appeared, though Ireland and Spain (Fig. 2.1b) show upward probings in the late 1980s that might turn into such trends.[12] In short, all of Europe is simply and consistently divided into northeastern and southwestern sectors by the tendency for the 17 populations in the former area, having come to the end of C-shape decline, to have already experienced some G increase in their crude death rates since World War II while the 10 other populations had not as yet done so by the 1990s.

There is, however, a second significant way in which the death histories of European countries can usefully be categorized. That is by the *timing* of their modern C curves of decline in crude death rates. Table 2.2 summarizes these sub-groupings of A-1 vs. A-2 and B-1 vs. B-2 populations. In 11 of the 17 ‘A’ populations of Europe, that is, a strong late 19th and early 20th century C trend of decline in death rates culminated between World War I and World War II; in 6 other nations, this transitional 19th to 20th century C-shape change in CDR lasted past World War II. Such a distinction separates the A-1 countries of England, Scotland, Norway, Sweden, Denmark, the Netherlands, Germany, Switzerland, Czechoslovakia, Hungary, and Yugoslavia--a northern and central core of regional decline in death rates--from the A-2 nations of Finland, Russia, Poland, Romania, Bulgaria, and Greece--a later “eastern frontier” of improving European mortality.[13] Similarly, among ‘B’ populations, which had of 1990 experienced *no* G-type rise in death rates after World War II, the early 20th century C-shape drop in crude death rates was completed by the 1930s in the B-1 countries of Belgium, Luxemburg, and Austria--three nations nestled geographically next to the core zone of A-1 societies. Meanwhile, the B-2 populations of Ireland, Northern Ireland, France, Spain, Portugal, Italy, and Albania saw these pre-World War II trends persist into the 1950s.

Previous analyses have tended to classify national mortality trends by *levels* reached at certain dates.[14] Tables B.1a and B.1b in Appendix B show how information on historic levels in death rates constructively relates the new perspective, organized on the basis of the behavior of G-based trends, to some earlier findings.

Beyond that extension of previous insight. however, the approach proposed here--which focuses more upon *shape* of change over time--casts more light than before toward locating and identifying the nature of *movements* in the demographic processes *by which* various alterations in CDR level were achieved. Such change in mortality can be attained several ways: 1) by improvement (or deterioration) in the treatment and the prevention of disease; 2) by better (or worsening) general standards of living--with respect to diet, but also clothing, shelter, sanitation, and habits like smoking, drinking, other drug use, and sexual practice; 3) by changes in fertility, which both alter the numerical base upon which crude death rates are calculated and insert new-born individuals with high risk into the population; and 4) by the aging of populations, which also modifies demographic structure in ways that affect CDR’s significantly. Success in providing long life can itself increase the CDR, which is at least part of what has been happening to generate the recent G-shaped rises of death rates in parts of Europe.[15] What the new approach that operates through identifying the G-based trends in the data does especially is to underscore which populations have seen CDR's change level *parallel* to each other across certain spans of time, and to ask what that parallelism suggests should be looked for in explaining how such movements have occurred.

For instance, it was suggested by Stolnitz (1974, 224) that recent increases for CDR's in countries that historically led the way in reducing mortality may be the result of aging populations--increasing life expectancy. That possibility can be verified directly by exploring comparatively and historically the nature of trends in mortality by age and by cause (for example, Preston, Keyfitz, and Schoen 1972).

A second instance of what can be learned from comparing the G-based patterns observed stands out from, not the lastest, but the earliest evidence of Table 2.1a. If one can diagnose what made English death rates dip in a 1/G' pattern from 1681 through 1731 then 1731 through 1761 (with t_0's at 1704 and 1752), the task of resolving how similar movements appeared in Sweden 1693-1743 (1716), Finland 1723-1763 (1724), Denmark 1737-1762 (1743), possibly Norway 1743-1773 (1760), some parts of Germany 1755-1795 (1772), and the Czech lands 1787-1812 (1787) is fruitfully simplified. In fact, particulars from any one of these cases of 1/G' sag in the CDR could leverage interpretation for all instances. Meanwhile, the fact that these similar changes (given distinctive underlining in Tab. 2.1a) happened, not simultaneously but *in sequence* across northern Europe, eliminates regionally shared weather impact upon agriculture as a likely source of the pattern. Advantage from having colonies to supply the homeland while draining off vulnerable population, furthermore, is possible for some of these populations but not others, while France--with overseas territories--does not display the 1/G' pattern (at least since 1752). Some diffusion of agricultural methods or medical practices, on the other hand, might well fit the observed international sequence of 1/G' dips in death rate.

The more detailed English data on deaths, furthermore, have displayed 1/G' patterns of mortality for some age groups, not others (Tabs. 1.4 and 1.5; Figs. 1.8b, A.3a, A.3b and 1.9). What does this distribution reveal that might help in understanding the dynamics that produced the 1/G’ pattern in CDR there, and how Scandinavian countries, parts of Germany, and the Czech lands of Bohemia and Moravia--and possibly other places as yet not documented this early--might progressively have experienced similar movements in their death rates across the 18th century in England’s wake? Will differences among age groups in these countries resemble what is found for England? If the age distributions vary, what will that indicate?

In England, finally, the second 1/G’ dip in the CDR occured at the beginning of a period of E-shape population growth that provided labor (at reciprocally falling real wages, it will be shown) for industrialization. In Denmark, too, E-type demographic expansion began along with a 1/G’ sag in the CDR. What economic change did such a demographic conjuncture foster there, if any? The northern Scandinavian countries, Germany, and the Czech lands, on the other hand, had no E pattern of population growth begin with their 1/G’ sags in the death rate during the 18th century. Such increase, and the industrialization that accompanied it, appeared in these populations only considerably later, in the 19th century, during other kinds of trends in the CDR. In the Netherlands, E expansion is evident between 1750 and 1838; but no CDR evidence is available until 1800. In the Gösgeramt district of the Swiss canton of Solothun, burials indicate two possible 1/G’ dips in mortality, first between 1718 and 1768, then between 1778 and 1828, with bottoms near 1728 and 1785. But no pattern of population growth is available for the district in this era. During the second of these movements, however, the proportion of burials that involved children sagged to a low near 1775, a finding that with the rather different English results may provide valuable guidance for further comparative study (Schlutter 1990, 396-97; 76).

A third topic that invites further investigation concerns relatively parallel C declines in death rates for England, Sweden, Norway, and Denmark in the late 1700s and early 1800s (with zero years for the curves at 1880, 1881, 1860, and 1846 respectively). This movement indicates some kind of reduction in mortality that was not shared by Italy, Finland, and the Czech lands, where records for this era display no such patterns (Tab. 2.1a and Figs. 2.1a and 2.1b). Looking at England alone (Fig. 1.1 in Ch. 1), it might be tempting to explain this particular historical improvement in mortality by the industrialization that was evolving there. The parallel shifts in Scandinavia, however, make this kind of causation suspect. Instead, some improvement in health or standard of living shared by these populations and not specifically linked to industrialization seems likely. Lowered death rates inflated population numbers, which *could* be harnessed to man industrialization; but this potential was not realized everywhere. What was the source of such shared or not-shared improvement in death rate? There is also the possibility, of course, that different dynamics in England and Scandinavia, or even a distinct set of causes in each country, produced similar patterns coincidentally; but a more systematic explanation seems worth exploring.

To continue with this example, the fact that in France the crude death rate declined along a similar curve through the same time period, with t_0 for the C in 1853 compared with 1860 in Norway and 1846 in Denmark, suggests that whatever force was at work affected the French population similarly, even though the *level* of the French CDR as the C pattern appeared was about 50 percent higher than in England and the three western Scandinavian countries, and in spite of the fact that after this particular phase French patterns of reduction in the CDR ceased to parallel the Scandinavian ones so closely.

This temporary French-English-Scandinavian convergence, on the one hand, serves as another reminder that populations can share similar paths of reduction (or increase) in death rate that begin from quite different starting levels. On the other, it also demonstrates that populations which together follow one pattern in one phase of history do not necessarily experience similar trends in other eras. At a later time, Hungary, Czechoslovakia, and Yugoslavia likewise experienced C curves of decline in their CDR's from the waning 1800s to the 1930s that also paralleled movements in core A-1 countries of northwestern Europe, which by then include evidence from Switzerland and Scotland. They did this, however, from an appreciably higher starting point, as France had done a century before. These findings raise some important implications for theories of international change in mortality and demographic transition. Parallels and divergences in trends and levels of crude death rate for the documented populations provide useful perspectives for organizing further investigation of what brought about various historical changes in mortality, a topic whose discussion could benefit from more, and more precise, systematic exploration of comparative evidence about what form changes took where and at what time.

Outside Europe (Tab. 2.1b), meanwhile, very few populations so far have shown a definite tendency to experience *increasing* death rates since World War II. Only Argentina (Fig. 2.1h) can be said to have a recent history of mortality like the A-1 countries of Europe in Table 2.1a, with the long century-to-century C there finished by the 1930s.[16] As in the European A-1 group, too, Argentina saw CDR's under 10 per 1,000 before the upward G trend began in the 1950s. Meanwhile, two other populations of Latin America (Uruguay and Cuba, Fig. 2.1h) and two in the South Pacific (the Philippines and Fiji, Fig. 2.1g) experienced rather later-timed early-20th-century C declines of CDR before the level turned upward after World War II (section A-2 of Tab. 2.2). In all four of these instances, too, crude death rates went well below 10 before reversing to ascend along G paths (Tab. B.1b). That has been seen to be typical A-type behavior from the European examples of Table 2.1a and Figures 2.1a through 2.1e. While in a few other countries recent data from the late 1980s suggest that G increases in CDR are possibly under way now,[17] both A-1 and A-2 patterns were, as of about 1990, relatively rare outside Europe.

Of both kinds of B sequences that were observed in Europe, however, cases are much more plentiful in the Americas, Asia, Oceania, and Africa. In the United States, Canada, Australia, New Zealand, Panama, Jamaica, and Trinidad and Tobago--all of them countries exposed to early-20th-century public health management of the Anglo-American tradition--C declines through the 1930s already carried death rates substantially downward, as in the A-1 and B-1 countries of Europe. Except in the three Caribbean members of this group, the CDR approached or passed below 10 already in the later 1920s, much like the then current level in the Netherlands, Norway, Denmark, Switzerland, Sweden, Germany, and England and Wales--where the northwestern European core of historical declines in mortality was seated. In Jamaica, Trinidad and Tobago, and Panama, the 10 per 1,000 level was generally reached two decades later, in the 1950s (Tab. B.1b).

The most common pattern outside Europe, though, has been the B-2 sequence, with early 20th century C declines that ran on past World War II and are being followed by C-shape reductions in CDR's that continued at least to the 1990s with no sustained G rise evident. Such movement characterizes 15 of the 33 populations covered in Table 2.1b. In Japan, Singapore, Hong Kong, Sri Lanka, Cyprus, and Puerto Rico the CDR's fell under 10 by the 1950s (Tab. B.1b). In time, they dropped as low as, or lower than, rates in the United States, Canada, Australia, and New Zealand. They just came down later. In China, India, South Korea, Brazil, Chile, Guyana, Venezuela, Costa Rica, Mexico, and Egypt, CDR's of 1955-1959 still ranged from 10.7 to 22.0. But by 1980-1982 Mexico, Guyana, Venezuela, Costa Rica, Chile, and Brazil on average had passed the U.S.A. and Canada; China and Korea were catching up with Japan and Singapore; and only India and Egypt had crude death rates in excess of 10 per 1,000 among the thirty-three recorded non-European countries. This was a time when in many European populations CDR's were now rising back above that level.[18] It remains to be seen whether, in the future, aging populations in these countries of other continents will begin to raise crude death rates somewhat, as in several European nations to date. It seems likely that many will also experience this transition.[19]

A final small cluster of Asian countries and islands off Africa saw their crude death rates in the 20th century decline not via the usual accelerating pattern, C, but according to the sagging, downwardly concave *decelerating* path D. Starting between 12 and 27 in the 1920s, however, their CDR's fell just as much as those taking the C track instead. Palestine/Israel and Taiwan broke the 10.0 level at the time of World War II. Malaysia, Mauritius, and Reunion did not; but by the early 1980s their CDR's were under 7 per 1,000 (Tab. B.1b). The significance of having had decline in the D form rather than the C path can perhaps best be understood when patterns over time for particular causes of death are examined.

Though there are some populations in which the death rate can be observed to have increased in one form or another before 'demographic transition' occurred, the overwhelmingly most common feature in the history of *modern* CDR's around the world has been decline in the C form. This proportionally downwardly accelerating curve--not linear, log-linear, or logistic decrease as the literature has argued--has been the norm for modern improvements in crude death rates.

National populations with extended records, moreover, do not display just *one* such C trend. Where the evidence goes back reasonably far, there has nowhere been only a single phase of improvement in mortality, one downward rush of death rates representing the input of lowered mortality toward creating--in country after country--an internationally diffusing 'demographic transition,' as has sometimes been theorized. Instead, two or three or more successive C-shaped declines in the CDR have appeared in one population after another. This repetition of reductions of the C type in crude death rates within many countries, extending across quite different historical settings since the early 1700s, suggests that more than one specific dynamic that lowers the CDR may lead to change in the C form. Beginning as far back as the first half of the 18th century, somehow this shape is almost universally characteristic of how improvements in medicine, sanitation, nutrition, life style, and economic conditions jointly, perhaps also individually, have affected the impact of death across populations through time.

As has long been understood, northern--particularly northwestern--Europe historically led the way towards lower rates of death. But just which populations accompanied which others down the road to lesser mortality turns out to have a rather different patterning than what has been argued. Knowledge of how populations did or did not share particular G-based movements--principally C trends--in their CDR’s provides valuable insights as to what types of dynamics bringing about demographic change may or may not have been common from country to country, suspicions that can be tested directly where evidence permits. Since so many trends move along the same C-shape tracks, meanwhile, the manner in which some general filtering effect of the structure of populations and their processes of renewal might repeatedly shape trends in crude rates of death this way deserves high priority as this analysis evolves.

SIMILAR G-RELATED PATTERNING IN BIRTH RATES ACROSS TIME AND CULTURE

While observed patterns for international trends in crude birth rates are somewhat more diverse and more complexly related than those for crude death rates, once again systematic comparison of the shape and timing of movements generates partially familiar yet also improved international groupings that indicate which populations altered along with which, and which did not. These re-categorizations help in better framing understanding how and why rates of reproduction have changed the way they did, and point to lines of continuing inquiry that should further elucidate how populations have evolved historically.

The international prevalence of G-related movements in birth rates as well as death rates, meanwhile, strengthens the probability that both are shaped by some fundamental way in which versions of G curvature are stamped upon population change very generally. This possibility has been raised by the wide range of English demographic trends encountered in Chapter 1 that display G-based shapes, and previously presaged by the recurrent paths of growth and decline identified by Volume I and the widely shared G-connected patterns of migrations and the way populations absorb them presented in Volume II.

Figures 2.2a through 2.2k and tables based upon them demonstrate the way that G-related models fit, and help to reinterpret, the histories of national crude birth rates that have been recorded since the early 1700s. Together the figures and the tables display various combinations, sequences, and timings of international trends in CBR that have evolved from place to place, pointing up some developments that have been shared and identifying others that have unfolded quite distinctively.

The most common modern shape of change in crude birth rates, as for crude death rates, has been the downwardly accelerating C curve. Virtually none of the five dozen societies surveyed has failed to experience a reduction in births of this C form at sometime since the mid-1800s.[20] About two-thirds of the CBR trends identified in these populations have been C's. Though historical declines of birth rate are already very familiar to students of population, among other things as part of modern 'demographic transition,' neither the demographic nor the historical literature has yet noted the standard G-related C shape that such adjustment has taken over and over again.

As Figure 2.2a through 2.2k and Tables 2.3a and 2.3b indicate, however, this ubiquity of the pattern does *not* mean that all birth movements in that shape have taken C paths with identical timing. Nor were C trends absent before the middle of the 19th century; they are, in fact, far from being just a phenomenon of modern 'transition.' The crude birth rate for Sweden (case 20 in the Table 2.3a), for instance, was probably starting to take shape as soon as the 1690s, though it moved so slowly at this early stage that decline was virtually imperceptible (Fig. 2.2a). By the 1680s a C curve probably also characterized the birth rate for Florentine Jews (Livi-Bacci 1977, 42; marked 'e' in entry 19 of the table and graphed in Fig. 2.2g); but that C trend already assumed *much* earlier acceleration in its decline than the prolonged Swedish one (with a t_0 of 1790 rather than 1941). In Finland (22), France (23), the Czech lands (26), and possibly Norway (21)--and among the Jews of Leghorn ('f" in entry 19 of the table)--birth rates were already taking C paths through the middle and later 18th century. Figures 2.2a, 2.2b, and 2.2g plot these accelerating declines. In England (1), furthermore, the first identifiable occurrence of the C trend in birth rates appeared as early as the third quarter of the *16th* century

(Figs. 1.1 and 1.2). Though this pattern of quickening downward change has indeed been ubiquitous in modern declines of birth rates, it must not be regarded as a particularly modern phenomenon, as ‘transition’ theory has tended to view it.[21]

At the same time, Table 2.3a indicates, the C pattern has scarcely been a universal form of change for European crude birth rates in modern times. In some parts of the continent, upward trends of accelerating ‘explosion’ in births (via the E curve) lasted nearly to, or even commenced well after, the opening of the 20th century, as cases 11, 12, 13, and 14 demonstrate for Hungary, Portugal, Romania, and Russia. No trending of this shape is recognized in the ‘transition’ representation of historical birth rates.[22]

A few recent declines, meanwhile, for some reason have taken the decelerating form D rather than accelerating C. Modern Austria (17) represents one of these 20th century cases. Ireland (15) is another, while perhaps two recent D-type decreases occurred in Czechoslovakia (26). For the first half of the 19th century, on the other hand, quite a few instances of this D phenomenon appear, as shown in the first tier of Table 2.3a (entries 1 through 10). During that era, this shape of change in birth rate may in fact have been a *common* phenomenon in the population histories of most countries from the North Sea to the Alps, though in Scotland, Belgium, and Switzerland the records do not reach back far enough to be sure, while in Norway (21) well extended evidence clearly displays no such D.

In the Republic of Ireland (15), Northern Ireland (16), Austria (17), and Albania (18), furthermore, birth rates actually *rose* steadily in sustained G trajectories, not temporary ‘baby boom’ surges, from the Depression to about 1960. Table 2.3b shows how CBR’s in several ex-colonial populations did the same thing (the United States, Canada, Australia, New Zealand, Jamaica, Trinidad and Tobago, and Fiji). These variations, while they still all take one or another G-based form, confirm the suspicion that, on the birth side as well as for the death rates already examined, there hardly occurred one single, typical ‘demographic transition,’ even within Europe.[23]

In spite of these several national differences, nonetheless, there appear to have been three broad groups of populations which generally shared modern historical patterns of change in their birth rates. Tables 2.4 summarizes these three prototypical modern A, B, and C sequences of CBR trends that emerge from Tables 2.3a and 2.3b. It also includes, by column sequence, some insightful sub-classifications within each broad category that reflect the *timing* of key trends within national series and the *levels* of CBR's that have resulted at successive stages. Tables B.2a and B.2b in Appendix B show the average rates at certain points in time upon which distinctions by CBR level are based.[24]

The groupings of populations by shape of trends, their timing, and the levels of CBR involved that result should not be overly stressed. The classifications become quite detailed; and they may well change somewhat as more data become available. These clusters do, however, usefully isolate and highlight questions of just what kinds of change--demographic, social, or economic--might have made crude birth rates for particular peoples share movement or behave differently at successive points in their histories.

The characteristic that separates two large groups of sufficiently documented countries from each other in terms of crude birth rate sequences is whether or not they experienced some sustained pattern of *increase* in CBR *before* modern C-shape decline typically associated with 'demographic transition' set in. Indeed, the most frequently shared phasing of trends--the 'A' patternings in Table 2.4--has in fact been some 19th or early 20th century *rise* in crude birth rate followed by one or more C-shaped declines. No less than 36 of the 62 studied populations probably followed such a sequence in some form.

More specifically, in England (1), Denmark (3), the Netherlands (4), localities in several different parts of what later became Germany (7), and Tuscany and Lombardy within northern Italy (10), an upwardly accelerating movement in crude birth rates of E shape across the later 1700s and early 1800s was followed by decelerating D decline in the 19th century. The first tier of Table 2.3a lists these movements. The timings of the successive curves, first up then down, were remarkably similar across national boundaries.[25] This suggests shared reproductive behavior located around well-recognized routes for trade, communication, and economic and social development which had long ago evolved across a swathe of Europe extending from the Po Valley northward over the Alps, down the Rhine, and across the Straits of Dover.[26] Since the Middle Ages, several centuries of international change, from economic to religious, had worked back and forth along that North-South network. In terms of modern demographic evolution in birth rates, this North Sea-Alps axis seems to have provided a channel for the spread of conditions and behaviors that gave a characteristic pattern to much of European population history. Whether the shared changes in birth rates were the product of parallel developmental movements across these countries or instead resulted from diffusions of less materialistic behaviors, customs, or values has to be determined. The geographical clustering by shape and sequence of trend, though, at least suggests where to look.

In the Austrian portions of the Hapsburg empire (9),[27] an D trend from 1822 to 1847, very parallel to English movement in crude birth rates at the time, was *followed*--as in Denmark and the Netherlands--by a short E between 1847 and 1872 before the ubiquitous C lasting into the early 20th century appeared. This subsequent C trend of 1872 to 1912, though a little late relative to the English and German patterns, (1) and (6), has its zero year very close to those of the Netherlands (4), Denmark (3), Scotland (2), Belgium (5), Switzerland (8), and Italy (10)--1952 vs. 1950, 1944, 1943, 1941, 1942, and 1955 respectively. The D of the Austrian CBR from 1822 to 1847 is likewise timed parallel to the same shape of decline in the early 19th century for crude birth rates in England, Denmark, the Netherlands, Germany, and Italy. In other words, with only a brief extra E intruding between these two phases, Imperial Austria (9) probably belongs along with the basic North Sea-Alps cluster of populations in terms of the behavior of her birth rate.[28] So, perhaps, does Belgium (5). National data there are elusive before the 1840s; but the three CBR patterns thereafter are virtually identical with those for neighboring Germany.

Meanwhile, though there is no evidence prior to about 1860 or 1870 in Scotland (2) and Switzerland (8), their known movements in birth rates subsequently are so close to those of the eight longer-documented populations of the A-1 group (including the local as well as national German and Italian series) that it seems best to consider them in this classification until new evidence proves otherwise.[29]

Following Italy in Table 2.3a, however, comes information from four southern and eastern European countries. This shows that E-type growth in birth rates has not strictly been a North Sea-Alps phenomenon. Though no D's appear, E's for the *later* 1800s do emerge in Hungary (11), Portugal (12), and Romania (13), while the CBR of Russia (14) pushed upwards in this shape very recently (from 1967 to 1984).[30] In local timing, these other European accelerations of crude birth rates extend appreciably later than those in the North Sea-Alps cluster, to about 1890 or afterwards. The birth side of 'demographic transition' was still delayed. This means that the fall in *level* of the crude birth rates lagged noticeably behind that of the A-1 countries (Tab. B.2a in App. B). As shown in Table 2.4, Hungary belongs in sub-category A-2 according to the level of its 20th-century CBR's and the later ending of its E surge, while Portugal and Romania fall into group A-3.[31] The former Soviet Union (14), finally, experienced an exceptionally late E-type increase in its crude birth rate as recently as 1967-1984, though calculations for 1989 suggest the possible beginning of a new C trend since then.[32]

From this patterning of later combinations of successive E and C curves emerge European clues as to what more recently demographically transformed populations elsewhere may have been doing. In fact, Hungary, Portugal, and Romania constitute only 3 of 23 documented countries around the world whose crude birth rates have evidenced more recent E-shape increase followed only by C decline, with no D pattern appearing since the data become available. The timing of transition between their successive trends is usually later than for European A-type populations. Thus their average CBR's typically occupied still the highest level, 4, in the late 20th century (Tab. 2.4, and Tab. B.2b). But since the late 1800s their *sequence* of trends is similar to that of the core A-1 group of North Sea-Alps nations (1 through 10 in Tab. 2.3a). In a 24th case, Japan saw her CBR rise in G (rather than E) fashion from 1877 to 1912 before dropping off in the C trend of 1912 to 1989 to produce rates for the period since World War II that resemble those of Portugal and Romania in 1948-52 and 1971-81 (Tab. B.2a).

Next, it should be noted that Table 2.3a distinguishes--still in its second tier--a quite different pattern of historical birth rates within Europe, ‘C,’ that has unfolded in Ireland (15), Northern Ireland (16), modern or “little” Austria (17), and Albania (18). In these populations, following the typical European C decline into the early 20th century, birth rates *rose* from the Great Depression to about 1970 in G form. Instead of an abrupt shift to a higher level of reproduction at the end of World War II, which was the common pattern elsewhere, the 1930s witnessed in these four places the start of sustained, if decelerating, increase in crude birth rates that lasted about thirty years or more. Since then, however, these populations have all resumed the C decline that has been typical of European countries after World War II. Provocative questions arise concerning why their population histories have departed this way from the more usual patterns in Europe. Meanwhile, the birth rates of the United States (57), Canada (58), Australia (60), New Zealand (59), Jamaica (61), Trinidad and Tobago (62), and Fiji (63) also display such a trend. Could the reasons for this patterning be the same in these far-away countries as for the three cases from Europe? Did alternative demographic processes have the same effect? Or is the similarity purely coincidental? Some further probing seems profitable. All together, however, these category ‘C’ cases of Tabs. 2.3a, 2.3b, and 2.4 compose less than one fifth of the five dozen populations examined.

Cases (19) through (29) and (30) in Figure 2.3a, finally, show how a last group of European populations, from Scandinavia to Greece, have--at least since their records begin--never before 1990 had anything but successive C-type declines in their crude birth rates. Over and over again their reproduction has shrunk in this one accelerating form. Never can it be documented to have increased in any sustained trend, nor can it be demonstrated to have declined in a shape significantly other than C. Various local Jewish populations in Italy (Livi-Bacci 1977, 42), it must be remembered (19), may well also show nothing but C-shape decline simply because the sources employed do not extend into the 20th century.

France (23) is the nation most noted in the literature for having had substantial and persistent fertility reduction. For CBR decrease only in the C form, however, the *simplest* illustration comes from Sweden (20). There, beginning with evidence from the central district of Närke in the 1690s (Utterström 1965, 538), it appears that right through the early 1930s (*Historisk statistik* 1967, 88-91, 99)--for almost 250 years, in all, the crude birth rate progressively declined along a *single* accelerating C curve. One of the reasons that the 'transition' model has so frequently been oversimplified seems to be that the Swedish series--which is of such good quality and unusual length, and is so pure and uncomplicated--has been known for so long,. In such a long C pattern, the early years are virtually flat. Following a short, sharp shift upwards in level from the mid-1930s through the early 1940s, a new C then carried the Swedish crude birth rate downward again through the 1970s, though the 1989 evidence suggests that this trend no longer applies. A new era in Swedish reproductive history has probably begun.

In Norway, there may have occurred a short-term G' hump in the CBR from 1743 through 1773, as the top plot in Figure 2.2b indicates by a finer line; but generally the birth rate came down along two successive C paths from 1748 or sooner to 1813, and from there to 1923. Somewhere about 1815, however, Norwegian fertility rose to a rather higher level before starting downward in C form once again. This phenomenon has been discussed previously (Harris 2001, 183) with respect to the four bishoprics of the country, which collected the demographic data of the time. Later, in the 1920s and 1930s, the CBR of Norway dipped significantly before recovering and then continuing downwards in C fashion from 1948 through 1985. It would be interesting to know why of all 60-odd national birth rates graphed that of Norway was most severely affected in the 1920s and 1930s. Here as in Sweden, though, in the last years of the 20th century there are signs of some increase in the birth rate.[33]

Finland (22), like Norway but a little earlier, may have experienced a temporary G' surge in the CBR from 1723 to 1738 following the Great Northern War and short, sharp swings down and up in the 1740s. Then crude birth rates fell from 1753 through 1808 along a C curve virtually parallel to that for France (23) over the years 1742 to 1802.[34] Similarly, the Finnish C trend between 1808 and 1938 is, like the long Swedish C of 1693 to 1933, very much timed along with the *French* C trend in crude birth rate for 1848 to 1912 and the higher but parallel French resumption of that movement for the years between the two world wars (1923 to 1937). The difference for France, as Table 2.3a and Figure 2.2a show distinctly, is that between 1802 and 1937 the crude birth rate there experienced not one C-shape shrinkage, as in Sweden and Finland, but *three*. These *successive* trends of accelerating decline carried the French crude birth rate from around 33 per 1,000 in the early 1800s to about 15 per 1,000 by 1937, in spite of the shift upwards that followed World War I (Tab. B.2a; Fig. 2.2a). From the middle 1700s to the Great Depression, however, the Swedish crude birth rate also declined, from about 33 to 14 per 1,000--no less change than in France, even if it did so all in one single C curve. After 1808, the Finnish data show parallel descend parallel with the Swedish from about 37 to 19, starting higher but achieving no less of a net adjustment (18 fewer per 1,000). In terms of the extent of *eventual*, long-term change from the age of Napoleon to World War II, in short, the French result in reducing the crude birth rate does not, in the end, stand out.

What really distinguished France, Table B.2a and Figure 2.2a demonstrate, was how the additional, early, shorter and sharper C declines of 1802 to 1848 and 1848 to 1912, especially the former, dropped the crude birth rate there to exceptionally low levels already for the *second half of the 19th century*. During these five decades or so, crude birth rates for France were clearly the lowest for which national records exist. The numbers in Table B.2a are bracketed for emphasis. After World War I, however, little further reduction appeared in the French CBR; and by the end of World War II, French rates had become only average for European countries. Earlier on, in the middle of the *18th* century, furthermore, French birth rates had been among the *highest* known at that time in Europe, around 40 per 1,000 (as in northern Italy and certain recorded German localities, or 44 in Bohemia and Moravia). This contrasts with levels of more like 30 to 35 in Norway, Denmark, England, Sweden, and Finland at the time, Table B.2a indicates. While the French CBR then fell markedly into the early 1800s in C form, the English rate *rose oppositely* (t_0's at 1864 and 1859) over the same period, along the E curve of 1725 to 1795, to where the French level had been around 1750: about 40. In the A-1 group of populations England displays the highest CBR at this time. By the 1870s, however, the English rate was returning to the level of the other A-1 populations, though for the time being it still trailed significantly the leveling out French CBR (about 36 to 25).

Around France in Luxemburg (24) and Spain (25), and also in the East from Bohemia and Moravia (26) into Poland (27) and the Balkans (28 through 30 in Tab. 2.3a), it appears that in modern times seven other European nations as far as the late 20th century saw their crude birth rates only decline, and decline only via C trends. The record in Luxemburg and the Czech regions goes back far enough to make this conclusion fairly certain. Elsewhere, the extension across earlier years is less evident, though the spans of time covered without indication of anything but C trends are substantial.

Tables 2.3b and 2.4 show, next, how these historical trendings of birth rates in G-based forms scarcely have been unique to Europe.[35] While the A-1, A-2, A-3 sequences have been (except for Japan) characteristically European (in so far as generally shorter records elsewhere allow one to tell), the bulk of the latest, the A-4, cases appear outside Europe. The main difference is that the accelerating E-shaped birth rate surges of Asia, Africa, and the Americas south of the Rio Grande have lasted into the 1930s, 1940s, 1950s, and even 1960s, whereas in Europe this phenomenon had generally terminated by 1900.[36] The new conclusion readers should grasp is not that birth surges have been common in 'less developed' lands since World War II:

that, after all, was the point made by writers on ‘population explosion’ in the 1960s. Instead, it is necessary to realize that beginning as early as the 1700s in England, Germany, and northern Italy *most* international birth rates at some point surged this way. Sweden and France, because they of their now for many decades extensively documented population histories, have distorted the impression of what more than half of known birth rates, even within Europe, have actually done. In Asia, Africa, and the Americas--as generally was the case earlier in Europe--however, typically the E surge has similarly been followed by one or more C-shape declines.[37] This is why the “doomsday” of ‘Third World’ population explosion prophesied in the 1960s has never generally come to pass. Instead accelerating decline in fertility spread from country to country. It has not been that non-European populations have never curbed their accelerating birth rates; they have just got around to it later than European societies, many of which had themselves experienced the menacing E form of CBR increase considerably sooner.

The French and Swedish pattern of only C declines in modern times, however, while a minority phenomenon, has not been just a European one. Four nations in southern South America--Uruguay (51), Argentina (52), Chile (53), and probably Brazil (54)--have repeatedly lowered their birth rates that way (Tab. 2.3a). From the 1800s to the 1930s, Argentina and Uruguay saw their CBR’s drop about 22 per 1,000. In Chile and Brazil the change came later. Still, by about 1980 crude birth rates there, too, had declined by 15 to 24 per 1,000 (Tab. B.2b). These South American changes in CBR began from higher levels than the European ones; but they took paths of the same shape and brought about as much difference in their own time. In Asia, similarly, India (55) and Palestine/Israel (56) apparently have experienced reduced crude birth rates repeatedly in C form without evidence of sustained increase since reliable records begin. This places them in the B catgory of patterning right along with France and Sweden, though they have of course made much later adjustments.[38] It also means that India experienced E-shape population explosion through the middle decades of the 20th century without the E form of surge in CBR that is found in Singapore, Korea, Taiwan, Malaysia, and perhaps Sri Lanka and the Philippines (Fig. 2.2j), or England and other European countries during earlier periods. Was this because by 1970, as opposed to the present, India had developed less?

In Figure 2.2h are graphed crude birth rates for four former British colonial societies with populations still primarily of European extraction. In the U.S.A. (57), Canada (58), and Australia (60)--other than during the years around World War II--the predominant pattern, Table 2.3b indicates, is one of successive accelerating C declines in birth rates. The exception in New Zealand (60) entails what is probably an E type of increase from where the records begin in the 1850s to the late 1870s. In this era, a pioneer society on North and South Islands was finding its economic feet and was moving towards more normal sex balance. Reliable and adequate aggregate birth rates are just not known for comparably distorted early phases in the demogaphic histories of colonizations in Australia, Canada, and the territories that became the United States.[39]

From the 1930s into the 1950s, however, Figure 2.2h and Table 2.3b show that an unusual modern pattern for birth rates, G, pertained in all four of these societies from the Depression into the aftermath of World War II. These are populations noted for their postwar 'baby booms.' The data indicate that for about two decades (from 1935 to 1954, taking the beginning and ending years of the quinquennial periods involved) crude birth rates--as opposed to rates of fertility--in these countries moved upwards quite steadily in G form. In most other populations (for example, Figs. 2.2a and 2.2b) there occurred, instead, either a sudden shift to a higher level of C decline or a much more temporary "bump" in the CBR. In Ireland (15), Northern Ireland (16), and Austria (17), though, sustained G increases of birth rate also have been seen to appear in the 1930s--in fact somewhat earlier, during the first years of that decade. In those three European cases, however, the G curves were both flatter and longer: they had base years in the later 1800s rather than in the early 1930s, as in the United States, Canada, Australia, and New Zealand. And these upward, but decelerating paths of change in Europe lasted through the 1960s or later, not just the early 1950s. In Albania (18), however, for some reason a G almost identical in slope and timing to that of the four erstwhile North American and antipodean British colonies appeared. The same was true in Jamaica (61) and Trinidad and Tobago (62), though the G for birth rates in the Fiji Islands (63) was longer and more gentle, like the Irish pattern (Figs. 2.2h, 2.2k, and 2.2j). Given the varied nature of these populations involved in parallel G movements, and the failure of other societies to show similar drawn-out change, some reinterpretation seems appropriate for the existing conception of postwar ‘baby booms.’

Before leaving the occasional occurrence of the G pattern in modern crude birth rates, it is important to note that in Japan (case 31 in Tab. 2.3b; graphed in Fig. 2.2j) from the earliest national records in the 1870s to World War I the birth rate increased along a sustained G trend. Then, in spite of short swings in the late 1940s and a generation later in the early 1970s, the secular trend to 1989 generally took the C form of decline. With its t_0 at 1977, this curve is very comparable to the ones followed in China (34), Hong Kong (35), and South Korea (36) over the years since World War II. Besides Japan, the only other documented case of G-type increase in national crude birth rates before the 1930s appears in England (1), from about 1660 to 1750. Some possibilities arise as to how this similarity to the Japanese pattern a century later might involve two somewhat parallel situations in which somewhat marginal societies and economies moved towards more central positions in world markets and networks of cultural change. In England, however, the G of 1656 to 1751 gave way to an equally long E-shape explosion across most of the 18th century that was supported by industrialization. In 20th-century Japan, the following trend was a downward C, though the two attempts to surge up above this curve (Fig. 2.2j) might signal forces somewhat comparable to those producing explosion in England during her threshold of economic development (*Japan, Statistical Yearbook* 1992, 1994). In the end, nevertheless, the Japanese, in a modern age of more readily controllable fertility, responded very differently to the opportunities and changes involved than had the English long before.

Classification such as this should not be overworked. It nonetheless brings to the fore possibly insightful similarities and dissimilarities among populations that the existing literature has missed. These throw better light upon *how* international birth rates may have risen or fallen historically.

Overall, an historical survey of patterns in crude birth rates indicates that inputs from reproduction into five dozen populations with adequate data did in fact repeatedly move along G-based paths. These are the same shapes--C, D, E, and G; never F or H (though occasionally G' or 1/G')--found also to characterize historical trends for death rates.

Certain stretches of available data are too brief or too variable to model. Even for longer, steadier periods, different patternings can certainly be argued here and there. A few alternatives have in fact been offered. Those more expert in particular historical cases may appropriately contend that their choice of shape or timing in trends not only constitutes a better fit quantitatively but makes more sense contextually, in terms of what they know about the particulars of local changes that affected births or deaths. Still, many should find that the type of summary patterning laid out in the figures and tables, taken as a whole, for the most part reliably and insightfully generalizes what is known so far about fairly receent international historical movements in birth and death rates, and suggests fruitful lines for further inquiry into questions of how the observed trends have moved in such similar or disparate fashion.

The manner in which these standard, repeated trends in birth rates and death rates have come about, what the origins of their shapes and their repetition seem to be, must be probed. Before moving on to such more detailed analysis of the contributing demographic dynamics of mortality and fertility, however, some general implications of the findings about vital rates that have been presented should be highlighted.

First, to look at trends in terms of rate of change in the demographic rate being considered (the bending of the curves) rather than just the level reached by a rate at a certain time, as other analysis has done to date, displays better how different populations are or are not likely to have been responding to similar stimuli (whether these come from economic development, spreading choice of lifestyle, shifting health conditions, improved and more readily available contraception or abortion, ideological change, aging, or whatever). The new approach better captures the pace and direction of movement, which populations share them, and which do not.

Second, analysis in these terms produces potentially insightful groupings of change across societies than have previously been established. Sometimes very large blocks of populations have evolved demographically together, as in the C-shape decline of birth rates culminating in the 1930s. In other situations, for instance sustained baby booms following the Great Depression or E phases of increase in CBR during the late 1700s and early 1800s in Europe, discovering that one handful of societies has experienced a particular pattern or sequence of patterns together, while another cluster has not, helps rewrite past generalizations that do not grasp the comparative evidence as well as they should.

Finally, and most fundamentally, what has made rates for both births and deaths repeatedly take G-based paths, whether the change was up or down? The answer needs to be reached through understanding better how shifts in fertility and mortality pass through populations as these constantly renew themselves with births replacing losses to death.

Notes for Chapter 2

1. European regional and local details that sometimes reach earlier are addressed in Ch. 5.

2. Luxemburg is added to the European cases because of good and historically lengthy series in spite of small population size, more is done with Korea, in spite of limitations to the series, and patterning is pushed back further across time in the United States, New Zealand, and

India--all at some risk.

Where specifically focused national series have not been handy, information for recent years comes from the United Nations, *Demographic Yearbook* for 1975, 1980, 1985, and 1990. Insights for Italy and Germany earlier in time than provided by Chesnais, have been probed by including regional studies within these populations, which did not have modern national boundaries until the third quarter of the 19th century. Particular sources for these and other populations are given where the discussion employs their evidence.

3. Other sources besides Chesnais and the U.N. include: Keyfitz and Flieger 1971, 60-108; Norway, Central Bureau of Statistics, *Historisk statistikk 1978*, 44-47; Sweden, National Central Bureau of Statistics, *Historisk statistik för Sverige*, 1969; Part 1. Population, 2nd. ed., 1720-1967), 86, 89, 91; Finland, Central Statistical Office of Finland, *Suomen tilastollenen vuosikirja*, 1991 , 80-81. Rates for the central Swedish district of Närke 1691-1750 come from Uttrström (1965, 538, his Table I that is cited being taken from D. Hannerberg, *Närkes landsbygd 1600-1820*, 1941). Evidence on Finland before 1750 (for that part held by Sweden as of 1749) is given by Jutikkala (1965, 555). For particulars from Wrigley and Schofield and other sources on England, see Ch. 1.

The local German trends are taken from W. R. Lee (1979, Tab. 4.5, 182). Mulsum, Hochdorf, Besenfeld, and Göttelfingen are grouped as having similar behavior in their death rates in the later 18th and early 19th centuries, as are Böhringen, Durlach, Landsberg, and Oldenberg. Trends for this latter group of communities from 1755 to 1795 and from 1795 to 1845 are used to extend estimates for “Germany” back before 1827 in Fig. 2.1.a. Rates for the five large territories of Württemberg, Baden, Prussia, Saxony, and Bavaria are similarly averaged for the period 1815 to 1855 and their C trend included in Tab. 2.1.a (Kaiserlichen Statistische Amt, *Statistisches Jahrbuch für das Deutsches Reich*, 1914, 35: 3; and Köllmann, 1980; vol. 1.

Data for the “Czech Lands” are provided by Chesnais (557-60, 562). The evidence covers

Bohemia and Moravia before World War I, all of Czechoslovakia thereafter. “Hungary” before 1919 refers to the Hungarian Kingdom of the Hapsburg Empire less Croatia and Slavonia (Mitchell 1980, 135, note 15). The calculation for “Yugoslavia” for 1881 to 1914 that is offered here averages rates for Croatia-Slavonia and Serbia in a 1:2 ratio; prior to that, the evidence covers only Serbia (ibid., 136, 122). For other historical boundary changes in various European countries see Mitchell, 135-36.

Rates for Luxemburg come from Ministère de l’Économie, *Statistiques historiques 1839-1989* (1990, Table B. 301). For France, Henry and Blayo (1975, 109) have provided early estimates. For the period from the 1770s through the 1930s, the basic evidence comes from Bourgeois-Pichat (1965, 474-506, especially Table 4, 506).

For Italy prior to modern nationhood, an average of the rates for Lombardy and Tuscany from 1810 to1859 is employed. For 1768 to 1799 the calculations are for Lombardy alone. These estimations come from Cippola (1965, 576-77). “Austria” before World War I refers to Cisleithania, the Austrian portion of the Hapsburg Empire, but without Lombardy and Venetia (Mitchell 1980, 135).

4. Tunisia, graphed in Fig. 2.1.i, represents an instance where--from local population behavior, or from the fragility of local demographic record-keeping--that generalization does not hold for presently available evidence.

5. Argentina, Uruguay, Cuba, the Philippines, and Fiji.

6. The figures also demonstrate, even employing relatively narrow five-year groupings of data, how the *variability* up and down around these trends shrank as populations entered the modern era. Such modern “taming” of mortality crises has been a topic for several authors (for example, Livi-Bacci 1992, 107-08; Perrenoud 1991, 18-37).

7. Chesnais (1992, 47) argued that “the direction of mortality trends is not as linear (or rather logistic) as generally supposed; it is attended by acceleration, but more frequently by deceleration, and sometimes unexpected reversals.” George J. Stolnitz recognized the

accelerating nature of such alterations, if not the specific G-based C path they follow in his path-breaking essay on national trends in mortality (1955, 31). His focus was upon improvements in life expectancy; but the tendency for change to become faster and faster for substantial periods of time also applies to crude death rates until quite recently.

8. An illustration of how alive the notion of *one* demographic transition, roughly repeated from country to country, remains can be found in Livi-Bacci 1992, 102-04. There, the expression "*the* transition" is applied over and over again (italics added). In contrast, the judgment of Vallin (1991, 43-49) embodies a perception of "phases of progress and phases of stagnation" in European declines of death rates and mortality that seems compatible with the patternings offered here.

9. The CDR in Massachusetts, a local extension of insight on the U.S.A. back before 1900, follows this B pattern, too (Tab. 2.1.b). "Germany" and "Local German" from Tab. 2.1.a are also counted as one "country" of the A group here.

10. The English upward reversal of trend for 1948-1978 (Fig. 1.1 in Ch. 1), like the Scottish for 1962-1984 (Fig. 2.1.d), was slight, and has since been replaced by new C-type decline.

11. This group of 'B's who may right now be becoming 'A's includes Ireland and Spain (Fig. 2.1b), but also: Australia, New Zealand, Canada, and possibly the U.S.A (Fig. 2.1f); Japan and Singapore (the left panel of Fig. 2.1g); Puerto Rico and Trinidad and Tobago (the right side of Fig. 2.1h).

12. Though the most recent evidence, until extended further, might also just signal the beginning of new C trends in their early, flat stages. Data coming available for the new century should soon tell which interpretation to prefer.

13. Within the A-1 group, moreover, traceable CDR's in the Czech lands, Hungary, and Yugoslavia experienced appreciably slower declines during the 19th century.

14. For example, Stolnitz 1955 and 1956; Tabah 1980, 355-89; Chesnais 1992, 47-87.

15. This was the dynamic to which Stolnitz in 1974 (225) attributed recently rising CDR's in wealthy countries. Smoking (particularly its mid-century spread among women), alcoholism, pollution, AIDS, poorly serviced immigration from less demographically 'modernized' areas, and--too often--degenerating infant care are other factors involved in raising the death rate in supposedly 'developed' populations, however, and must not be ignored. Ch. 8 examines some aspects of what has been happening to the frequency of various causes of mortality and the distribution of their victims.

16. Though one more C decline ensued before the upturn of the 1950s (as in most of those European A-1 cases).

17. Canada, Australia, New Zealand, Japan, Singapore, Puerto Rico, Trinidad and Tobago, and perhaps the U.S.A.

18. By 1974 Stolnitz (224) noted this rapid plunge of CDR's in developing countries, decreases often taking their rates well below those of richer nations with older histories of controlling mortality. He, however, emphasized that these CDR's were falling faster than in most previous international experience without recognizing that their adjustments were taking the same accelerating C-shape curves previously pioneered by the populations of northwestern Europe to which he contrasted them.

19. Japan faces such tendencies as her population ages (*New York Times* (Kristoff) Aug. 1, 1999).

20. A possible exception is in Fiji, though there are no data until 1923, which allows for C-type decline before that point as in other territories under British sway such as Trinidad and Tobago and Jamaica.

21. For a brief overview of this link between the output of children and 'modernization,' especially in writings of the 1950s and 1960s, see Alter 1992, 18-20.

22. Though it is expected for population size as a result of the interaction of falling death rates and only delayed decrease in birth rates.

23. Chesnais has emphasized the marked differences in historical *levels* of both CBR’s and CDR’s from which modern demographic changes have begun (1992, 139). The argument here is that variation also holds true for the *shapes of paths* taken by those adjustments and for their *timing*.

24. For this analysis, the CBR’s employed by Chesnais (1992,118-20) are incorporated, but the European data in particular have been pushed back further in time where feasible from other sources cited in notes 3 and 4 or the text.

25. In Scotland, Belgium, and Switzerland, the data series are too short to tell what happened in this earlier period. In Italy and England, C declines in crude birth rate began right after the D trends; but in Denmark, the Netherlands, Germany, and perhaps Imperial Austria one further E-type increase inserted itself before lasting reduction in CBR began.

26. For Germany from about 1755 to 1815, among local data provided by W. R. Lee (1979, 181), Hochdorf, Besenfeld, and Göttelfingen and Durlach in the southwestern vicinity of Karlsruhe, Böhringen in the nearby Schwarzwald, and Mulsum and Oldenburg bordering the North Sea have the most continuous evidence of birth rates for the later 1700s and early 1800s. After what may well have been the tail end of a C decline over the initial documented period of 1755 to 1775, these five local rates each rose according to something like an accelerating E trend from 1775 to points between 1805 and 1825, with zero years for the E curve placed from about 1840 to 1870, very much like the 1867 for England between 1725 and 1795 and 1841 for the fragmentary first known span of 1808 to 1823 in the nearby Netherlands. Rather later E trends with base year in the 1870s are also possible for Württemberg and the community of Friedersdorf, eastward in Silesia, over the period from 1815 to 1835. The ‘Local German’ E for 1775 to 1810 in Tab. 2.3a represents a crude averaging of these findings.

Thereafter, from 1815 to 1855, the birth rate in Oldenburg declined approximately along a D trajectory with its zero year around 1760, much as in the England of Wrigley and Schofield for 1816 to 1846 and the Netherlands for 1823 to 1853. So did the average of rates for nearby

Mulsum and four of the southwestern communities studied by Lee (evidence for Durlach ceases after the decade of the 1800s). Comparable D's in birth rates appear for Prussia and Saxony, as averaged between 1815 and 1845, for Friedersdorf in Silesia, but not for Bavaria. Once again a little late--as in its preceding upsurging E--Württemberg may have been starting its own D decline between 1845 and 1855; but there are only two decadal estimates upon which to draw in trying to identify that movement. Fig. 2.2e graphs some of these probable or possible trends.

The Italian regional evidence before 1862 comes from Cippola (1965, 576-77). Here, as previously for deaths, rates for Lombardy and Tuscany are averaged from 1810 to 1859; data for 1768 to 1799 are for Lombardy alone. From 1861 forward, *Sommario di statistiche storiche dell'Italia, 1861-1975* (1976, 19) supplements data from Mitchell, Chesnais, and the U.N..

Information for the Netherlands is augmented from Hofstee (1981, 123). For Denmark, see also Andersen (1979, 85) and Gille (1949, 63).

27. 'Cisleithania,' or Austria, Bohemia, Moravia, Austrian Silesia, and Austrian Poland. Prior to World War I, Bohemia and Moravia also are recorded as 'Czech Lands,' while they composed the demographic bulk of modern Czechoslovakia prior to the recent separation of Slovakia. Through 1912, in other words, their regional populations compose a part of category (9) and all of area (26) in Tab. 2.3a.

28. Helczmanovski (1979, 73-75) as well as Mitchell, Chesnais, and U.N. sources.

29. For instance, Scottish rates are clearly *not* moving parallel to Irish (second tier of Table 2.3a). In the Canton of Zürich, moreover, R. Braun (1978, 301) found population increase in E shape from 1792 (perhaps 1762, with a dip at 1771) through 1836 that moved towards a t_0 near 1864, just about what the CBR was doing in Germany, northern Italy, the Netherlands, and England. If this demographic growth was driven primarily by fertility, as Braun's text infers, Switzerland may belong with the North Sea-Alps cluster of populations in terms of birth rate history.

30. In fact, two E's occurred in Portugal, sandwiched around a C that did not last very

long--from 1888 to 1898 (Livi-Bacci 1971, 21).

31. Mostly on the basis of higher CBR level in the 20th century. In Portugal and Romania--and Spain (25)--furthermore, unlike the A-1 group not one but *two* further C's have followed World War II. The second of these, moreover, has been steeper than the first (with earlier t_0), meaning that about 1970 these populations shifted into a higher rate of contraction in their births. More usually a new C brings on a *slowing* of the fall in birth rates for the time being. Recent political change in these countries probably had a significant role in the unusual patterns observed. So may the postwar aging of their populations.

32. This decrease seems to be accelerating (*Philadelphia Inquirer*, August 12, 1993). Such very late E increase puts Russia into sub-category A-4.c, though its 20th century CBR *level* is generally like that of Romania and Portugal. Data to 1913 are for European Russia alone, less Finland, Poland, and the Caucasus (Mitchell 1980, 135, note 21).

33. For Norway, *Historisk statistikk 1978*, 44-47, is also employed.

34. The Finnish information for 1722-1749 comes from Juttikala (1965, 555); for later years, *Suomen tilastollinen vuosikirja 1991*, 86, 80-81. French calculations to 1860 are taken from Henry and Blayo (1975, 109).

35. Supplementary sources beyond U.N. publications and Chenais are noted where appropriate.

36. The exceptions being a short second E in Portugal from 1892 to 1922 and the unusual postwar surge between 1967 and 1984 in the Soviet Union.

37. Exceptions include a 1/G' dip in Sri Lanka between 1927 and 1947. Was a policy tried there that did not last? In Guyana, a D for 1952 to 1982 followed two E's.

38. As their positioning in the 4th column of the B section of Tab. 2.4 reflects. India's decline of about 20 per 1,000 between 1886 and 1989 brings its CBR level only to that point from which Norway, Denmark, Sweden, and England started the early modern era, just above 30. While only a 7-point decline took place in Israel/Palestine from the 1920s to the 1980s,

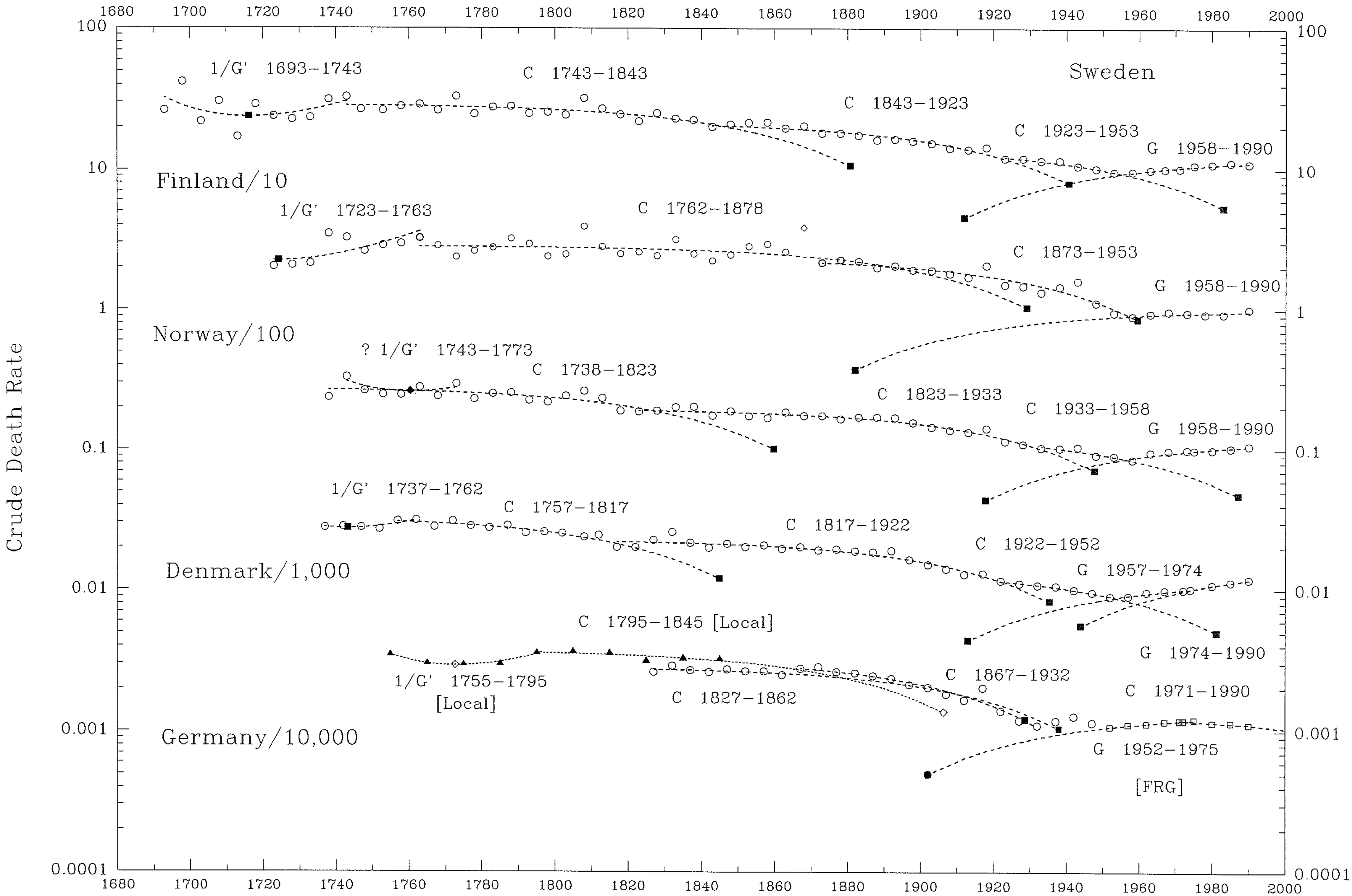
Please note that the order of notes 30 and 39 was upset – MSW 31 July 2015

starting in the 1920s Palestine already had a rate as low as 35. It is unknown what change had already transpired there by Word War I under the Turks.

39. Though for the U.S.A., at least, some useful local evidence exists (Ch. 6).

Figure 2.1a

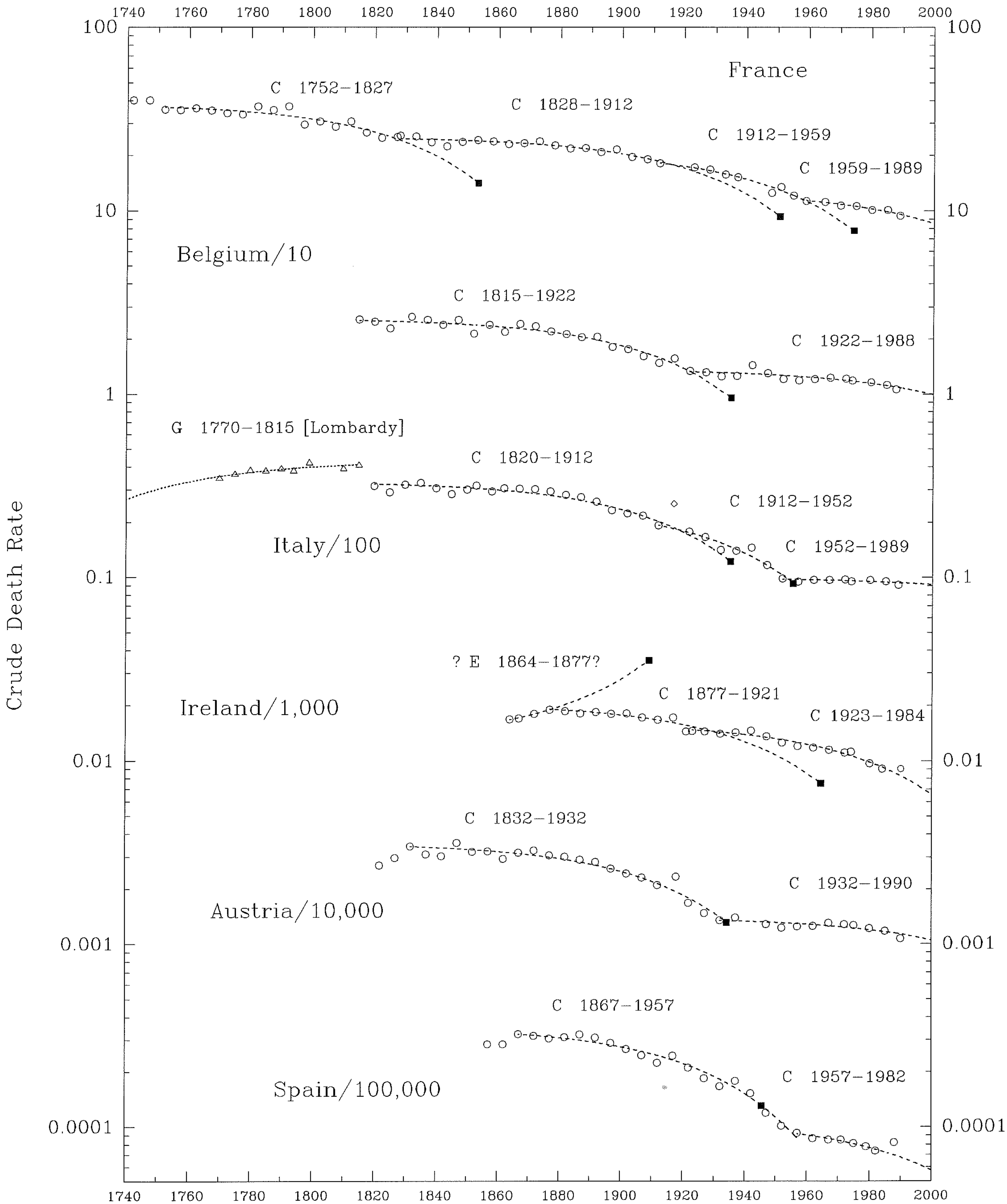
Crude Death Rates in Selected Populations:
Northern European Countries with Recent Increases



Sources: Chesnais 1992, 555–78; also notes 3 and 4.

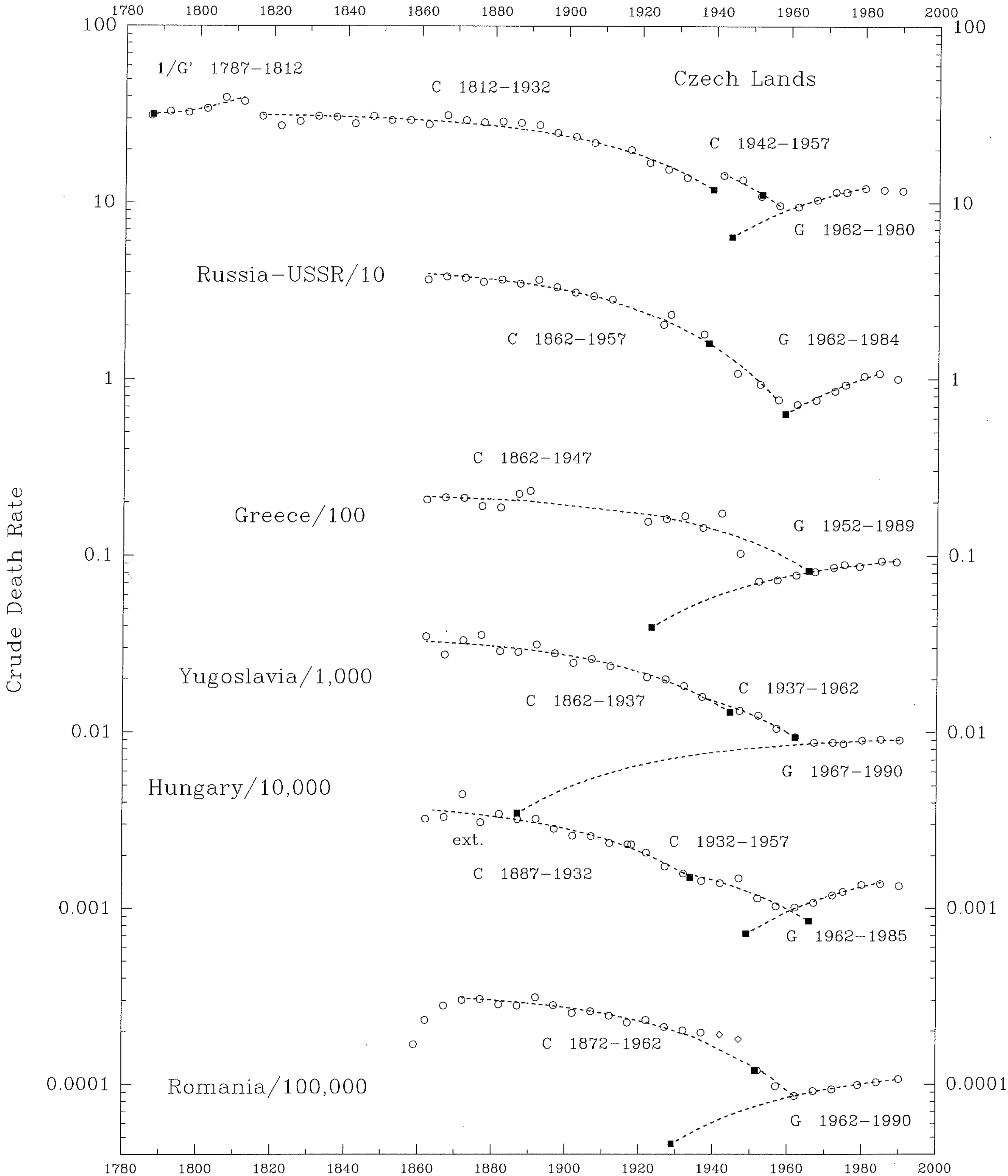
Figure 2.1b

Crude Death Rates in Selected Populations: Some European Nations with Only Modern C Declines



Sources: Chesnais 1992, 555–78; notes 3 and 4.

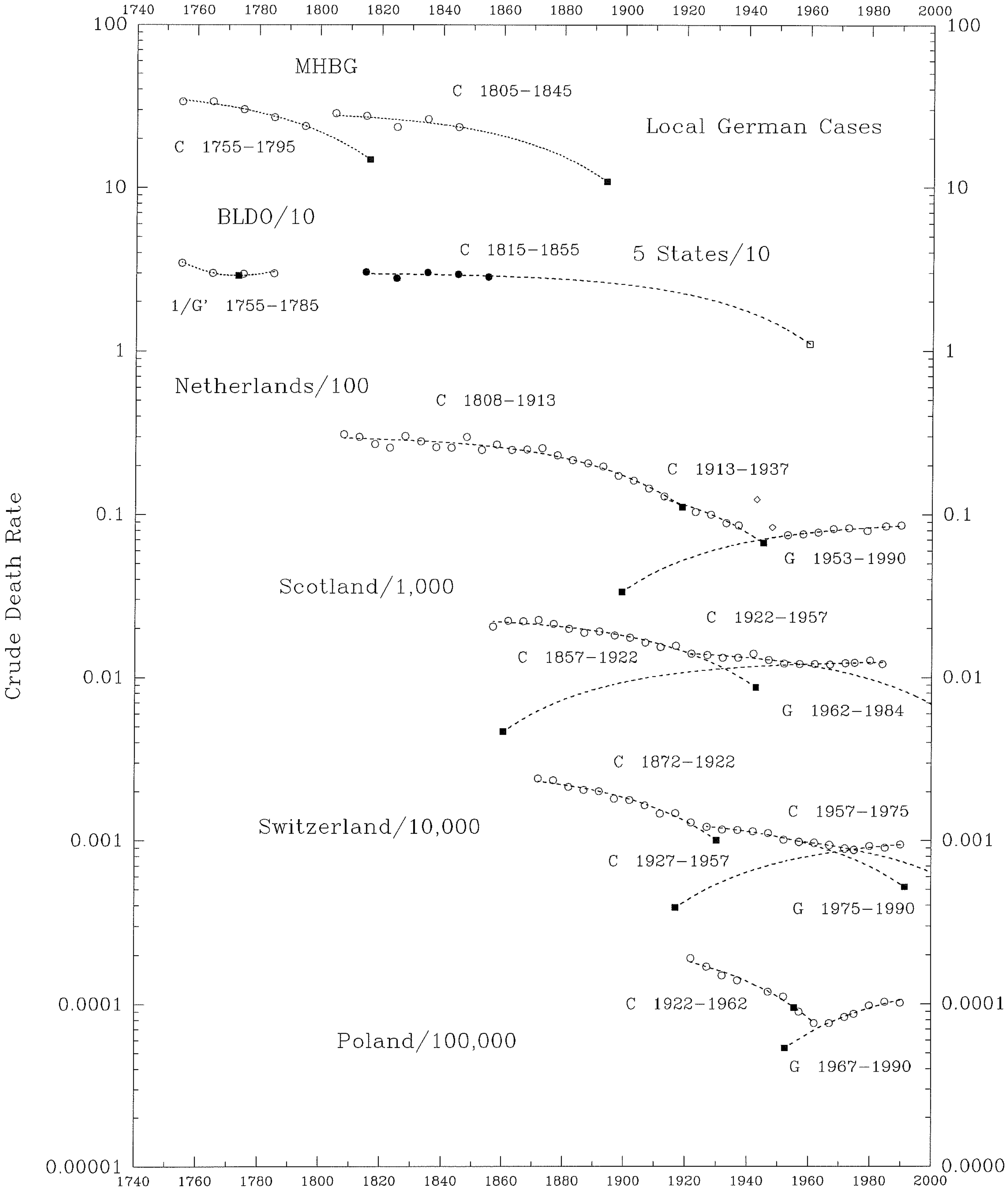
Figure 2.1c
Crude Death Rates in Selected Populations: Eastern European Societies with Recent G Increases



Sources: Chesnais 1992, 555–78; notes 3 and 4.

Figure 2.1d

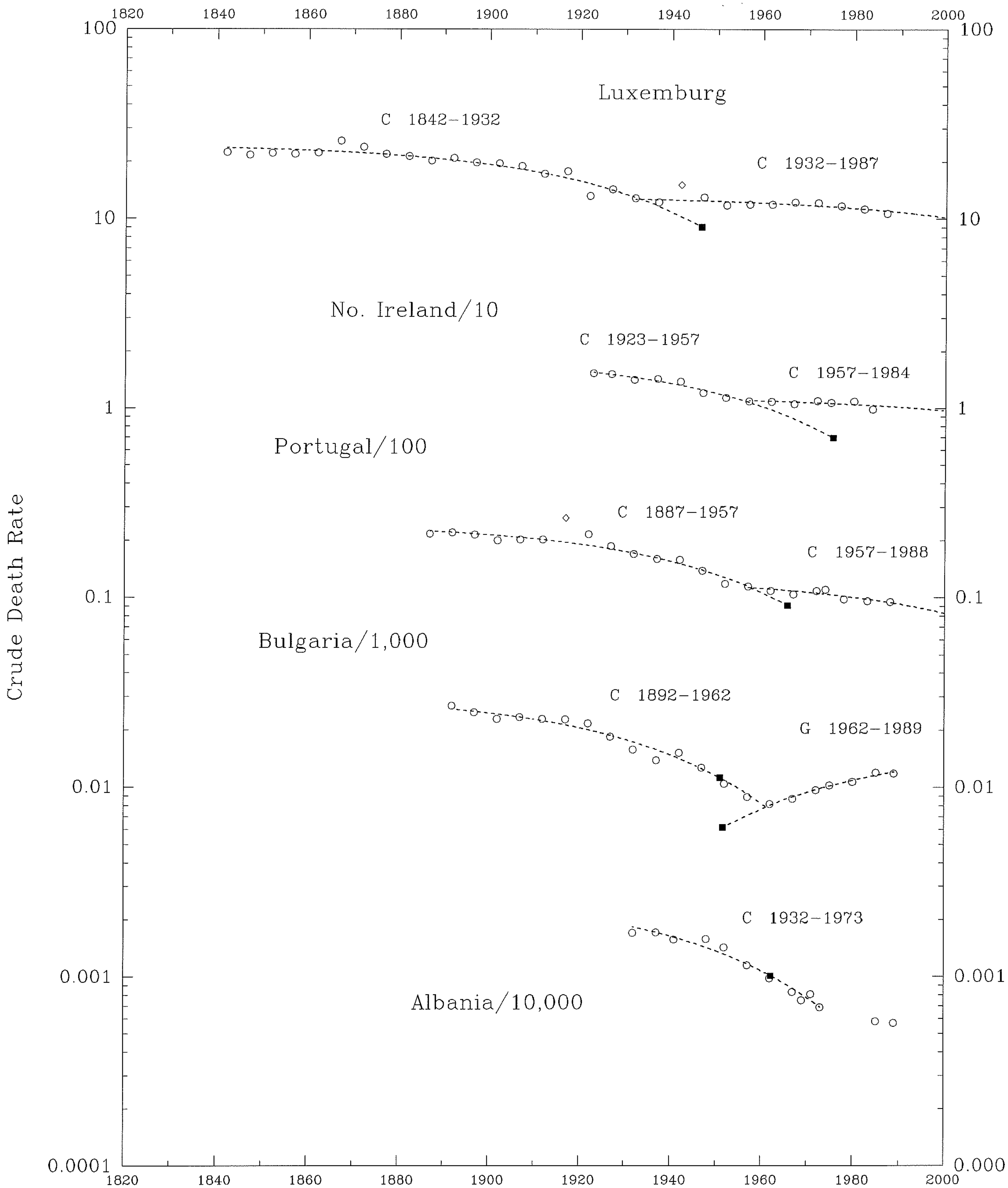
Crude Death Rates in Selected Populations:
More Cases from Northern Europe



For 'MHBG' and 'BLDO' see text.
Sources: Chesnais 1992, 555–78; notes 3 and 4.

Figure 2.1e

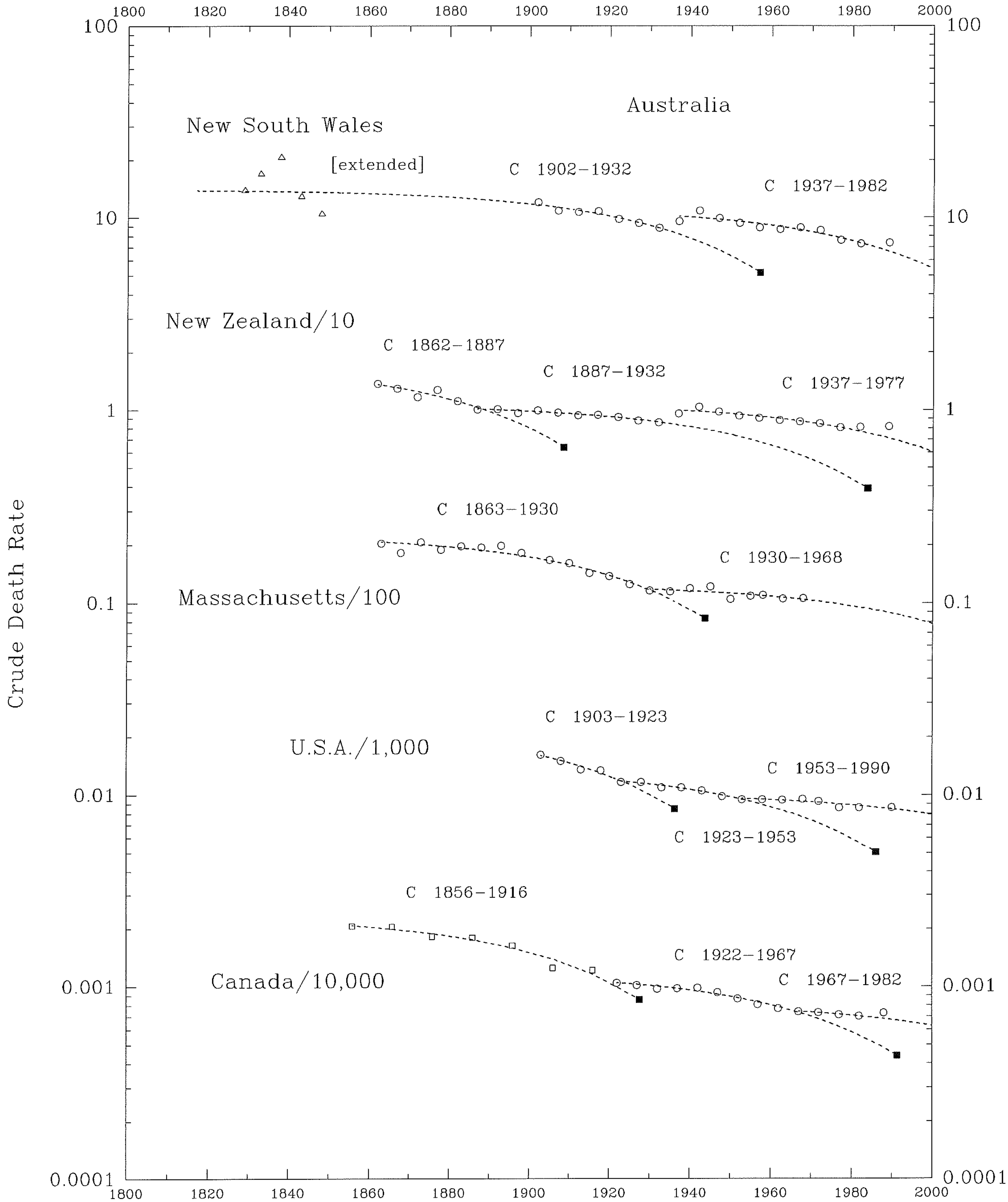
Crude Death Rates in Selected Populations:
Other Cases from Western and Eastern Europe



Sources: Chesnais 1992, 555–78; notes 3 and 4.

Figure 2.1f

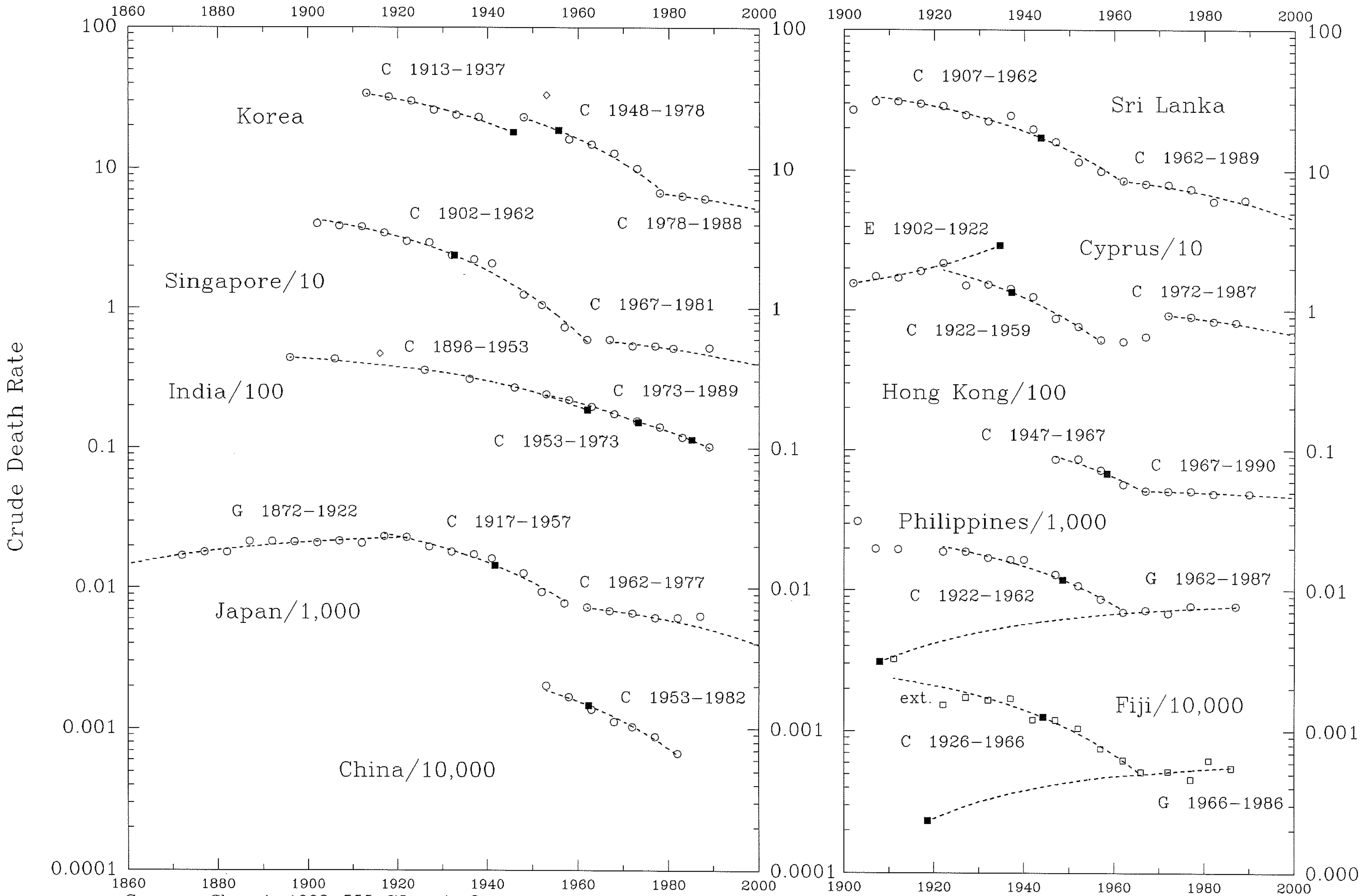
Crude Death Rates in Selected Populations: Mostly European Former British Colonies



Sources: Chesnais 555–78: note 3.

Figure 2.1g

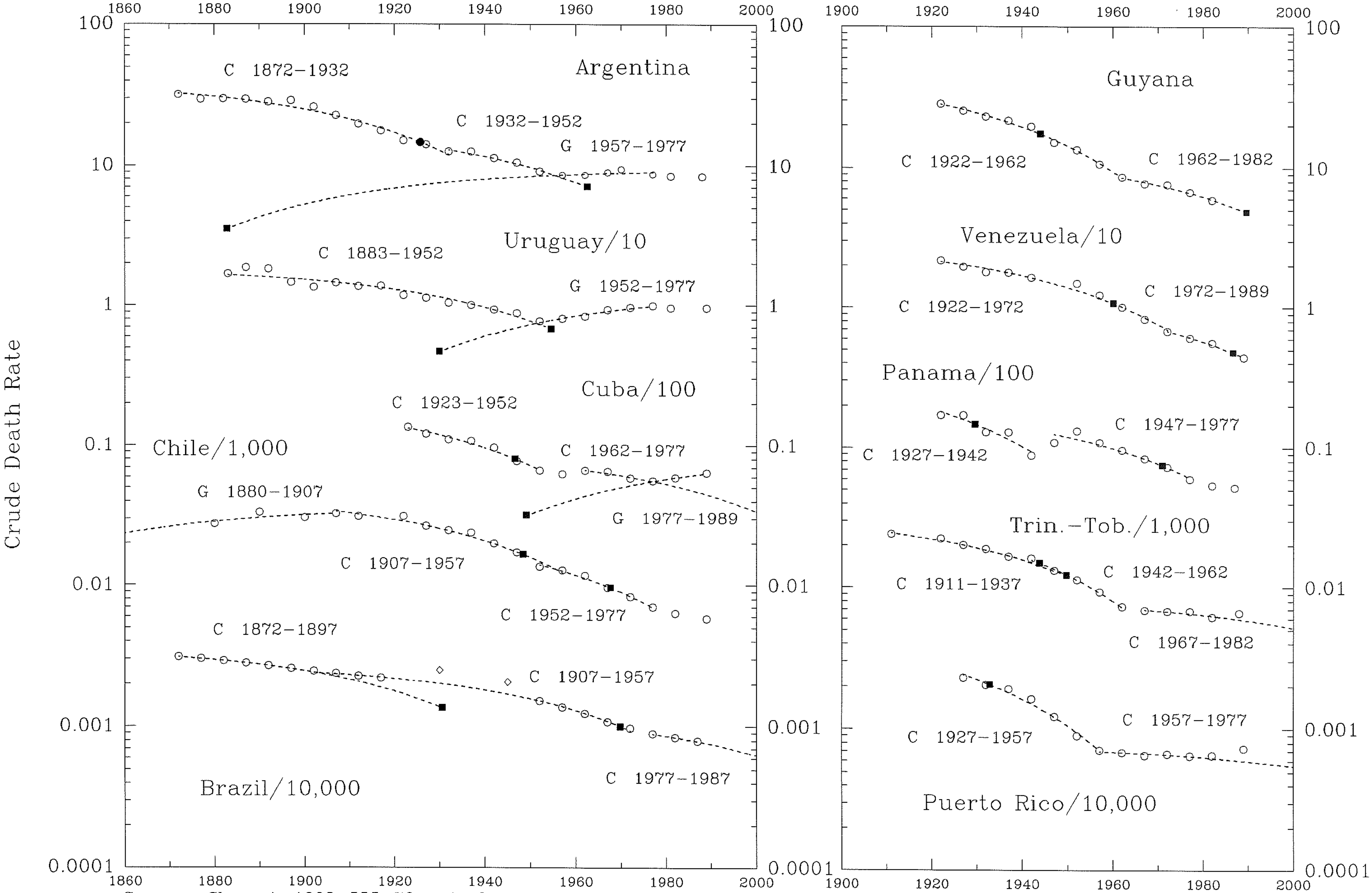
Crude Death Rates in Selected Populations: Examples from Asia and Oceania



Sources: Chenais 1992, 555–78; note 3.

Figure 2.1h

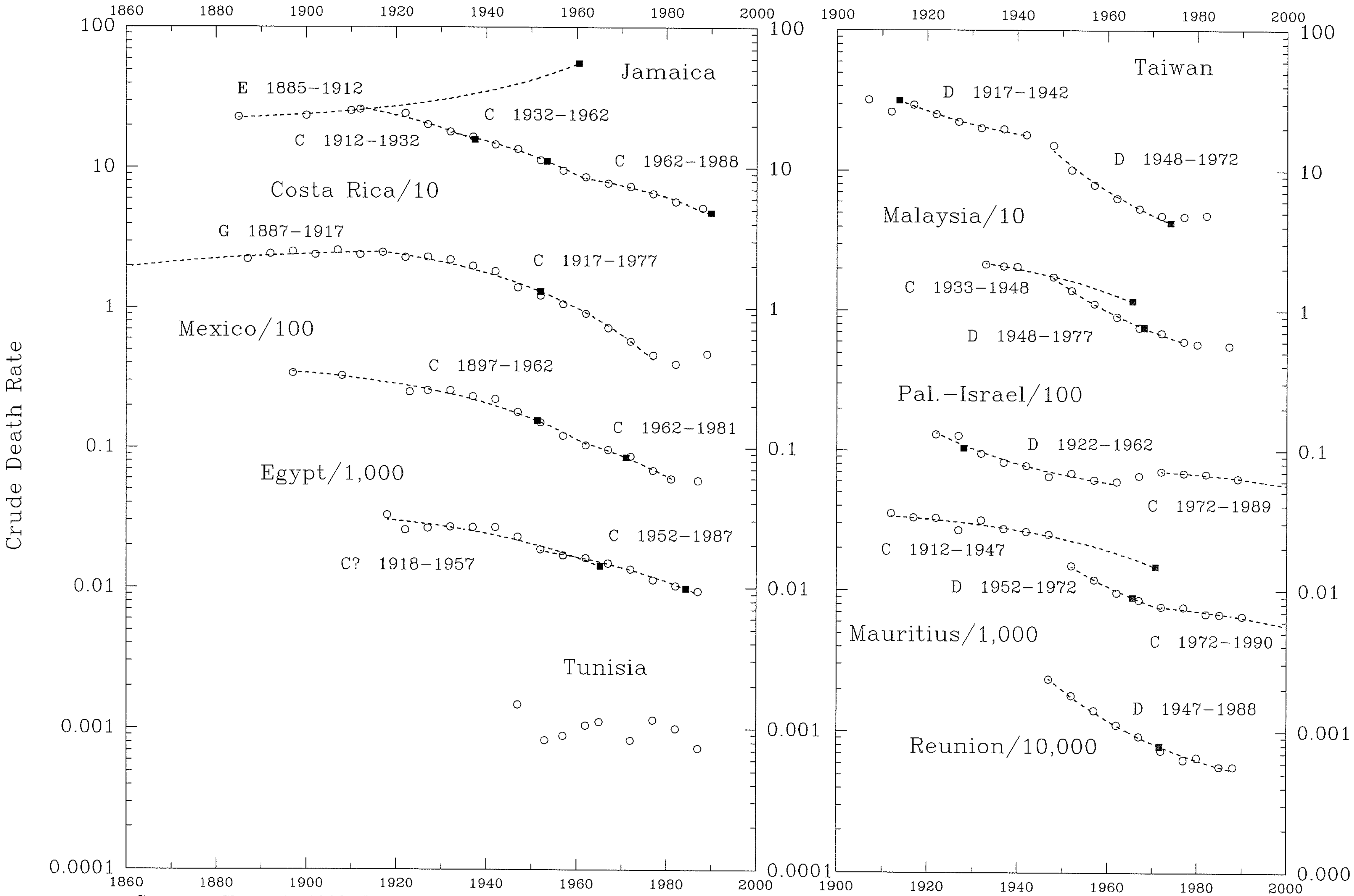
Crude Death Rates in Selected Populations:
Examples from the Caribbean and Central and South America



Sources: Chesnais 1992, 555–78; note 3.

Figure 2.1i

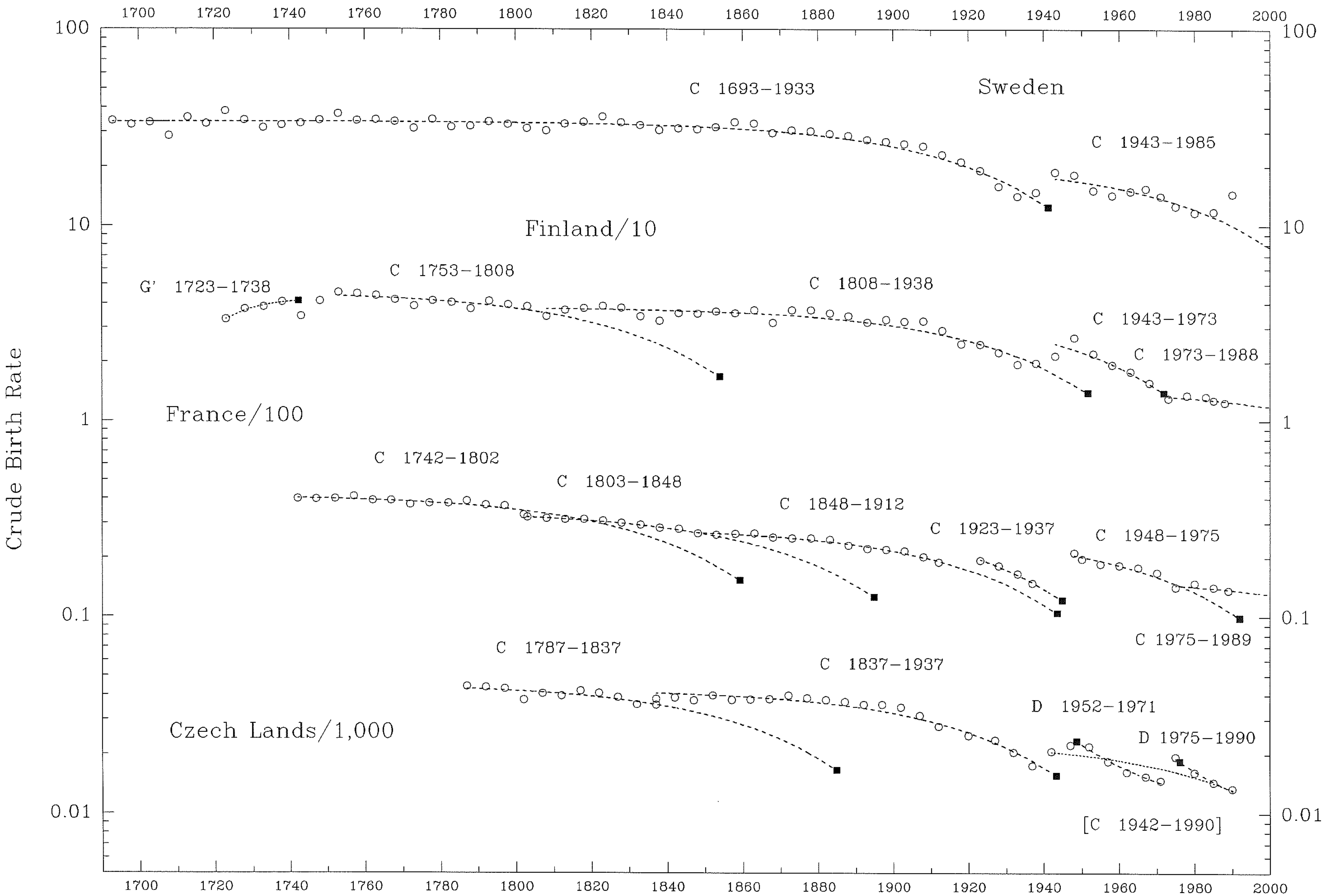
Crude Death Rates in Selected Populations: Other Non-European Cases



Sources: Chesnais 1992, 555–78; note 3.

Figure 2.2a

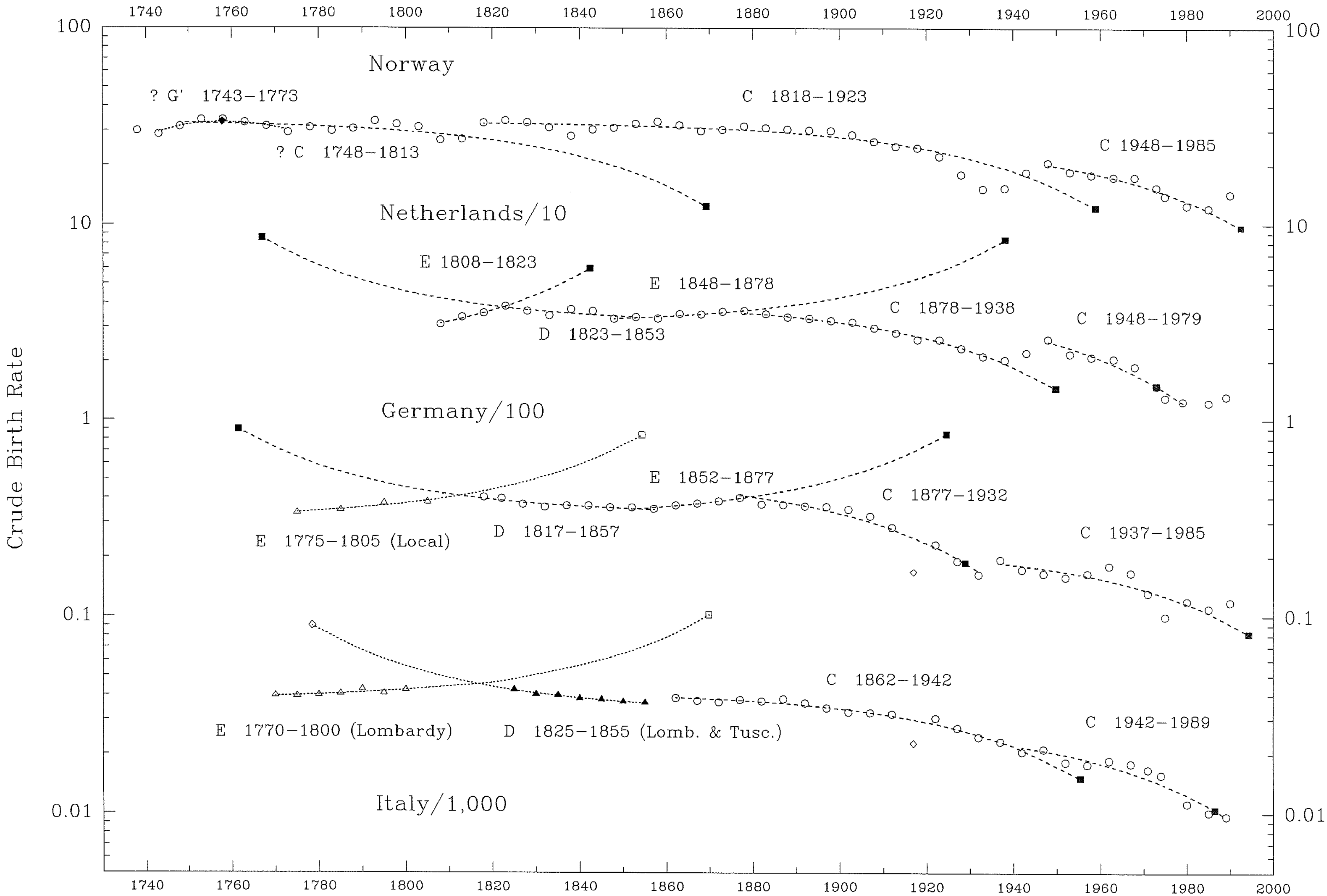
Crude Birth Rates in Selected Populations: European Countries Generally Having Just Accelerating C Declines



Sources: Chesnais 1992, 517–41; notes 3 and 4; text.

Figure 2.2b

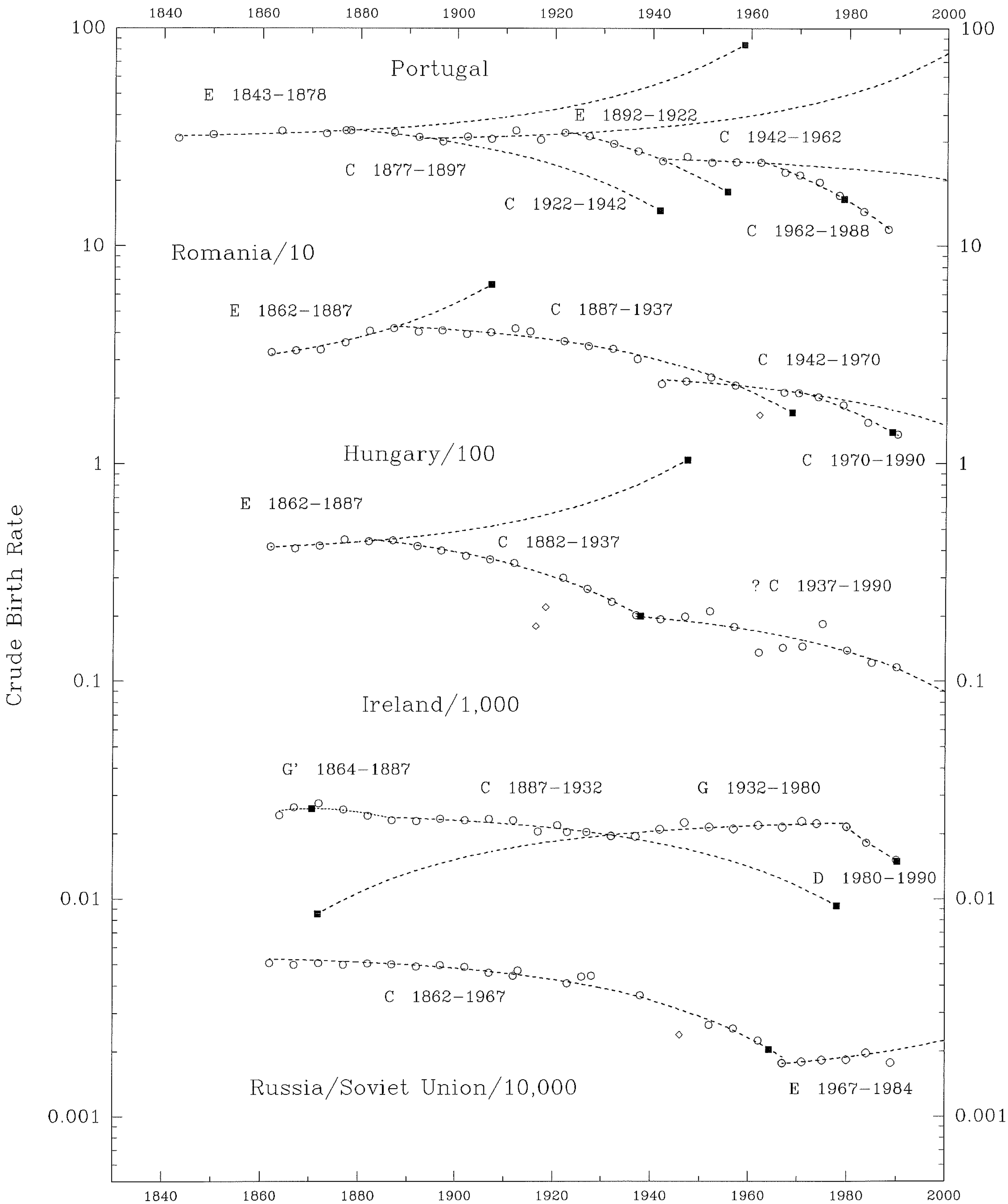
Crude Birth Rates in Selected Populations:
Norway and Some European Cases with E–Type Increases



Sources: Chesnais 1992, 517–41; notes 3 and 4; text.

Figure 2.2c

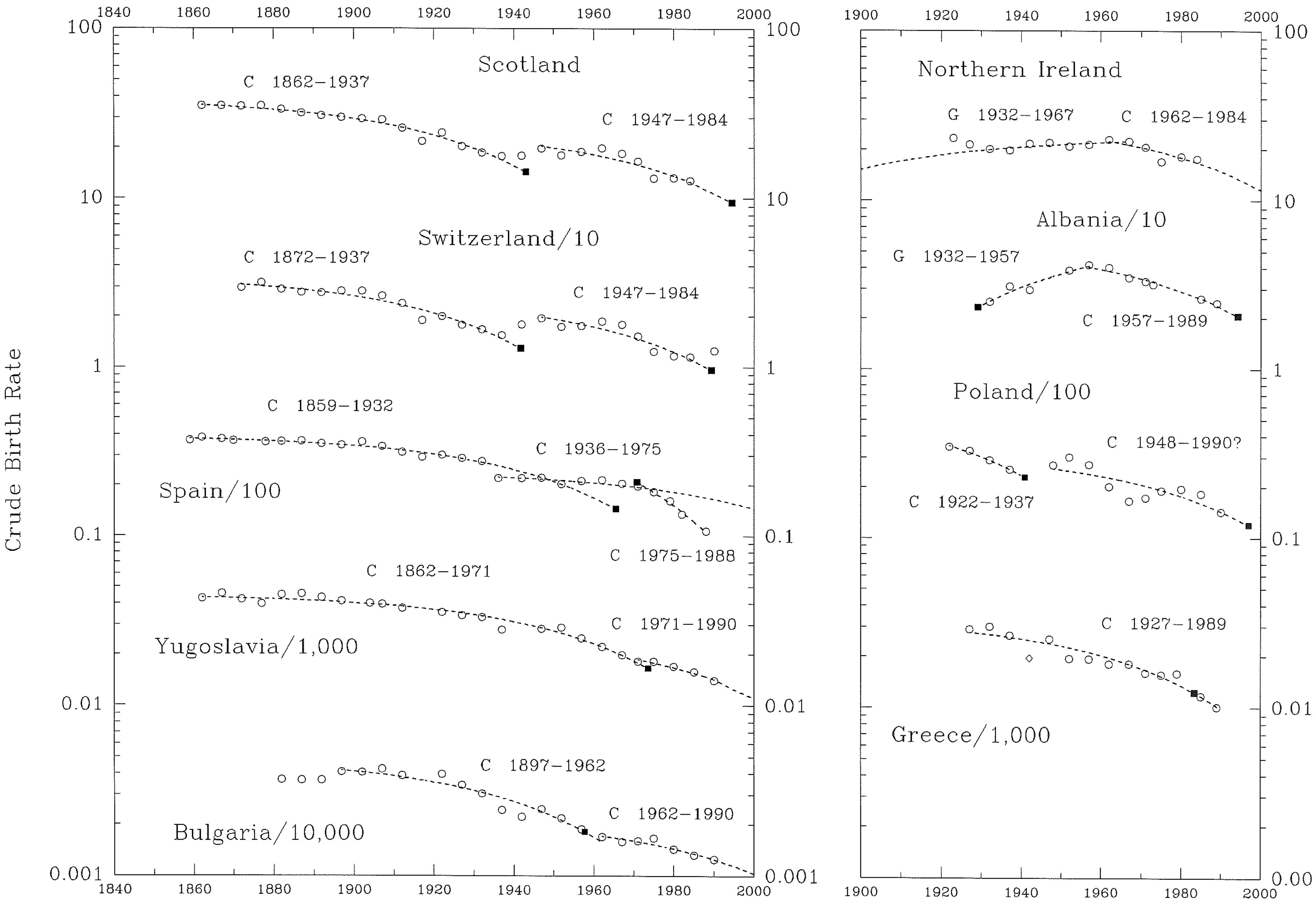
Crude Birth Rates in Selected Populations: European Examples of Other Sequences in Trends



Sources: Chesnais 1992, 517–541; notes 3 and 4; text.

Figure 2.2d

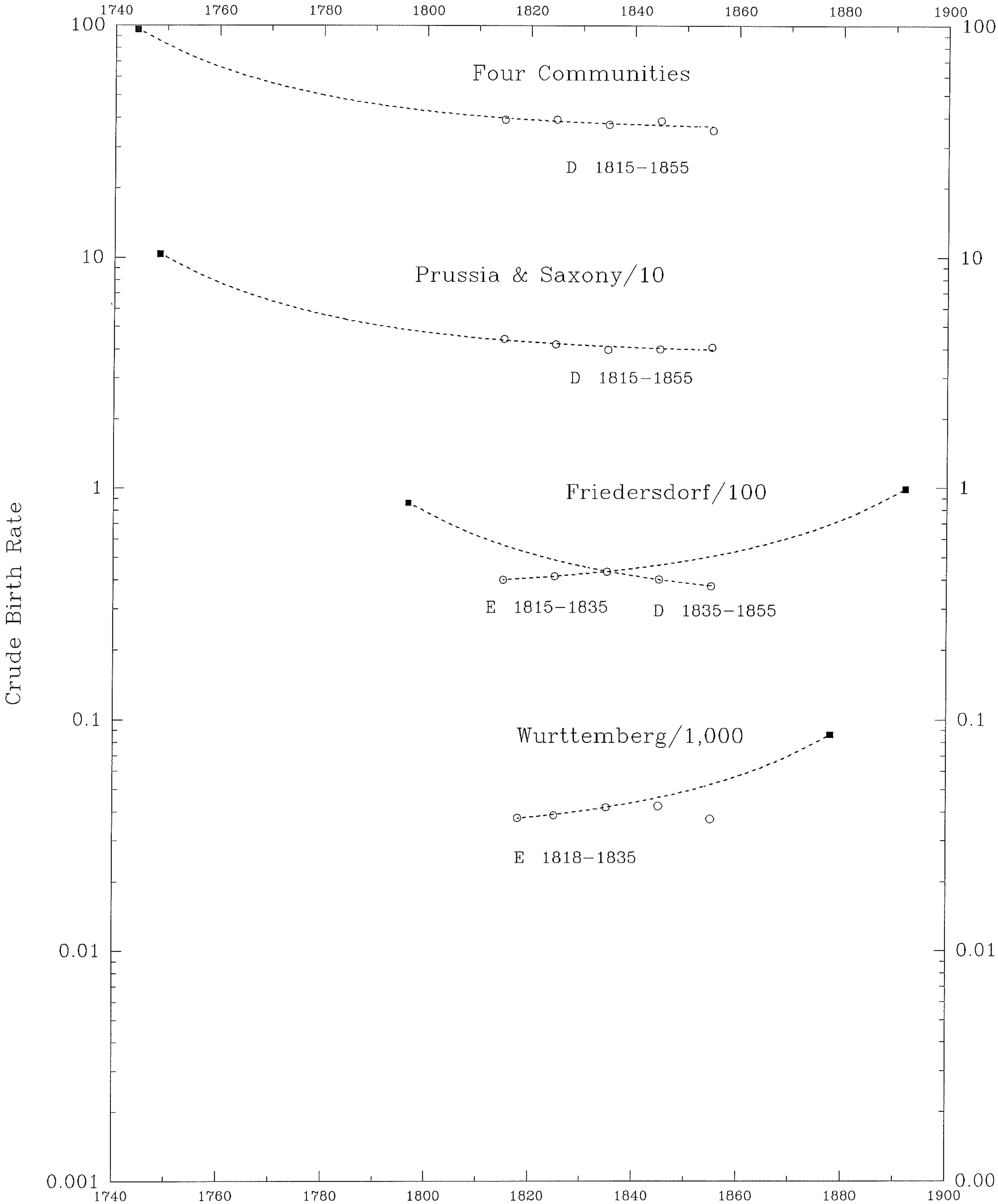
Crude Birth Rates in Selected Populations:
Other European with Mostly Recent Data



Sources: Chesnais 1992, 517–41; notes 3 and 4; text.

Figure 2.2e

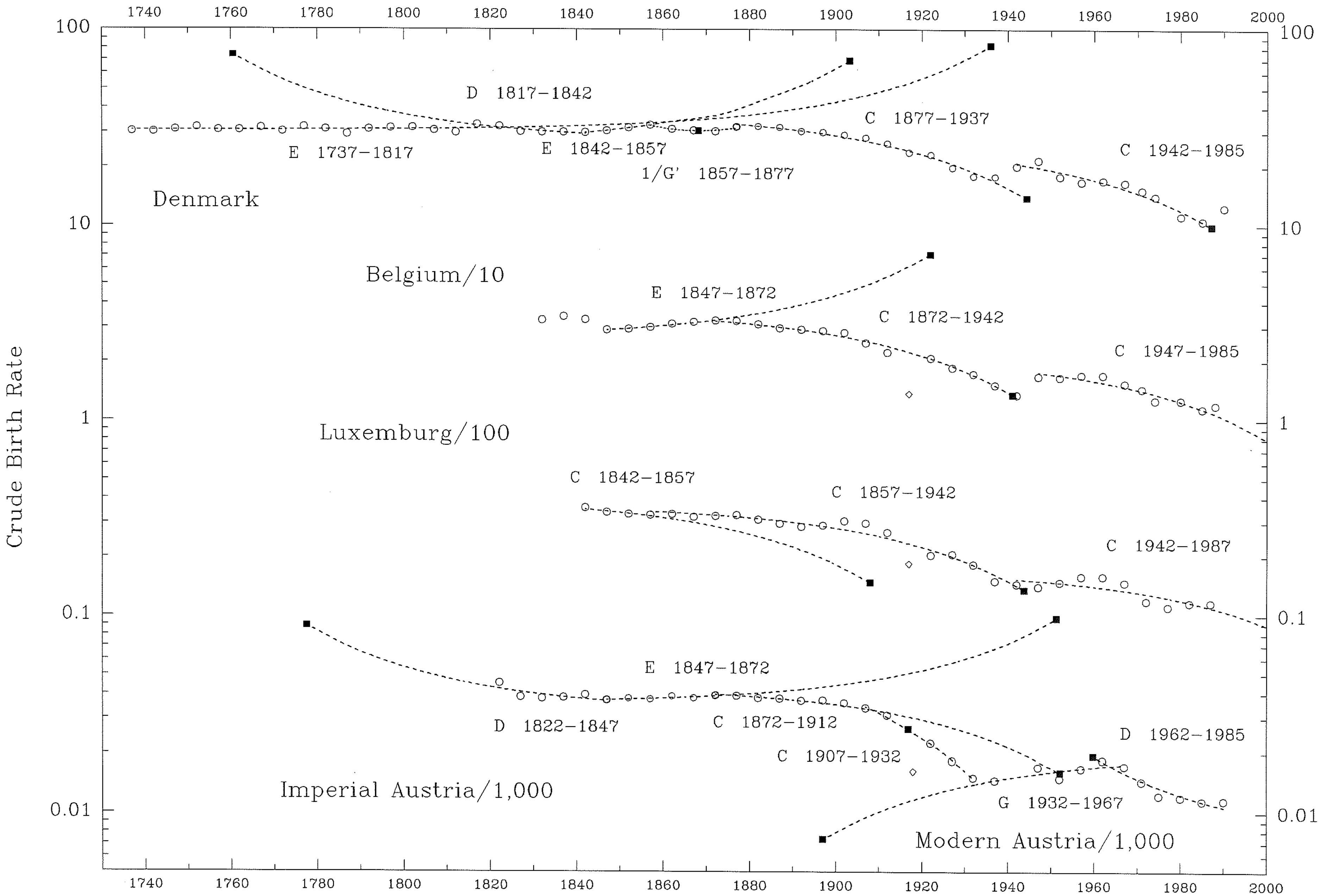
Crude Birth Rates in Selected Populations:
Early German Local Evidence



Source: W. R. Lee 1979, 181.

Figure 2.2f

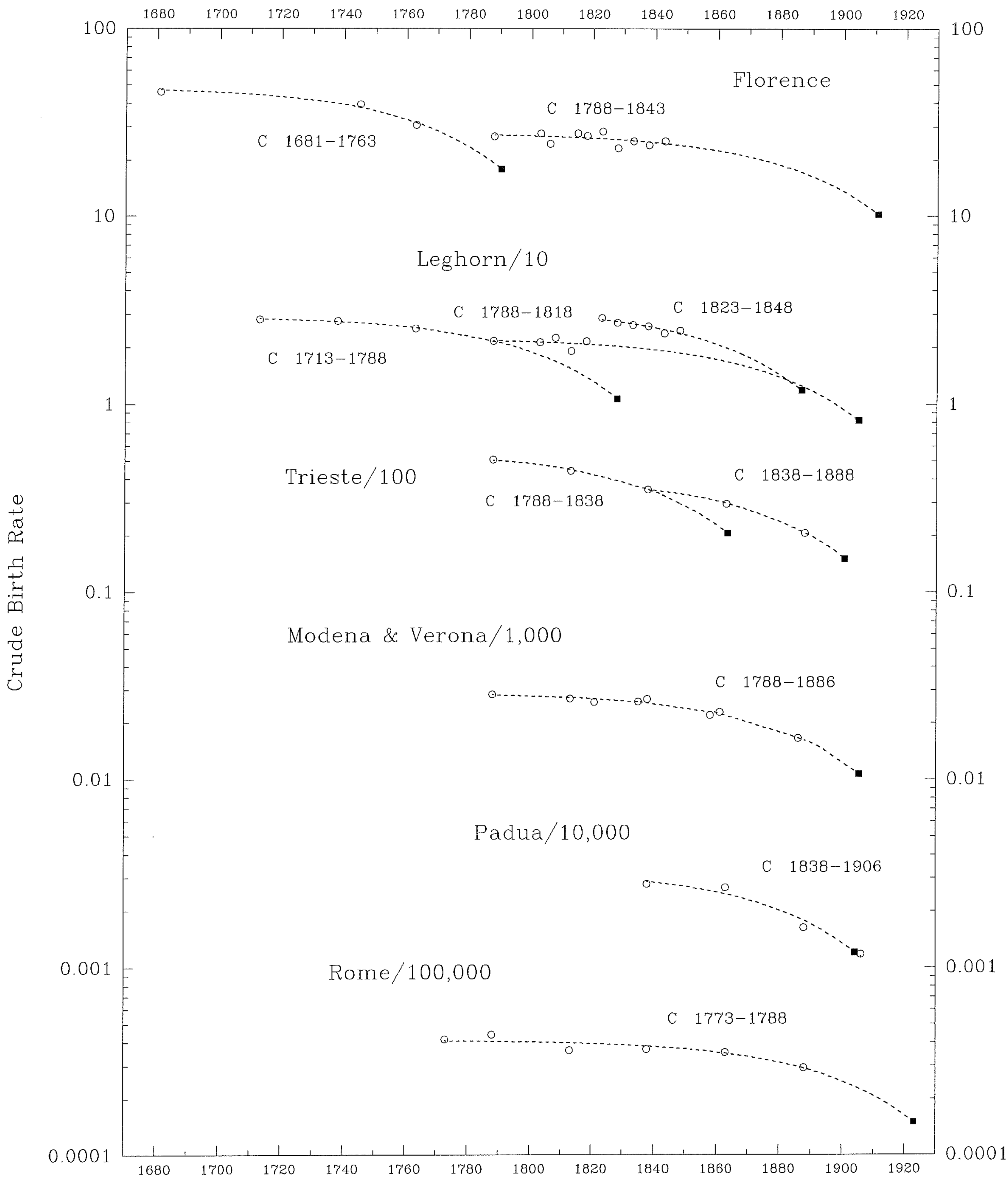
Crude Birth Rates in Selected Populations: Various Other European Cases



Sources: Chesnais 1992, 517–41; notes 3 and 4; text.

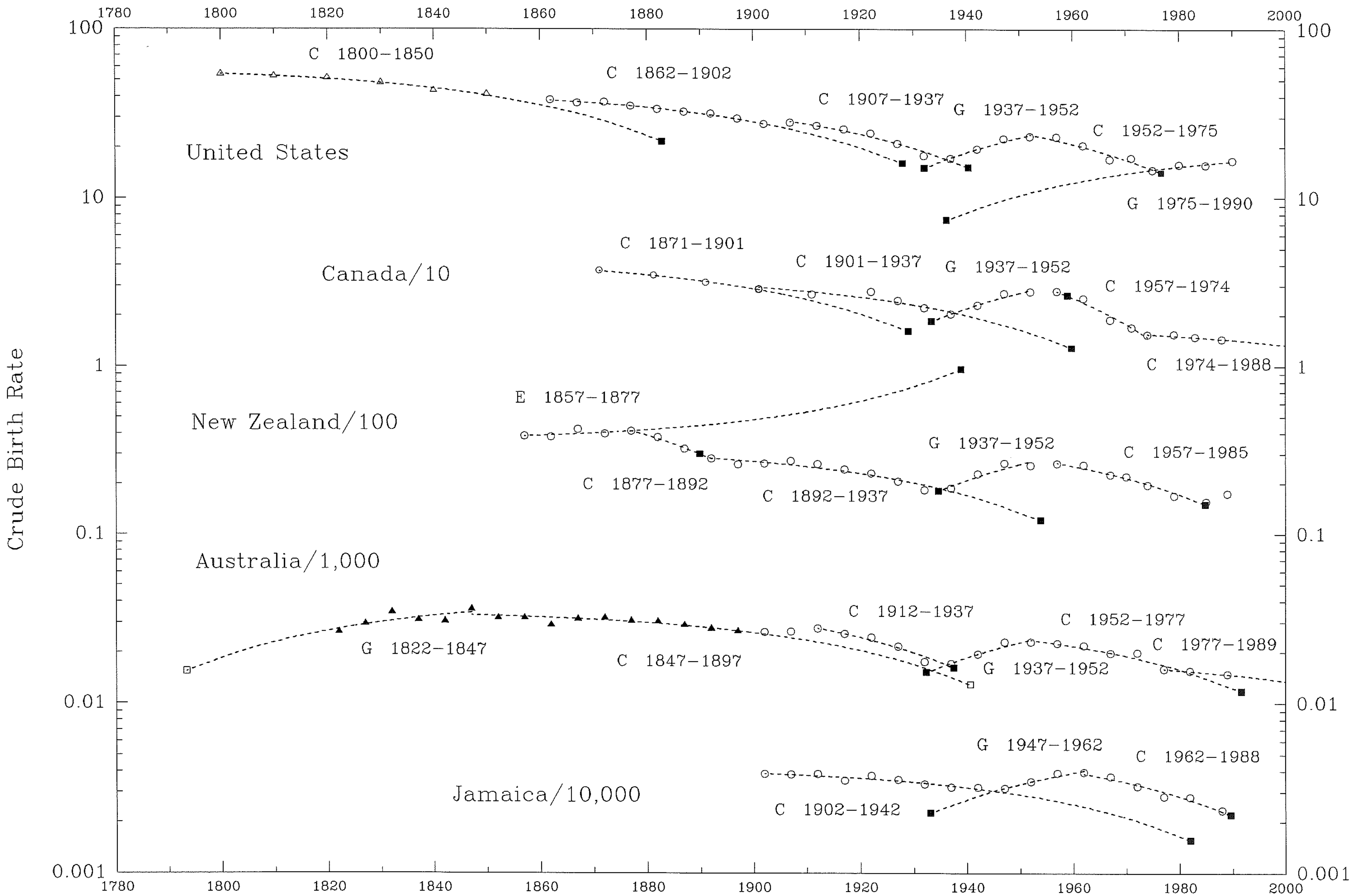
Figure 2.2g

Crude Birth Rates in Selected Populations: Italian Jewish Communities



Source: Livi-Bacci 1977, 42.

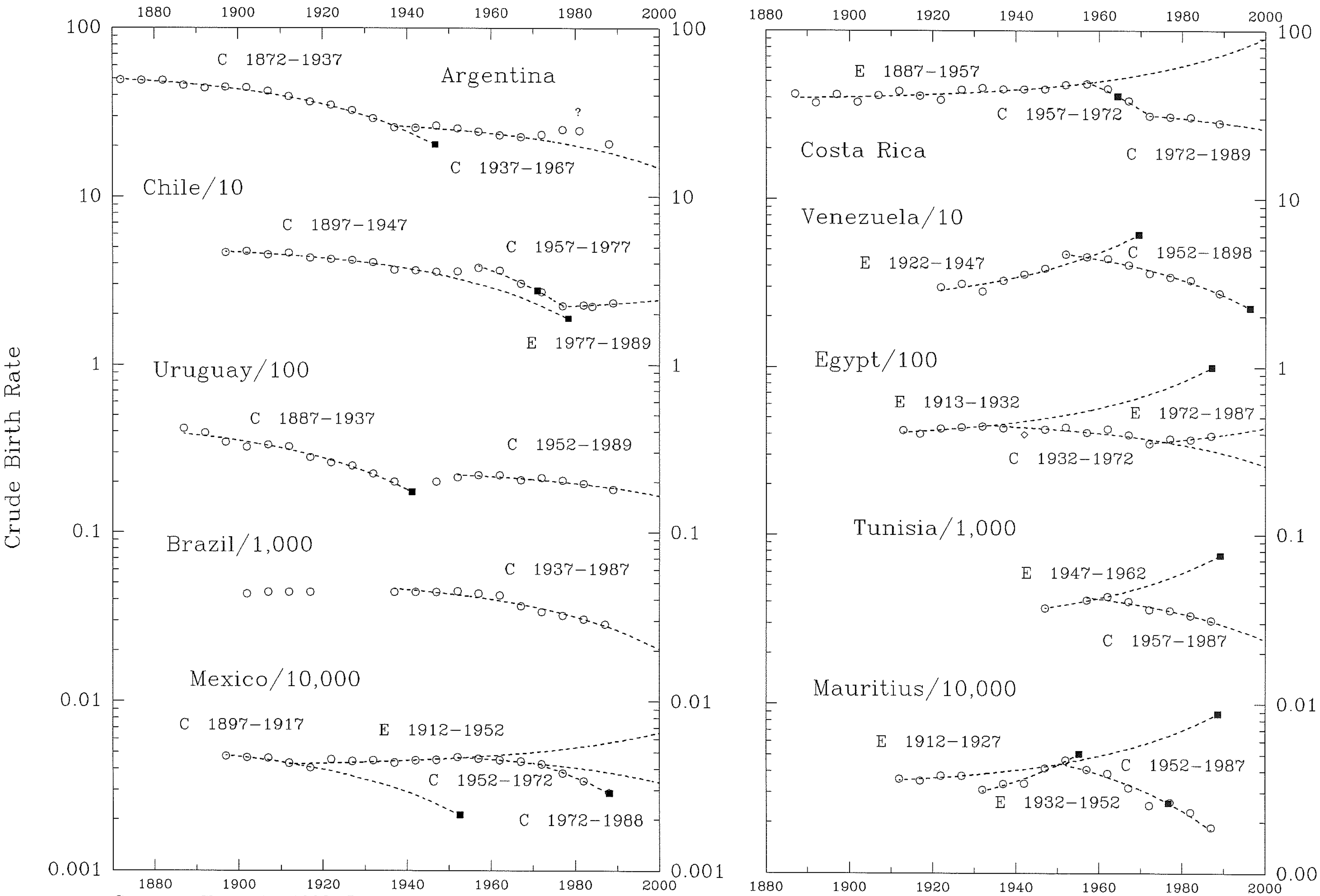
Figure 2.2h
Crude Birth Rates in Selected Populations:
British Colonizations with Extended Post–W.W. II Baby Booms



Sources: Chenais 1992, 517–41; notes 3 and 4; text.

Figure 2.2i

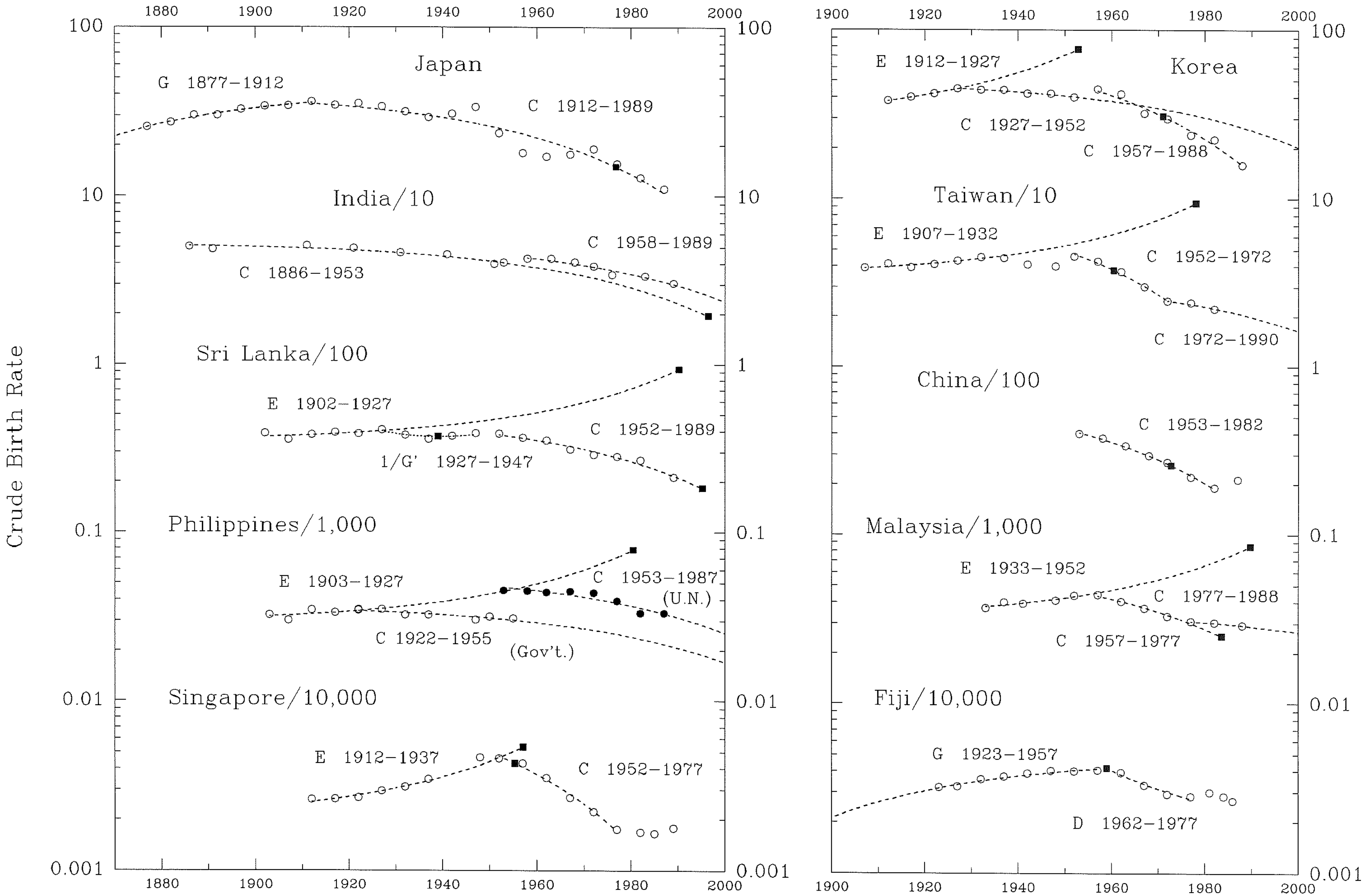
Crude Birth Rates in Selected Populations: Examples from Latin America and Africa



Sources: Chesnais, 1992, 517–41; notes 3 and 4; text.

Figure 2.2j

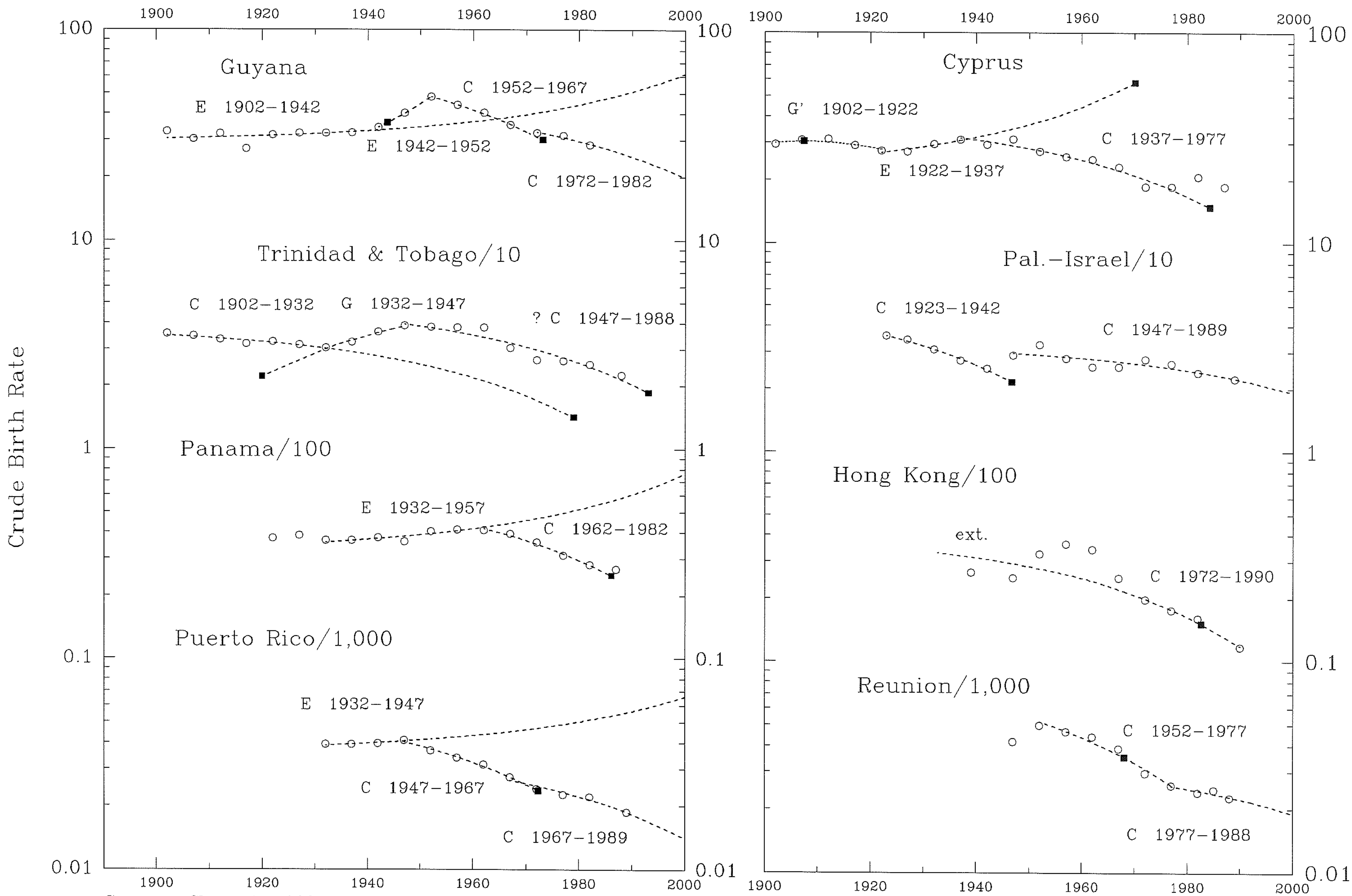
Crude Birth Rates in Selected Populations: Examples from Asia and Oceania



Sources: Chesnais 1992, 517–41; notes 3 and 4; text.

Figure 2.2k

Crude Birth Rates in Selected Populations:
Other Cases Outside Europe



Sources: Chesnais 1992, 517–41; notes 3 and 4; text.

Table 2.1a

Trends for Crude Death Rates in Selected Countries: Europe

A. Countries with Sustained G Increases since World War II

A-1: Late 19th and Early 20th Century C Decline Culminated in Interwar Years

1) England	2) Scotland	3) Norway	4) Sweden	5) Denmark
1566-1681 E 1722				
1681-1731 /G' 1704			1693-1743 /G' 1716	
1731-1761 /G' 1752		1743-1773 /G' 1760?		1737-1762 /G' 1747
1736-1831 C 1880		1738-1823 C 1860	1743-1843 C 1881	1757-1817 C 1846
1831-1923 C 1936	1857-1922 C 1943	1823-1933 C 1948	1843-1923 C 1941	1817-1922 C 1935
1923-1948 C 2030	1922-1957 C 2008	1933-1958 C 1987	1923-1953 C 1983	1922-1952 C 1981
1948-1978 G 1848	1962-1984 G 1860	1958-1990 G 1918	1958-1990 G 1912	1957-1974 G 1913
1973-1990 C 2044				1974-1990 G 1944

A-1 (cont.): Eastern Countries with Higher CDR's

A-2: Strong C Decline through mid-1900s

10) Czech Lands	11) Hungary	12) Yugoslavia	13) Finland	14) Russia
1787-1812 /G' 1767			1723-1763 /G' 1724	
			1763-1878 C 1929	
1817-1932 C 1939	1887-1932 C 1934	1862-1937 C 1944	1873-1953 C 1959	1867-1957 C 1938
1942-1957 C 1952	1932-1957 C 1966	1937-1962 C 1962		
1962-1980 G 1944	1962-1988 G 1949	1967-1990 G 1887	1958-1988 G 1882	1962-1984 G 1959

B. Countries with Nothing But C Declines in Modern Times

B-1: 19th to 20th Century C's Culminated Interwar

B-2: Strong C Decline through Mid-1900s

19) Belgium	20) Luxemburg	21) Austria	22) Ireland	23) No. Ireland
			1864-1877 E 1907	
			1877-1921 C 1964	
1815-1922 C 1935	1842-1932 C 1947	1832-1932 C 1934	1921-1957 C 1997	1923-1957 C 1976
1922-1988 C 2038	1932-1987 C 2046	1932-1990 C 2043	1957-1984 C 2006	1957-1984 C 2059

For groupings, see Table 2.2 and its discussion.

Sources: Figures 2.1a through 2.1e; Chesnais 1992, 555-78; notes 3 and 4 cite supplements.

Table 2.1a (cont.)

Trends for Crude Death Rates in Selected Countries: Europe

6) Netherlands	7) Germany	8) Local German	9) Switzerland
	1755-1795 /G' 1772[a]		
		1755-1795 C 1816[b]	
	1795-1845 C 1906[a]	1805-1845 C 1894[b]	
1808-1913 C 1919	1827-1862 C 1938	1815-1855 C 1960[c]	
1913-1937 C 1945	1867-1932 C 1929		1872-1932 C 1930
			1922-1957 C 1991
			1957-1975 C 2016
1953-1990 G 1899	1952-1975 G 1902		1975-1990 G 1917
	1971-1990 C 2051		

15) Poland	16) Romania	17) Bulgaria	18) Greece
1922-1962 C 1955	1872-1962 C 1951	1892-1962 C 1951	1862-1947 C 1965
1967-1990 G 1952	1962-1990 G 1929	1962-1989 G 1952	1952-1989 G 1923

24) France	25) Italy	26) Spain	27) Portugal	28) Albania
1752-1827 C 1853	1770-1815 G 1715[d]			
1828-1912 C 1951	1820-1912 C 1935[e]			
1912-1959 C 1974	1912-1952 C 1955	1867-1957 C 1946	1887-1957 C 1966	1932-1973 C 1962
1959-1989 C 2030	1952-1989 C 2080	1957-1982 C 2015	1957-1988 C 2028	

[a] Lee: Böringen, Durlach, Landsberg, Oldenburg.
[b] Lee: Mulsum, Hochdorf, Besenfeld, Göttelfingen.
[c] Lee: Württemberg, Baden, Prussia, Saxony, Bavaria.
[d] Cippola: Lombardy.
[e] To 1860s, Cippola: Lombardy and Tuscany.

Table 2.1b

Trends for Crude Death Rates in Selected Countries: Outside Europe

B. Countries with Only C Declines in Modern Times

B-1: Late 19th and Early 20th Century C Decline Culminated in Interwar Years

29) U.S.A.	30) Massachusetts	31) Canada	32) Australia	33) New Zealand
				1862-1887 C 1909
1903-1923 C 1936	1863-1930 C 1944	1856-1916 C 1928	1902-1932 C 1957	1837-1932 C 1984
1923-1953 C 1986				
1952-1990 C 2045	1930-1968 C 2025	1922-1967 C 1991		
		1967-1982 C 2043		

B-2: Strong C Decline through Middle of 20th Century

37) Japan	38) Singapore	39) Hong Kong	40) Sri Lanka	41) Cyprus
1872-1922 G 1839				1902-1922 E 1935
1917-1957 C 1942	1902-1962 C 1933	1947-1967 C 1958	1907-1962 C 1944	1922-1957 C 1937
1962-1977 C 2004	1967-1981 C 2014	1967-1990 C 2061	1962-1989 C 2003	1972-1987 C 2020

46) Puerto Rico	47) Mexico	48) Costa Rica	49) Guyana	50) Venezuela
		1887-1917 G 1821		
1927-1957 C 1933	1897-1962 C 1951	1917-1977 C 1952	1922-1962 C 1944	1922-1972 C 1960
1952-1977 C 2037	1962-1981 C 1971		1962-1982 C 1990	1972-1989 C 1987

C. D Decline in Lieu of C

53) Pal./Israel	54) Taiwan	55) Malaysia	56) Mauritius	57) Reunion
	1917-1942 D 1914	1933-1948 C 1965		
1922-1962 D 1928	1948-1972 D 1974	1948-1977 D 1968	1952-1972 D 1966	1947-1988 D 1972
1972-1989 C 2030			1972-1990 C 2019	

A. Countries with Sustained G Increases since World War II

A-1: 19th/20th Century C Ends Early — A-2: Early C Decline Lasts Later

58) Argentina	59) Uruguay	60) Cuba	61) Philippines
1872-1932 C 1926	1883-1952 C 1955	1923-1952 C 1947	1922-1962 C 1949
1932-1952 C 1962		1962-1977 C 2000	
1957-1977 G 1883	1952-1977 G 1930	1977-1989 G 1949	1962-1987 G 1908

Sources: Figures 2.1f through 2.1i; Chesnais 1992, 555-78; notes 3 and 4 cite supplements.

Table 2.1b (cont)

Trends for Crude Death Rates in Selected Countries: Outside Europe

34) Panama

1927-1942	C	1930
1947-1977	C	1971

35) Jamaica

1885-1912	E	1961
1912-1932	C	1937
1932-1962	C	1953
1962-1988	C	1990

36) Trin. & Tobago

1911-1937	C	1950
1942-1962	C	1944
1967-1982	C	2025

42) Korea

1913-1947	C	1946
1948-1978	C	1956
1978-1988	C	2021

43) China

1953-1983	C	1962

44) India

1896-1953	C	1962
1953-1973	C	1973
1973-1989	C	1985

45) Egypt

1918-1957	C?	1965
1952-1987	C	1984

51) Brazil

1872-1897	C	1931
1902-1972	C	1970
1977-1987	C	2013

52) Chile

1880-1907	G	1833
1907-1957	C	1948
1962-1977	C	1968

62) Fiji

1926-1966	C	1944
1966-1986	G	1919

Table 2.2

Groupings of National Changes in Crude Death Rates by Sequences of Trends and Timing of Early-20th-Century C's

A. C Declines Followed by G Increases since World War II

1) Late 19th-early 20th century C decline ending by World War II:

England	Argentina
Scotland	
Norway	
Sweden	
Denmark	
Netherlands	
Germany	
Switzerland	
Czech Lands	
Hungary	
Yugoslavia	

2) This C decline lasted through middle of 20th century:

Finland	Uruguay	Philippines
Russia	Cuba	Fiji
Poland		
Romania		
Bulgaria		
Greece		

B. Nothing But C Declines in Modern Times

1) Late 19th-early 20th century C decline ending by World War II:

Belgium	Canada	Australia
Luxemburg	U.S.A.	New Zealand
Austria	Panama	
	Jamaica	
	Trin. & Tob.	

2) This C decline lasted through middle of 20th century:

Ireland	Chile	Japan	Egypt
No. Ireland	Brazil	Korea	
France	Guyana	China	
Italy	Venezuela	Hong Kong	
Spain	Costa Rica	Singapore	
Portugal	Mexico	Sri Lanka	
Albania	Puerto Rico	India	
		Cyprus	

C. <u>No G Increases, but Some D Decline in Lieu of C</u>

Pal./Israel	Mauritius
Taiwan	Reunion
Malaysia	

Tunisia cannot be classified.

Sources: Tables 2.1a and 2.1b.

Table 2.3a

Trends for Crude Birth Rates: In European Populations

A-1: <u>E and D Followed by C's</u>

1) England	2) Scotland?	3) Denmark	4) Netherlands	5) Belgium
1556-1661 C 1710				
1656-1751 G 1602				
1726-1816 E 1862		1737-1817 E 1936	1808-1823 E 1842	
1816-1846 D 1779		1817-1842 D 1760	1823-1853 D 1767	
		1842-1857 E 1903	1848-1878 E 1938	1847-1872 E 1922
		1857-1877/G'1868		
1851-1933 C 1933	1862-1937 C 1943	1877-1937 C 1944	1878-1938 C 1950	1872-1942 C 1941
1933-1990 C 2032	1947-1984 C 1995	1942-1985 C 1987	1948-1979 C 1973	1947-1985 C 2001

A-2 & 3: <u>Later E-C Sequences</u>			A-4: <u>Recent E</u>		C: <u>Recent G Increase</u>
11) Hungary	12) Portugal	13) Romania	14) Russia/S.U.	*	15) Ireland
				*	
				*	
				*	
				*	
	1843-1878 E 1959			*	
	1877-1897 C 1942			*	
1862-1887 E 1947	1892-1922 E 2002	1862-1887 E 1907		*	1864-1887 G'1871
1882-1937 C 1938	1922-1942 C 1955	1887-1937 C 1969	1862-1967 C 1964	*	1887-1932 C 1978
1937-1990 C 2002	1942-1962 C 2045#	1942-1970 C 2018#	1967-1984 E 2031	*	1932-1980 G 1872
	1962-1988 C 1979	1970-1990 C 1898		*	1980-1990 D 1990

B (cont.): <u>Only Accelerating C Decline</u>

20) Sweden	21) Norway	22) Finland	23) France	24) Luxemburg
	1743-1773 G'1758?	1723-1738 G'1742		
	1748-1813 C 1869	1753-1808 C 1854	1742-1802 C 1859	
			1802-1848 C 1895	1842-1857 C 1908
			1848-1912 C 1944	
1693-1933 C 1941	1818-1923 C 1959	1808-1938 C 1952	1923-1937 C 1945	1857-1942 C 1944
1943-1985 C 2001	1948-1985 C 1992	1943-1973 C 1972	1948-1975 C 1992	1942-1987 C 2014
		1973-1988 C 2051	1975-1989 C 2054	

\# Following C dated earlier, is retroactive.
[a] Lee: 5 localities from Black Forest to North Sea.
[b] Lee: 4 of these localities without Durlach; similar pattern for Saxony and Prussia 1815-1855 and Friedersdorf 1835-1855.
[c] Cippola: Lombardy.
[d] Cippola: Lombardy and Tuscany, averaged.

Sources: Figures 2.2a through 2.2g; Chesnais 1992, 517-41; Livi-Bacci 1977, 42; notes 3 and 4.

Table 2.3a (cont.)

Trends for Crude Birth Rates: In European Populations

6) National German	7) Local German	8) Switzerland?	9) Imperial Austria	10) Italy
	1775-1805 E 1854[a]			1770-1800 E 1870[c]
1817-1857 D 1761	1815-1855 D 1744[b]		1822-1847 D 1778	1825-1855 D 1778[d]
1852-1877 E 1925			1847-1872 E 1951	
1877-1932 C 1929		1872-1937 C 1942	1872-1912 C 1952	1862-1942 C 1955
1937-1985 C 1994		1947-1984 C 1989		1942-1989 C 1986

B: <u>Only C Decline</u>

16) No. Ireland	17) Modern Austria	18) Albania	*	30) Greece	19) Italian Jews
			*		
			*		1681-1763 C 1790[e]
			*		1713-1788 C 1828[f]
			*		1788-1843 C 1911[e]
			*		1788-1818 C 1905[f]
			*		1823-1848 C 1886[f]
			*		1838-1888 C 1901[g]
	1908-1932 C 1917		*		1788-1886 C 1905[h]
1932-1967 G 1873	1932-1967 G 1897	1932-1957 G 1929	*		1839-1906 C 1904[i]
1962-1984 C 2001	1962-1985 D 1960	1957-1989 C 1994	*	1927-1989 C 1983	1773-1888 C 1923[j]

25) Spain	26) Czech Lands	27) Poland?	28) Bulgaria	29) Yugoslavia
	1787-1837 C 1885			
1859-1932 C 1966	1837-1937 C 1943	1922-1937 C 1941	1897-1962 C 1958	1862-1971 C 1974
1936-1975 C 2024#	1942-1990 C 2008?	1948-1990 C 1997	1962-1990 C 2010	1971-1990 C 2006
1975-1988 C 1971	1952-1971 D 1949			
	1975-1990 D 1976			

[e] Livi-Bacci: Florence.
[f] Livi-Bacci: Leghorn.
[g] Livi-Bacci: Trieste
[h] Livi-Bacci: Modena and Verona, averaged.
[i] Livi-Bacci: Padua.
[j] Livi-Bacci: Rome.

Table 2.3b

Trends for Crude Birth Rates: In Populations Outside Europe

A-3: <u>G-C Sequence</u>	A-4: <u>Later E-C Sequences in Asia</u>			
31) Japan	32) Singapore	33) Taiwan	34) China	35) Hong Kong
1877-1912 G 1855	1912-1937 E 1957	1907-1932 E 1978		boomlet
1912-1989 C 1977	1952-1977 C 1955	1952-1972 C 1960	1953-1982 C 1973	1972-1990 C 1982
		1972-1982 C 2010?		

A-3: <u>Later E-C Sequences in Africa</u>				A-4: <u>Later E-C</u>
41) Reunion?	42) Mauritius	43) Egypt	44) Tunisia	45) Venezuela
	1912-1927 E 1989			
	1932-1952 E 1955	1913-1932 E 1987	1947-1962 E 1989	1922-1947 E 1969
1952-1977 C 1968	1952-1988 C 1977	1932-1972 C 2015	1957-1987 C 2008	1952-1989 C 1996
1977-1988 C 2016?		1972-1987 E 2033?		

B-3 or 4: <u>South American C Decline Only</u>				B-4: <u>Asian C Only</u>
51) Uruguay	52) Argentina	53) Chile?	54) Brazil	55) India
1887-1937 C 1941	1872-1937 C 1947	1897-1947 C 1978		1886-1953 C 1996
1952-1989 C 2033	1937-1967 C 2014	1957-1977 C 1971	1937-1987 C 2002	1958-1989 C 2006
	1967-1988 boomlet	1977-1989 E 2056?		

C-4: <u>Other Recent G Increases</u>		
61) Jamaica	62) Trinidad-Tob.	63) Fiji
1902-1942 C 1982	1902-1932 C 1979	
1947-1962 G 1933	1932-1947 G 1920	1923-1957 G 1893
1962-1988 C 1990	1947-1988 C 1993	1962-1977 D 1959

[k] Thompson and Whelpton, whites.
[l] Coale and Zelnick, whites.

Sources: Figures 2.2h through 2.2k; Chesnais 1992, 517-541; notes 3 and 4 cite supplements.

Table 2.3b (cont.)

Trends for Crude Birth Rates: In Populations Outside Europe

36) Korea/S. Korea	37) Cyprus	38) Philipines	39) Sri Lanka	40) Malaysia
	1902-1922 G'1907			
1912-1927 E 1953	1922-1937 E 1970	1903-1927 E 1980	1902-1927 E 1990	1932-1952 E 1990
1928-1953 C 2003#	1937-1977 C 1984	1922-1955 C 2009	1927-1947 1/G'	1957-1977 C 1984
1957-1988 C 1971		1953-1987 C 2007	1952-1989 C 1995	1977-1988 C 2042

Sequences in the Americas

46) Panama	47) Costa Rica	48) Mexico	49) Puerto Rico	50) Guyana
		1897-1917 C 1953		1902-1942 E 2010
1932-1957 E 2005	1887-1957 E 2005	1912-1952 E 2026	1932-1947 E 2016	1942-1952 E 1944
1962-1982 C 1986	1957-1972 C 1964	1952-1972 C 2027#	1947-1967 C 1972	1952-1967 C 1973
	1972-1989 C 2007	1972-1988 C 1988	1967-1989 C 2000	1972-1982 C 2004

C-1: Overseas British with Recent G Increases

56) Pal./Israel		57) United States	58) Canada	59) Australia	60) New Zealand
	*				
	*	1800-1850 C 1883[k]		1822-1847 G 1793	1857-1877 E 1939
	*	1862-1902 C 1928[l]	1871-1901 C 1929	1847-1897 C 1941	1877-1892 C 1889
1923-1942 C 1947	*	1907-1937 C 1940[l]	1901-1937 C 1960	1912-1937 C 1938	1892-1937 C 1954
1947-1989 C 2021	*	1937-1952 G 1932	1937-1952 G 1933	1937-1952 G 1932	1937-1952 G 1935
	*	1952-1975 C 1977	1957-1974 C 1959	1952-1977 C 1992	1957-1985 C 1985
	*	1975-1990 G 1936	1974-1988 C 2043	1977-1989 C 2037?	

Table 2.4

Groupings of National Changes in Crude Birth Rates by Sequence of Trend Shapes and Level of 20th-Century Rates

A. Increase Followed by Repeated C Declines:

(1)	(2)	(3)	(4.a)	(4.b)	(4.c)
No. Italy	Hungary	Romania	Korea	Puerto Rico	Reunion
England[a]		Portugal	Sri Lanka	Venezuela	Russia
Denmark		Japan	Philippines	Mexico	Egypt
Scotland?			Taiwan	Guyana	
Belgium?			Singapore	Malaysia	
Imp. Austria			Cyprus	Mauritius	
Switzerland?				China	
Germany				Panama	
Netherlands[b]				Costa Rica	
				Tunisia	

B. No Modern Increase, Just C Declines:

(1)	(2)	(3)	(4)
Sweden	France[c]	Spain	Brazil
Norway	Finland	Poland	Israel
Luxemburg	Czech Lands	Yugoslavia	India
	Bulgaria	Uruguay	
	Greece	Argentina	
		Chile	

C. G Increase in the 20th Century after C Declines:

(1)	(2)	(3)	(4)
Austria	United States	No. Ireland	Albania
	Canada	Ireland	Fiji
		Australia	Jamaica
		New Zealand	Trin. & Tob.

[a] The English CBR became high for Europe for about a half century beginning in the early 1800s.
[b] Dutch rates were low for Europe to 1850, became only average 1875-1950, but are now low again.
[c] French rates were high in the 1700s, fell to lowest of all countries around 1850, 1875, and 1900, but became only average for Europe for the second half of the 20th century.
Tables 2.6a and 2.6b present the CBR levels for the reported countries at various points in time.

Sources: Tables 2.3a and 2.3b.

Chapter 3

Vital Rates in Demographic Growth and Renewal

Together, trends in birth rates and death rates determine how populations renew themselves and grow or decline as some of their members die and fresh births replace them. How did the vital movements surveyed for some five-dozen countries shape, or adjust to, changes in the size of their populations that have been identified in Volume I of this study?

The English example in Chapter 1 already indicates that, even within a single population, growth in a particular pattern can, in successive historical periods, be generated by quite different combinations of trends in CDR's and CBR's. The implication is that from country to country, too, significantly varying interacting movements of death rate and birth rate can be part of the G, H, E, or F shapes of expansion identified (or of contraction in D or C shape).

What, then, do the 60-odd national cases in hand demonstrate about the nature of these combinations? When some populations share CDR and CBR pairings for certain historical periods and others do not, what insight does that provide about forces at work in those societies that might be steering rates of reproduction or death in particular ways? Identifying the crude patterns of vital rates during growth (or decline) begins to provide a framework within which to interpret commonalities and differences in more specific developments of fertility, nuptuality, and mortality. While more refined, that evidence is less extensive in historical perspective than the indirect outlines provided by vital rates and offers more limited opportunities for systematic international comparison and contrast.

{Please note that the Figures and Tables referenced in Chapter 3 are not interleafed in the text but appear at the end of the text (notes) – MSW 31 July 2015}

COMBINATIONS OF BIRTH RATES AND DEATH RATES IN INTERNATIONAL PERSPECTIVE

Categories of similarly behaving population histories shrink and multiply toward useless particularity when diverse patterns of CDR and CBR are considered simultaneously, as they must be in determining how natural increase evolved and resulted in the recurring G-based international patterns of demographic growth and decline identified in Volume I. Certain observed tendencies of combinations in trend to cluster are insightful, nonetheless.

Attempting to give some structure to the diverse global demographic experiences encountered, Table 3.1 tentatively cross-classifies the surveyed populations by their historical patterns of crude death rates and crude birth rates. While some insightful groupings emerge of types of populations with similar histories in both their birth rates and their death rates, other cases are spread well around the page. The distribution calls into question certain conclusions of the literature that have relied too much upon the best- and longest-documented national records.

Findings of so much international variation, first of all--as has been noted by others--pose very limiting implications for the theory of 'demographic transition.' Evolving internationally over the second quarter of the 20th century, this way of thinking about modern demographic history seemed plausible until research of the 1960s and 1970s began to challenge its specifications.[1] Essentially, the argument was that very generally across the modern world the death rate declined before the birth rate comparably decreased, causing accelerated population growth for the time being in society after society. Repeatedly, this development has been illustrated by two succeeding reversed 'S' curves--the first for death rates, the second for birth rates--coming down from equal starting points and ending up, eventually, at identical levels (for example, Livi-Bacci 1992, 103; Keyfitz 1985, 24). As a generalizing representation, this depiction--after decades of additional evidence--now misleads as much as it enlightens.

In modern populations very generally, both death rates and birth rates have indeed declined. In arithmetic scale, furthermore, the C curve--a path that these decreases have repeatedly followed--does have reversed ‘S’ shape, resembling the form suggested. That does not mean, however, as the theory proposes: 1) that in the move toward modern levels CDR’s and CBR’s have always come down in this pattern; 2) that when they have, there has been a single trend of such shape in each vital rate; or 3) that such decline in death rates has always preceded decrease in birth rates. Nor have adjustments in the C shape of path occurred only as recent, felicitous, and potentially universal aspects of ‘modernization.’ The birth rate in England shrank this way as early as between the 1560s and the 1650s; in France and most of Scandinavia, the death rate took C form by 1750 or earlier. The extensive variation in Table 3.1, and Tables 2.1a and 2.1b and 2.3a and 2.3b which lie behind it, in other words, indicates that the notion of a single, simple lag from CDR decline to CBR decrease, upon which the theory of ‘transition’ was built, is more of a special case than a model for generalization.

This broadly comparative evidence also also clarifies the particular significance of the French experience, which has been an influential example for the development of the history and theory of populations. The French population, long noted for curbing fertility early, was exceptional in another important fashion. Among nations with long documentation, it came closest to experiencing *parallel*, not lagging, movement in birth and death rates all the way from the 18th century into the 20th (Tables 2.1a and 2.3a). As the CDR fell, the CBR was mostly reduced in tandem. Among many other historical cases covered in Table 3.1, not even Finland approached France in such tight parallelism of successive C declines in both death and birth rates. The French population, in other words, has come closest to a constantly adjusting equilibrium between fertility and mortality. This does not mean, however, that--as per the reasoning of Malthus--the supply of resources constantly determined French health and French reproduction over the 250 years following about 1750. To the contrary, the secularization that accompanied the revolution of 1789 is known to have fundamentally shaped French values and French institutions, significantly affecting both fertility and mortality there.

Meanwhile, another extensively established national case, the English one, has been far from unique or just a figment of the Cambridge group's method of back-projecting calculations for years before 1870 (as some have claimed). Instead, the particular pattern of mixed, shifting death and birth trends found in English population history has been typical of at least several other European nations over recent centuries. And, though usually only much shorter series of evidence exist, Tables 3.1 and 3.2 indicate that such differing, even contrary, juxtapositions of patterns for CDR's and CBR's have been common, too, around the world--in Asia, Oceania, the Americas, and Africa.[2]

Similarities and differences in combinations of vital rates provide a framework within which to explore to what extent and in what ways populations that generally shared similar trends, and combinations of trends in crude birth and death rates also experienced comparable movements in specific contributing aspects of fertility, nuptuality, and mortality. They also can suggest how much, and in what ways, these demographic developments may have been connected with changes in economy, culture, society, and natural environment.

Though it must be considered only a tentative framework, Table 3.1 indicates how some populations at least did share movements in crude rates of birth and death, and from these similarities might be suspected also to have in common other aspects of their historical development. Tables 3.2 and 3.3 relate these patterns in vital rates to trends of demographic growth identified in Volume I. Table 3.2 is arranged to highlight how similar or how different were contemporary movements in growth, CDR, and CBR. Table 3.3 focuses more narrowly on just a few long-term cases to emphasize simultaneous patterns observed (a) in England, Denmark, the Netherlands, and Germany; (b) in Norway, Sweden, and Finland, and (c) in France.

From these three tables, there does seem to emerge some insightful grouping for the ways in which the known birth and death rates of national populations have altered historically and have related to patterns of population growth. For decades, demographic historians and theorists have been making such classifications, mostly stressing shared levels or amounts of change in vital rates rather than the shape of the paths taken to get from one point to another. Greater attention to the *patterns* which the rates have followed through time, though, suggests the following half-dozen clusterings of populations and the demographic movements that have linked or separated them:

1) England, Denmark, the Netherlands, Germany, and probably Scotland and Switzerland (where reords begin only later) have shared: (a) both E and H trends of population growth since the middle of the 1700s; (b) some E-shaped increase in the birth rate along with periods of population explosion in this form, but also subsequent D-type retreat of the CBR; and (c) death rates that dipped temporarily in the 1700s, followed mostly parallel C declines to World War II, but have risen along G paths across recent years.

2) Several other European countries, mostly geographically contiguous to this North Sea-Alps set, have experienced parts--but only parts--of this patterning. Belgium apparently fit the mold until World War I, after which her demographic movements switched to emulate those of neighboring France. Italy, most particularly northern Italy, had the typical sequence of trends in birth rate to World War II, but not the same changes in death rate and therefore not a comparable history of population growth, except for the H of 1861 to 1936. Austria also displayed the characteristic CBR patterns of the North Sea-Alps countries up to World War I, but produced an extended G-shape baby boom through the Depression and World War II--a phenomenon shared in Europe (as opposed to New World societies) only by Ireland and Albania. Also her death rate did not rise after World War II, as in the northwestern zone (and in the Czech territories and

Hungary nearby); and while the country experienced two E trends of population growth in modern times like nearby Germany and Switzerland, no H path of increase ever developed. Ireland, Portugal, and Spain to the west, and Hungary, Bohemia and Moravia, and possibly other countries to the east with shorter demographic records similarly partook of fragments, but just fragments, of the patterning that seems to have prevailed in a geographical band that extends diagonally southeastward from Scotland to Switzerland (Tab. 3.2).

3) The peoples of northern Scandinavia have shared both recent G-type increase in the crude death rate and an early 1/G' dip in the CDR in the 1700s with Denmark and the other nations of the North Sea-Alps cluster. Sweden and Norway, though not Finland, have also experienced some H-shape growth, but no population explosion. Contrary to what distinguishes Italy, Portugal, and Austria, it has been the *birth* rate movements of the region that have separated northern Scandinavia from the North Sea-Alps zone to its southwest.

4) Francophone Europe, as argued for some time, has broken trails of its own down the slope of demographic change (Knodel and van de Walle 1967, 47-55; Coale 1973, 53-72). France and her little neighbor Luxemburg stand out (except during France's brief postrevolutionary era of 1790 to 1829) for having only G trends of population growth and C paths of decline in both birth and death rates. These movements represent the most extreme departure in modern demographic history from the paths followed by neighboring North Sea-Alps countries lying to the north and east.

5) In six former colonies of Britain strung from North America to Australasia, population history has been characterized recently by both extended baby booms and rises in the death rate, each in G form. The latter constitutes a familiar feature of the northwestern European zone (including England herself); the former does not. The older of these originally colonial societies--Canada, the United States, and Jamaica--display substantial periods of demographic increase in the H and even the F trajectory (unfortunately most often in a period before the type of birth and death rates that accompanied these trends of demographic expansion can be

determined). In all these ‘New World’ cases, net in-migration (including the importation of slaves, convicts, and bound servants or contract workers as well as the relocation of free persons) has played an important role.

6) Without trying to categorize definitively the numerous populations that possess only very brief and recent records, it is still possible to recognize in Asia and Latin America many that have experienced population explosion--accelerating growth in the E form. In several, such as Korea, the Philippines, Ceylon/Sri Lanka, Mexico, and Costa Rica, an E surge in the birth rate has also occurred, as happened historically in the countries of northwestern and central Europe (though this CBR trend has not always been timed precisely alongside that for population increase--as it was in England for example). The H form of growth has only infrequently *preceded* population explosion in the manner of the North Sea-Alps model (in the Philippines and Mexico), however;[3] and among these ‘Third World’ countries with E-type expansion only the Philippines has not been distinguished from the northwestern European cluster by failing as yet to show recent G increase in the death rate. Singapore and Guyana, meanwhile, have had E-shape trends in their birth rates without accompanying population explosion. In nations like India, Japan, and Chile, in contrast, accelerating growth of the E type has taken place without any surge of this form in the birth rate. The same thing had happened in France briefly--starting in the 1790s but disappearing by the later 1820s.

Not only does this phenomenon divide populations of Latin America and Asia into groups with population histories more and less like others. It demonstrates fundamental differences in how E trends of population increase, or explosion, can be generated. On the one hand, as in 18th-century England or 20th-century Mexico, acceleration in the birth rate has contributed significantly to population explosion. In other instances, E type surges in population size have occurred without such quickening increase in the CBR. This was the case in France for a while after the Revolution and in India and Japan not long ago. The E movement of population growth in those places resulted simply from divergences between the downward C paths of decline in birth and death rates, more like what the theory of ‘demographic transition’ calls for than other historical cases surveyed.

In all, what is known at present about population changes since the 1700s is suggestively structured for further study by these half-dozen groupings of past demographic behavior. The resemblances and discrepancies that delineate the clusters and set them apart from each other highlight fundamental issues of population history and contemporary demographic process and their likely relationships to economic and social developments. They provide valuable hints as to where the answers are likely to lie, and should help prioritize from one historical case to another the significance of the several different types of causality seen to be at work in modern demographic change (Kirk 1996, 367-84).

For instance, what did the North Sea-Alps core countries have in common that might make their demographic behavior, in growth and in vital rates, move so much together and distinguish them from other populations? Many familar themes of history, economics, and sociology urge that this grouping of several societies of northwestern and central Europe by their population movements not be lightly dismissed as just a chance result of the kind of trend analysis employed. In economic development, values, and social structure certain historical experiences were common to this region.

From the Po valley north and west to England and Lowland Scotland stretched the most urbanized areas of early modern Europe.[4] Along the artery of the Rhine and across a swathe of hinterland that was nourished by the activity of this and connected or parallel river systems coursed commerce, fashion, and ideas (and also armies, disease, and famine). Granted peace, expanding middle classes thrived more readily here than they could under the laws and economies of most other parts of Europe. New things were made and traded to serve their growing consumption; new world-views, both secular and religious, arose to explain their environment and their place in it. During the later 1500s and the 1600s the leading activity within this belt of western Europe shifted northward. The Low Countries, northern France, and England rose at the expense of societies more sensitive to what happened in the Mediterranean basin. First the Netherlands and then England came to rule the seas, linking northwestern Europe to the Baltic, to the Mediterranean, to the Americas, and to Africa and Asia, absorbing much of the former business and other connective functions of Venice and Genoa, Portugal, and Spain. In the 1700s, protoindustrialization thrived, then factory-based production and fresh urbanization appeared--first in Britain, but soon spreading in Belgium, northern France, the Rhine lands, and other early-developing parts of 19th century Europe. These emerging activities were located chiefly in the continent’s northwestern and central regions.

As historically minded social scientists have long maintained, the places where modern economic development went were also sites of political and cultural change, however one may read the nature of the specific relationships among these contemporaneous forces. The power of various social groups altered. Legal development contributed a central element to economic growth. New values and aspirations disseminated through larger and larger portions of the population. New religious views appeared. What is seen here is how aggregate demographic behavior constituted one aspect of this package of complex, interrelated changes in human life--a role that is hardly unfamiliar to students of recent and contemporary population and society. The likely linkages are long familiar, if still hotly debated. What Table 3.1 and the figures and tables from which it is constructed do is to reassess the geography of the demographic dimension of this much-discussed nexus of changes in human history and to specify the types of trends in birth and death rates that shaped it, both in societies central to such ‘modernizing’ development and among those more peripherally, or just differently, engaged.

One indication of these findings is that, though economic forces remain relevant, analysts might profitably give more emphasis to cultural factors in the historical environment of demographic change. Within Europe, for instance, societies with predominantly Catholic heritage tend to group differently from Protestant ones. Among the latter, furthermore, uniformly

Lutheran populations are for the most part distinguished from those containing more Calvinists and sectarians. The secularizing impact of the French Revolution, on the other hand, separates out certain predominantly Catholic societies from others. Elsewhere, meanwhile, the British colonial heritage pervades one group of populations with distinctive demographic trends; and Chinese, Japanese, and Korean peoples of eastern Asia cluster in another.

The role of values in underpinning historical groupings of evolution in birth and death rates, and the demographic behavior underlying them, is not easy to trace; but it seems to lurk in several areas of Table 3.1. For example, only 2 among 11 Asian countries (India and Palestine/Israel) did not experience E-shape gain in their births before recent declines (were ‘B’s in CBR). Most of the others, 8 populations in all (without the Philippines), have had ‘A’-type patterns in birth rate and ‘B’- or ‘C’-shape movements in their death rates. In the Americas, peoples with a history of British control, as noted, cluster with ‘C’-type histories in CBR and ‘B’-form experience in CDR, while most populations of Hispanic colonial background--except neighboring Argentina, Brazil, and Uruguay, with their histories of heavy and diverse immigration--instead have ‘A’-type patterns in their birth rates (unlike many European countries of Catholic heritage). Did having a predominant or diluted impact of indigenous peoples structure the differences within modern Latin America?

Students of population change in the present time, particularly investigators of fertility, repeatedly see religion and ethnicity to be central in individual and group decisions about demographic behavior. The geographical findings here suggest that historically they have been no less important. They also may prove to be related to developments in death rates as well as birth rates, for instance via views that social problems are divine will, not inspirations to enact this-worldly reform.

Fundamental may be the ways that a particular cultural history shapes how secular values evolve: for instance the individualism, pluralism, political liberalism, and attitudes toward work and property that so concerned the 19th and early 20th century fathers of historically oriented sociology; or, the ideological consequences of the French Revolution. These can affect reproductive behavior, directly or indirectly--as through the way that education (especially the education of women) evolves and what happens to support for, and the practice of, medicine and public health on the mortality side of the demographic equation. Thornton (2001, 449-65) has declared the diffusion of ‘developmental idealism’ a determinative factor for demographic change from about 1800 forward.

Those who know local cultures well, and variations of demographic behavior across sub-populations within the relevant countries, will have to determine just how far such differences are linked to religious and other cultural distinctions. Many already work in these terms, for example on the historical effects of pre- and post-revolutionary secularism within the otherwise generally Catholic populations of France and Belgium (Lesthaeghe 1991 and 1992 and his citations). Meanwhile, though, approaching the question from national historical comparisons and contrasts downward, rather than just upward from the impact of values on current individual behavior, indicates that more systematically comparative study is warranted on questions of how cultural heritage has, in aggregate, significantly shaped historically the way various kinds of modern economic and social change have worked themselves out and involved particular patterns of collective *demographic* development.

Analysis of the similarities in demographic history that make for North Sea-Alps, Francophone, Scandinavian, ex-British colonial, or other clusterings of populations, which will firm up and fill out as evidence becomes more extensive, indicates that general comparative classification still provides useful insight and framework within which to place and determine the significance of detailed findings, while provoking fruitful questions for further inquiry, even if older generalizations such as the diffusion of a single, oversimplified ‘demographic transition’ or the Trieste-St. Petersburg dividing line for European population history do not work as well as once thought. Equally insightful, though, are the many instances in which common movements in births or deaths or expansion have only been *partially* shared by populations. These variations serve as a reminder that shared cultural or social change, shared health conditions, shared economic development-- also shared wars and events of nature--can set off movements in births or deaths that are common to two or more countries without generating similar trends of population increase or change in the other vital rate. The whole "package" does not have to alter together, even though some populations have in fact for long periods followed each other in this more comprehensive way. Likewise, similar movements in population growth do not have to involve the same contributing patterns in vital rates. This last conclusion raises questions of how trends in births, deaths, and the often theoretically neglected third dimension, migration, fit together within a given pattern of population growth that is observed.

DEATH RATES, BIRTH RATES, AND NET MIGRATION IN DEMOGRAPHIC GROWTH

Trends for England (Figs. 1.1, 1.2 and 1.3; Tab. 1.1) have indicated how a variety of patterns in birth rates and death rates can contribute to produce both comparable and dissimilar movements in the size of a population. Evidence from Sweden, France, and Denmark--where vital rates, growth, and the net migration that accompanies them can all be at least roughly outlined over considerable stretches of time since the 1700s--further elucidates how CBR's and CDR's moving in G-based forms interact with each other and with migration as particular types of change in the size of populations unfold.

Figure 3.1a recapitulates at its top, for Sweden from the 1720s through the 1980s, the curves that have been fitted to the national death and birth rates in Figures 2.1.a and 2.2.a. It then presents, across the middle of the figure, the movements of natural increase that were generated by the differences between the actual CBR's and CDR's every five years (not just the modeled G-related trends for them that are graphed for simplicity of viewing and analysis). Superimposed upon this CRNI plot are the log-linear trends of -.03 and -.03/*e* (or -.011036) that successive patterns of G and H growth in the population *imply* for the rate of total expansion reported for the Swedish population through various periods.[5] To hold actual movements of the crude rate of natural increase up against these slopes on the graph is not precise; but the comparison offers a sense of how the CRNI currently followed or failed to follow the crude growth rate that is implied by the model for the size of the population. Figures 3.1b and 3.1c present comparable information for France and for Denmark, respectively, since the middle of the 1700s.

In assessing how quinquennial calculations of natural increase vary around model trends for rates of overall population increase, certain things should be kept in mind: 1) The fitted growth trends do some averaging, and therefore fail to represent short-term variations in population size around the proposed pattern. 2) These meanderings in the size of the population are so small, relatively, that they are scarcely visible when graphing growth (for example, Harris 2001, 150-51). Meanwhile, the total numbers involved are so big--fleshed out by people of so many different ages, few of whom are currently being born or dying--that considerable variations in natural increase for five, or more, years scarcely dent their long-term pattern of expansion. 3) Some net migration accompanied natural increase in determining the path of demographic growth for the country.

Across the bottoms of Figures 3.1a, 3.1b, and 3.1c appears information about migration. The dotted lines show *implied* movements of net emigration (E) or net immigration (I) derived by subtracting the death rate from the birth rate and then simply taking this calculation of the rate of natural increase from the crude growth rate that has been computed from actual quinquennial population numbers (not their modeled trends). From the middle of the 19th century to the middle of the 20th, on the other hand, *recorded* net migration for Sweden, independent of birth and death rates is included in Figure 3.1a to illustrate that, while volatile, estimates derived by subtracting natural increase from growth can at least provide a rough sense of actual broad movements in net migration. The hollow circles represent rates of observed net emigration, the filled triangles rates of net immigration. Rates for England and Wales in Figure 1.3 from the later

1800s forward are also based upon actual net migration. Estimated rates for earlier periods there are checked against independent calculations where possible.

In Sweden, the way that the net of birth rates less death rates (natural increase) falls below the G-type growth of 1723 to 1748 implies immigration that on average peaked about 4 per 1000 (or 0.4 percent) from the early 1730s through the early 1740s (*Historik Statistik* 1969, 1: 86). Demographic historians of Sweden will have to determine whether this result makes sense, or whether something is just wrong with the vital rates or the population sizes available for making such a calculation. In the late 17th and early 18th centuries, however, many Finns were recruited to help develop the forest lands of Sweden. And the brief period in question involves the aftermath of the Great Northern War, during which some significant population adjustments in the Baltic region seem likely. This early, furthermore, the data are only for Stockholm and nine other counties. Some regional migration just *within* Sweden may have had a significant impact upon the phenomenon of implied immigration that is generated by the difference between birth rate and death rate.

Natural increase without major net migration one way or the other then seems mostly to account for the G-shape growth of the Swedish population that has been identified from 1748 through 1783. The dotted line for CRNI and the -.03 slope of the decelerating growth rate for the G path of population increase over these years, that is, move very much together at quite close to the same level. During the subsequent G trend for 1783 to 1818, however, substantial *emigration* is at first implied (with the difference between births and deaths rising above the -.03 line characteristic of decelerating G-type movement for a decade or so). The quinquennia around 1808, 1813, and 1818--during and just after the Napoleonic wars--however, then on average saw some offsetting *immigration* into Sweden, the differences between birth and death rates imply. How such possible swings of migration might have come about, and their validity, must be determined by local historians. For one thing, the relative influence and attractiveness of Sweden and neighboring Denmark probably fluctuated due to their fortunes in the military and political conflicts of the time as well as their relative pace in urbanization and economic development. (Denmark, for example, lost Norway as punishment for siding with Napoleonic France.) Then during the fourth, relatively short, G-shape growth since the early 1700s--from 1823 through 1848 (especially before the 1840s)--net migration of either sort appears again to have lost major significance. Finally, for the return to still another era of G-shape expansion between 1943 and 1990 or later, net *immigration* supplemented elevated--if nonetheless slowing--natural increase, and surged as the difference between birth and death rates plummeted during the years surrounding 1980.

How successive growth trends in G form seem to have been triggered is suggested in Figure 3.1a by the way that natural increase tended to surge at their beginning. In the late 1740s, early 1820s, and early 1940s, significant upward shifts in CRNI accompanied the beginning of new G trends in population increase. What generated those relatively abrupt changes in balance between birth rates and death rates? On the whole, the top two plots of Figure 3.1a indicate, both vital rates independently followed quite stable long-term paths. Only in the 1940s did the trend for Swedish births suddenly rise relative to deaths.[6] On the other hand, the population seems to have treated the perhaps delayed upward surge of natural increase that came around 1793 rather than 1783 as an "overshoot," damping it with significant emigration for the time being during years of upheaval in Europe. Or should the G trend of growth simply be considered to have begun a decade later than previously thought (Harris 2001, 151)?

It has been seen how the G-shape expansion of the English population after World War II, the only growth pattern of this shape for that country since the 1550s, started with a jump of natural increase out of Depression levels (Fig. 1.3). How universally, then, is a digestion of this type of upward shift in CRNI, whether it is part of a modern 'baby boom' or not, the source of G-shape decelerating growth for populations?

Evidence from Denmark and France as well as Sweden and England indicates that the phenomenon is probably quite general. Table B.3 in Appendix B summarizes some characteristics of G trends in these four populations. Drawing upon Figures 1.1, 1.3, 3.1a, 3.1b, and 3.1c, it comparably analyzes the roles of vital rates and migration for growth movements of H and E shape in the four long-documented countries.

On the whole in evidence viewed so far, G-type expansion appears to have commenced historically with relatively abrupt gains in the rate of natural increase, which, having shot above, then tended to fall below the pace of growth, thanks to net immigration. During these movements the birth rate typically came down in C form and the crude death rate cut back natural increase by steeper C-shape decline, or by turning around to rise--sometimes in G fashion, particularly following World War II as populations aged and public welfare was strained by immigration and a shift in political climate.

H-form population increase, on the other hand, has mostly begun with more gradual elevation of rates of natural increase, which have continued rising before falling back to the trend of the crude growth rate. This ‘bowing’ above the path of the CGR has been accompanied by net *emigration*. The ability to unload some population allowed domestic growth to decelerate in the slowly slowing H form rather than take up log-linear increase as in the Eulerian expectation. In the underlying vital rates, it is the frequency of *deaths* that displays the C pattern (except in England before 1730), mostly twice, while the birth rate about half the time has taken the type of long C path observed during G trends of growth, but otherwise moved quite variously.

E-shape or accelerating population increase in England and Denmark, finally, was distinctively characterized by long-term E-type gain in the birth rate. The death rate, meanwhile, after dipping in 1/G’ fashion, declined via C. This path was shared by France, though comparable movement in the CBR did not appear there.[7] The rate of natural gain in England and Denmark, on the other hand, generally began moving upward but then fell below the rate of growth, with time lessening or eliminating emigration. Thus during E-type expansion the population increasingly held onto those who might have left, suggesting economic improvement in some form.

Later chapters--though not as fully as for England in Chapter 1--examine the more specific trends in nuptuality fertility, and mortality that contributed to such crude changes of vital rates in not only these few best-documented populations but several others with adequate historical records, allowing the analysis to dig below a surface mapping of the relationships among birth rates, death rates, and recurring forms of demographic increase. This preliminary framework for what tended to be common and what did not, however, serves to inform and structure that deeper exploration.

THEORETICAL AND ACTUAL CONSEQUENCES OF LAGGING REDUCTIONS IN BIRTHS OR INCREASES IN DEATHS

Before moving on to such particulars beyond vita rates, however, it is useful to understand something about how combinations of C trends in births and deaths, which are so evident in populations of the 19th and 20th centuries, can interact mathematically to produce patterns of population growth. This addresses the basic premise about lagged death and birth rate adjustments that is so central for the theory of 'demographic transition.' What value does that conceptualization retain? And how does analysis in G-related terms clarify this frequent phenomenon of demographic change?

Though it is not universal, the most common shape of trend for both death and birth rates since the early or middle 19th century has been the C form of decline, which has constant proportional acceleration.[8] In many populations, meanwhile, at some point the CDR has in fact fallen rather earlier and therefore faster along such a path than the CBR. While it has been important to emphasize that, contrary to some presentations of 'demographic transition,' this does not happen everywhere, especially not via a single pair of C curves, such a lagging relationship remains a sometimes observed, if by no means universal, phenomenon in modern demographic adjustment. It is thus still useful to probe what kind of population growth results simply from this particular lack of simultaneity in the C curves of those two vital rates.

Figure 3.2a, first of all, plots in *arithmetic* scale death rates (solid symbols) falling in C paths 30 and 60 years before the birth rate (hollow symbols) comes down in the identical pattern from the same starting level to the same finishing level. The choice of 30 and 60 years is arbitrary, for illustration only. A lag of about 30 years (roughly a generation) has, however, not been infrequent historically. In arithmetic scale, each C curve takes a reversed 'S' shape of the general sort employed to illustrate 'demographic transition'.[9] The figure also shows how the rate of growth in the population from natural increase, *r* (for 30 and 60 year lags in births), rises then falls as the gap between the CBR and the CDR first widens than contracts. Such behavior is likewise well known in principal, though the particular pattern of path taken as the CDR and the CBR come down along C curves has not been identifed.

Without net migration,the growth rate is nothing but the birth rate less the death rate: $r(t) = b(t) - d(t)$. When C trends of death rate and birth rate are paired, however, the growth rate takes a particular path. This, Figure 3.2b displays in semi-logarithmic form with filled upward triangles for a lag of 10 years from the CDR to the CBR, is the first derivative of C, or C' (which is the reverse of G' with respect to time).

Figure 3.2b shows in proportional or semi-logarithmic scale how variously timed C trends in which the CBR lags behind the CDR during the same amount of decline from an identical starting level produces a difference or a growth rate that always follows a C' path. Three relationships of the CDR to the CBR are illustrated: in these, the decrease of the death rate precedes that of the birth rate by 10, 20, and 30 years, as is shown at the bottom of the figure. Then the differences between these two curves, CBR - CDR, are plotted across the middle of the figure, and the C' fit is presented by short dashes for the 10-year case. For each lag, this C' curve has a zero year half way between the t_0's of the C paths for the birth rate and the death rate whose difference is involved. Figure 3.2b illustrates how with a 10 year lag between decline in the CDR and the fall of the CBR the curve whose derivative represents the rate of growth over time has its t_0 5 years before that of the CBR and 5 years after that of the CDR. The base year of the curve of *r* for a 20 year lag comes 10 years after that of the C curve for the CDR, and so forth.

In simple subtraction of death rate from birth rate, without considering other factors that might be involved, a century or so before the average for the zero years of the C curves for the CDR and CBR arrives the gap, or growth rate (*r*), is rising at approximately 3 percent. It slows down more and more below this constant pace (the straight ".03" line matched with a 10 year lag on the semi-logarithmic graph of Fig. 3.2b) until it stops increasing at all half-way between the t_0's of the CDR and the CBR and begins to go down, progressively faster and faster, as both vital rates reach the end of their declines.

What are the implications of such a path in *r* for the resulting pattern of population growth? To expand at a rate of increase that itself increases at the .03 pace is what the E curve does. Therefore, in the early stages of simple, theorized 'transition' that specific form of population explosion can be started off by nothing more than the timing of C shape declines in CDR followed, with delay, by CBR. And even as divergence between the two curves begins, for a long while just a little change in net migration (more immigrants or fewer emigrants) can make up much of the difference, pushing up the actual resulting size of the population, and sustaining its rate of growth near +.03, generating somewhat more slope for *r* than what just the gap between the current CBR and the CDR provides.

In some northwestern European core populations of Table 3.2.a (England, Denmark, and the Netherlands), and several other places more recently (Austria, Portugal, Korea, Mexico, and Costa Rica), birth rates have been seen themselves to take the E form while population exploded in this pattern, significantly helping to push up the acceleration of growth. Elsewhere, however, the E shape of demographic expansion has occurred without any contemporaneous E trend in the

CBR. Now, looking at a few prominent national illustrations, it is possible say more about what happened via vital rates in those other, less obviously explicable, cases to produce the E form of accelerating population increase.

In India (part E of Table 3.2), the birth rate declined in C fashion from 1886 through 1953 towards a zero year at 1996. The C of the death rate for 1896 to 1953 meanwhile headed for a t_0 at 1962, some 34 years sooner. From 1901 (78 years before the average of the t_0's for the C's of the death and birth rates, at 1979) through 1961 or 1971 (8 to 18 years preceding that point) the population of India increased along an E trajectory with t_0 at 1972. Falling net emigration rates following heavy flows of contract labor to Africa, Oceania, and the West Indies around the turn of the century probably made up the difference. In the mode illustrated by Figure 3.2b, however, by the decades after World War II increase in the rate of growth that was simply derived mathematically from the two C paths of the birth and death rates would have been significantly falling below .03. As of the 1950s, though, the C-shape CBR and CDR trends that had started off this population explosion in India were replaced by new movements in vital rates, which now soon swung accelerating expansion of the E type over into the robust but gradually decelerating H pattern of demographic growth that is currently being followed.

In Chile (part F of Tab. 3.2), the birth rate contracted between 1897 and 1947 in C form towards a t_0 at 1978 while from 1907 through 1957 the death rate followed a C path aimed at the considerably earlier base year of 1948 (30 years sooner, or again about a generation different). From 1907 through 1960 the population of the country expanded via an accelerating E curve with t_0 at 1960. This received its start from the way the C's of the birth and death rates had related to each other from about 1900 to 1950. The final spurt of the E to 1960, however, occurred as the birth rate itself shifted up in level after World War II before beginning to decline in C fashion again (Fig. 2.2i). Inverse to the experience of India with shrinking emigration, rising *immigration* to Chile probably offset the way the impact of the sheer mathematical difference between the C's of the CBR and CDR weakened as mid-century approached.

Between 1792 and 1827 the population of France (part B of Tab. 3.2 and part B of Tab. 3.3) has been seen to start exploding in E form (headed towards t_0 at 1876) in spite of there being no E trend for the birth rate here, as there was nearby in England or the Netherlands. From about 1750 to the 1790s, the downward-heading C trends in the vital rates of this population had been very parallel (with base years at 1853 from the death rate and 1859 for the birth rate). What happened after the Revolution, however, was that while the CDR kept to the same C trend, the decline of the CBR became much flatter (noticeably slowed), taking a new C path that would reach a zero year only in 1895. This meant that, during the exceptional years of accelerating E-shape growth for France between 1792 and 1827, C movements in vital rates that were lagged 42 years stood at points of comparison ranging from 82 to 47 years preceding the t_0 of the average C trajectory for the CDR and CBR. Figure 3.2b shows how, that far back, the rate of change in the rate of growth is very close to the .03 log-linear path of *r* that is inherent in E-type population explosion. That alone--without obvious change in migration (Fig. 3.2a)--could make the demographic expansion of France temporarily follow a path that resembled those of some of her neighbors in northwestern Europe, though not for the same reasons (since France lacked an E pattern in the birth rate).

Later on in the 19th century, for Spain the difference between a birth rate falling in C fashion from 1859 to 1932 and a death rate for 1867 to 1957 that took the same shape of path timed 26 years earlier (with t_0 at 1940 rather than 1966) similarly of itself provided a foundation for the E-type expansion of the population that appeared from 1887 through 1920. From 66 to 33 years before the base year of average C for the two vital rates this gap again increased much like the .03 rate of population explosion that is characteristic of the E pattern. Just a little change in net migration could do the rest.

Thus, while in some countries around the world there has been at least some direct contribution of accelerating E-form increase in the birth rate to ‘population explosion,’ elsewhere other peoples have expanded along E paths without any similar trend in the CBR--

principally just from the way differently timed declines of vital rates along C paths progress (as called for in the theory of 'demographic transtion'). Questions for further investigation are raised by this distinction between alternative dynamics that can underlie the same E pattern of 'population explosion.' For one thing, what has caused some peoples, but not others, also to have had birth rates increases in the E form as demographic growth took this shape? Economic conditions? Exogenous change in the health environment? On the other hand, what in turn are the consequences for demographic, economic, and social change that are inherent in the two quite distinct ways in which E growths of population seem to have been generated?[10]

The tendency for E-type growth to result from just the comparative timing of C movements of the vital rates is considerably weakened, however, if the CBR and CDR do not start downward from very much the same level. Any proclivity to mimic constant .03 proportional gain in *r*, the rate of growth, diminishes as the initial gap becomes larger. At the top of Figure 3.2b is an example in which the CBR starts out 2 per thousand higher than the CDR, which goes down 10 years earlier. This difference maximizes much more flatly than the "-10" plot across the middle of the page for rates starting and ending at the same levels. A 5 per thousand difference between the CBR and the CDR as they began and finished transition would produce an even more weakly sloping climb in *r*. Populations in which the birth rate and the death rate are about equal are, in other words, more likely to accelerate in growth along E paths just from the timing of their C trends for CBR and CDR than ones already expanding from natural increase. In Sweden in Figure 3.1a, for example, lagging decline of the birth rate in C form between the 1740s and the 1840s already began with a gap above the death rate that was much wider than that for France around the time of the Revolution (Fig. 3.1b). No E trend of population increase appeared in Sweden. A maximum rate of growth comparable to that in France was attained via different paths.

Even when the CBR and the CDR start down C paths from the same level, furthermore, the tendency for their difference to follow an upward .03 incline erodes progressively, soon rapidly, with time. The path of $b(t) - d(t)$, first of all, more and more fails to keep up the .03 pace. Right away it begins to diverge somewhat from the $e^{.03}$ trajectory. Modification of the pace for net migration can hold this erosion off for a while; but then, half way between the t_0 of the C of the death rate and that of the birth rate, r starts actually to fall. Such divergence followed by decline makes an E growth in a population that has resulted simply from the C_b - C_d arithmetic of Figure 3.2a *unstable*. Even as extended by the momentum of the age structure, it has to be supplemented more and more by immigration or some fresh changes in the CBR and/or CDR to keep up the .03 pace. And eventually the pull is *downward* into proportionally *decelerating* growth. Contrary to what some commentators predicted in the 1960s, this is precisely what has happened to most observed ‘population explosions’ historically, looping outwards from their upward-accelerating trajectories into G or perhaps H forms (Harris 2001, *passim*).

Finally, limits to how fast a rate of growth is likely to be generated simply by the lag of C curves in birth and death rates must be recognized. In Figure 3.2a the letter “I” along the growth rate curve for a 30 year lag stands for India. There, the base point of the C for birth rate came 34 years after that of the death rate and the pairing of these curves ended by 1953, or 9 years before the 1962 t_0 of the CDR (part E of Tab. 3.2). At this stage of the r_{30} curve, growth of about 8 per 1,000 is implied for India whereas many ‘exploding’ populations of the 20th century have achieved rates of 30 (the velocity at the zero year for the G formula) or more. For France (“F”), the lag of C curves running into the early 1800s amounted to 42 years (about halfway between the two illustrated r_{30} and r_{60} plots) and the C of the CDR ended some 26 years before the t_0 for that curve (part B of Tab. 3.2 and part B of Tab. 3.3). This suggests a limit in growth at about 7 per 1,000 before new patterning took over. In 20th century Japan (“J”), the 35-year lagged pairing lasted 15 years *past* the t_0 of the CBR at 1942. These circumstances boosted the growth rate of Japan to the top of the r_{30} curve; but that would mean only about 9 or 10 per thousand annual increase from the lagging of C trends alone. Though it has had a real effect in some historical settings, the kind of gap in timing between CDR and CBR declines that ‘demographic transition’ has stressed has mostly of itself generated only relatively moderate growth, and has not always led to E-type demographic expansion in any case.

In Sweden, between 1843 and 1923 the C paths of the birth rate and the death rate were almost exactly parallel (with t_0’s each around 1941, shows part B of Tab. 3.2), and growth took the only slowly decelerating H form apparently regulated by change in net migration. Earlier, between 1743 and 1843, there *was* a lag--of 60 years--for the C trend in the CBR. Starting from a relatively wide gap between the birth rate and the death rate, however, the E-type population acceleration up to a level of about 7 that ‘transition’ theory would expect, reaching to “S*” in Figure 3.2a, never occurred. Instead, growth during this period of 100 years took the form of a series of three successive G trends (Fig. 3.1a; Harris 2001, 150-51) as the influence of factors other than just the sheer mathematics of lag proved stronger.

The explosive demographic expansion that so worried observers a few decades ago has usually resulted, instead, from a compounding of the lag effect by *re-started* C movement in one of the vital rates, by more than one C-to-C pairing (as in India or Brazil), by an E movement also in the birth rate (as in Mexico or Costa Rica), or by some other combination of trends in vital rates (as in Ceylon/Sri Lanka or Jamaica). In historical actuality, even since the 1800s simple contemporary pairs of lagged C-type declines in death rate and birth rates have, contrary to the typical representation of ‘demographic transition,’ not been the predominant form of demographic adjustment. On the one hand, more than one C has appeared in the CDR or CBR or both. On the other, trends taking other G-based shapes--G, D, and E (and sometimes G’)--have been common in one or both of the vital rates. In this quite diverse picture, nonetheless, the matches of contemporaneous curves of the same shape in CBR and CDR that do occur, are relatively modern, and such parallels have so far appeared in the C form only.

It is profitable, nonetheless, to examine theoretically how time lags between vital rates of the same form would unfold mathematically if at least one other G-related curve were lagged: namely G itself. Figure 3.3a diagrams growth rates that would emerge if CDR's of the same height were to echo equal G-shape increase in CBR's by 30 or 60 years before. In such a model, the birth rate breaks free from the common level to rise in G form, but the death rate responds tardily in a similar fashion to catch up only somewhat later. This is the chronological reverse of the C-then-C combination of downward movement that is frequent in the modern era. None of the mostly fairly recent historical evidence reviewed has included such a case.[11] In pre-modern times or other simpler conditions of human life, however, it could easily be expected to represent how Malthusian homeostasis might work, with nasty restraints coming to bear on a population that was pushing the limits of its resources or 'carrying capacity' too far (R. D. Lee 1987). This kind of situation might be encountered, for example, in Europe during the middle ages, in the Americas before European invasion, in Asia or Africa before modern records begin, or in recent societies or communities that anthropologists study.

Figures 3.3a and 3.3b show, hypothetically, what would happen if a birth rate rose in G fashion from equilibrium with a death rate and then the death rate followed, also via a G track. The first of the figures again presents the movements in arithmetic scale while the second displays the relevant trends semi-logarithmically or in terms of proportional change. There, with lags of 10, 20, and 30 years the difference between the CBR and the CDR (at the bottom of the Fig. 3.3b) now takes the shape of G'. Comparison of Figure 3.3a with Figure 3.2a reiterates how the growth rate (*r*) curve for two C's in turn represents in C' just the derivative of G, G', reversed with respect to time. It is not unimportant, however, that the steeper, more rapidly bending, and gentler, nearly log-linear, slopes are reversed. Via G', Figure 3.3b shows, the rate of increase *converges* across the years upon the downward proportional slope of -.03, which is the constant rate of deceleration that is imbedded in G-shape growth. This is the *stabilizing* path according to which equilibrum is restored after an opportunity to increase fertility is duly disciplined by an echo of rising mortality. In contrast, a C-to-C lag from death to birth rates with time less and less approximates growth rates that would foster population increase in E form. It is increasingly *unstable*.

The finding that, if a birth rate goes up in G form and it takes a while for the death rate to follow (also via G), G-shape growth for the population results, implies that in the Malthusian conceptualization, lax or tardy demographic discipline produces G-type growth. For earlier and smaller or simpler populations without durable economic development, G has in fact been the universal form of demographic increase according to the wide-ranging historical findings of Volume I of this study (Harris 2001, 384, 382). Early enough or local enough birth and death rates just do not yet exist, however, for verifying that this is why the G form of expansion is ubiquitous under those conditions. But the connection makes sense in theory. That leaves the challenge of *how* birth rates and death rates might repeatedly take G shape.

For the actual evidence that appears in the overwhelmingly more modern international historical record, however, growth along observed paths seems most usually *not* to involve simple pairings of similar curves of vital rates which just have somewhat different timing from comparable starting levels. This assumption constitutes the core of the typical 'demographic transition' diagram; and that is why such presentation is misleading. Instead, more complex and variable combinations of C, D, E, and G (and sometimes G' or 1/G') trends in CBR and CDR are the norm. That finding underscores how net migration must simultaneously be considered in order to understand the ways in which the six witnessed G-based growth patterns (G, H, F, and E; or D and C for negative growth or decline) have occurred over and over again in populations. The assumption of closed populations, which leaves migration out of the calculation, has simplified demographic theory in certain insightful respects; but it has obscured crucial matters as well.

Most notably, the same shape of historical growth pattern--be it G or one of the "relatives" connected with this formula --has typically been achieved by a *varying mix* of G-based trends in births, deaths, and migration, even within the experience of the same country. Such variation indicates that there is an essential *exogenous* component in how particular G-based trends of births, deaths, and migration fit together to fashion a given G-related form of growth. This long-familiar conclusion about a crucial role for the environment or the support system in determining the shape and the timing of change in population *size* was once again evident already in the international survey of Volume I, which simply examined where and when, and under what apparent conditions, the six types of recurring G-based trends of growth and decline have appeared historically. Present findings about which documented populations have shared trends in birth rates or death rates (or both), and which have not, develop further a framework for exploring the roles of mixed factors like natural environment, economy, social characteristics and culture in demographic change.

INSIGHTS AND ISSUES FROM COMPARING PATTERNS IN VITAL RATES

As was found in England across four and a half centuries since the middle of the 1500s, among about five dozen extensively documented modern populations, both crude death rates and crude birth rates have likewise repeatedly followed G-related trends since their later-starting records begin. The phenomenon appears to be quite general.

Though there have been exceptions, since the middle of the 18th century death rates for the most part have not once (as pictured by proponents of 'demographic transition'), but repeatedly, decreased along C-shape paths in country after country as better health, shelter, and nourishment have widely disseminated. Beginning in the middle of the 20th century, however, in several nations--so far mostly, but not exclusively, in northern and eastern Europe--CDR's have risen in G fashion as populations have begun to live longer while producing fewer children. This distinction, along with the timing of successive C-type reductions previously found in the death rate, suggests groups of global populations with shared historical patterns of change in CDR. These categorizations differ somewhat from international classifications that have previously been proposed, and seem to offer more insight as to what might have distinguished particular populations from others.

Crude birth rates in these same 60-plus countries, meanwhile, also typically declined in C form, similarly more than once this way in populations with long records. In parts of Europe in the 18th and early 19th centuries, but also frequently in modern Asia, Africa, and Latin America , however, CBR's rose before they fell like this in C fashion. Such increase mostly took accelerating E shape, as first observed in England between 1726 and 1816. More recently, rises in G form have followed a nadir for birth rates in the 1930s in several countries where a sustained 'baby boom' rather than just an abrupt jump to a new downward C path at a higher level characterized adjustments in fertility through World War II and its aftermath. In the evidence currently available, this more gradual and lasting recent increase in CBR was concentrated mostly in former British colonies of the Americas and Oceania, and has been followed since the later 20th century by renewed C-shape decline. Finally, some gain in the birth rate appears in the *earliest* records of several countries before their era of downwardly accelerating C trends began. In Australia during the first half of the 19th century and Japan across the Meijii era, this quite clearly took G form, as in England from the 1650s through the 1750s. In Finland and Norway during the 1700s, and perhaps Cyprus in the early 1900s, G' was the more likely pattern.

Such movements in birth rates and death rates continually interact (with some input from net migration) in determining how populations renew themselves. Though any cross-classification by patterns of birth rates and death rates can be only approximate, and should not be pressed too far, geographical clusterings that have been noted produce valuable insight into how demographic change might be better understood.

The amount of variation in contemporaneous movements of the CDR and the CBR, first of all, significantly limits the applicability of the simple theory of ‘demographic transition’ for real historical populations. In one-quarter of the sixty or so best-documented populations, for example, after the C-shape decline in death rate had begun, the birth rate rose via E or came down via D rather than steadily following a later-timed C.

Even when--as often has happened--modern declines in birth rates and death rates have both taken C shape, furthermore, in one or the other series there have been two (or more) such trends successively. That one of these stopped for the moment to start new, initially flatter C-type decrease, while the other continued to go down, has had greater effect upon the course of natural increase and population growth than the lag between matched trends in vital rates that has been typically emphasized.

C-type decline in birth or death rates, moreover, should not be considered a distinctively modern form of demographic adjustment. The English CBR contracted this way between the 1560s and the 1650s; the French, Swedish, Danish, Norwegian, and Finnish CBR’s *and* CDR’s both assumed such paths by about 1750 or sooner. For the remaining national populations surveyed, evidence one way or the other is simply absent this early.

The types of countries that experienced particular combinations of trends in death rates and birth rates suggest possible causes for the differences in movement observed. England, the Netherlands, Denmark, Germany, and probably Switzerland and Scotland composed a geographical area in which C-shape reduction of the death rate had reached a low by World War II, giving way to increase in G form thereafter, while the birth rate had risen in accelerating E fashion before taking a C path downward. To a considerable extent, these countries shared common cultural heritage and also early participation in economic modernization. To the east, Hungary, Romania, and Russia trailed behind, with similar patterns but with C-shape declines in the CDR that lasted later into the 20th century, and later-timed decreases of the CBR in that form.

Belgium, Imperial or Greater Austria, Portugal, and at least the northern part of Italy experienced the same kinds of E then C movements in their birth rates, but their C declines in death rates did not reach bottom until the end of the 20th century or after. While France is noted for strong early C-shape reduction in fertility, there--as in Spain and Luxemburg--not only did the death rate continue to decrease in C fashion during the later 1900s; the birth rate showed no sign of rising with economic change before falling, as in several countries to the north and east of France. In Sweden, Norway, Finland, Bohemia and Moravia, Poland, and most of the Balkans, on the other hand, while death rates did reach a low during the 20th century and began to rise, birth rates display no increase before coming down via C.

Beyond these generally longest and best-documented European cases, two clusters of populations with particular combinations of pattern stand out. One, so far at least, is largely composed of former British colonies. In these, whether predominantly European in demographic stock or instead (as in Trinidad and Tobago and Jamaica) principally African in origin, the death rate was still declining as the end of the 20th century approached, unlike the recent rise in England and several companion countries in Europe. The birth rate, meanwhile, unlike the tendency almost everywhere else (particularly if Ireland for most of its population history is considered a *de facto* colony) rose in G form over some decades during the middle of the 1900s.

The most numerous group of populations outside Europe, however, while experiencing death rates that did not reverse and rise before the 20th century came to an end, shared the tendency (though at later dates) that is found in northwestern and central Europe for birth rates to increase--mostly in E fashion--before coming down along the C path characteristic of 'transition.' This group included Japan, Korea, Singapore, Sri Lanka, and probably China,[12] but not India (where the combination of trends in vital rates by shape, though not by timing, up to 1990 resembled the patterns of France), Taiwan and Malaysia (like other eastern Asia, except that death rates for some decades were cut back via D rather than C), or the Philippines. Egypt and Cyprus also belong to the group, but Mauritius, Reunion, and Palestine/Israel also saw their death rates fall in D, not C, form. Mexico, Puerto Rico, Panama, Costa Rica, Guyana, and Chile show similar patterns, too, but not Argentina and Uruguay, whose trends instead resemble those of northern Scandinavia and the Balkans, or Brazil (which has been more like France and India in shape of vital movements).

With longer and better records, over time some of these clusters will probably be revised, and new similarities and contrasts noted. The groupings offered, nevertheless, would seem to highlight usefully for further exploration conditions that may have shaped populations one way or another. E-type increase in birth rates, for example, appeared in many countries at the beginning of economic development. Shared rule, religion, ethnicities, or institutions seem to have bound other groups of countries in other ways. No one factor seems to have been dominant globally. And what had an effect upon death rates did not necessarily have the same impact on birth rates, though the two were always somewhat tied to each other through the age structure of the population under study, which fertility and mortality both shaped.

Unusually extensively documented examples from England, Sweden, France, and Denmark indicate, finally, how the G, H, and E forms of growth in population size have been generated historically by quite varied interactions of comparably G-based movements in birth and death rates. To make this possible, some significant net migration has been at work most of the time since the early 1700s, though it has been more important for some countries than for others, and for certain eras within and among the countries examined. Such conclusions can be verified by modern evidence in which the amount of migration, in or out, has been independently recorded, not just inferred from the gap between crude natural increase and crude or modeled growth trends.

If birth rates and death rates, which themselves have taken G-related forms, have interacted in a wide variety of combinations within comparable patterns of change in demographic growth, and have often not determined these G-based trends of alteration in population size just on their own, certain dynamics are emphasized. 1) First of all, how might the G-related patterns of CDR and CBR themselves occur, and keep recurring whatever the shape of population growth in which they become involved? 2) What types of interactions between a population and its environment generate the demographic trends that are taken, blending a variety of G-connected movements in vital rates cemented and adjusted by migration to create certain patterns of growth? 3) How might the ubiquitous G-related demographic patterns that appear--in growth, in vital rates, in migration, and elsewhere in the development of populations (as the English example has illustrated)--in turn imprint themselves upon economic, social, and cultural change?

NOTES

1. Alter 1992, 13, 18-20, and Chesnais 1992, 1-9, provide brief--and different--histories of the ‘transition’ approach. Early questioning of transition theory was advanced by Knodel and van de Walle (1967, 47-55) and by Ansley Coale (1973, 53-72). The significant way that the data for France fail to fit the ‘transition’ model, however, differs from the terms of Coale’s critique.

2. More examples can be culled from Figs. 2.1a through 2.1i and 2.4a through 2.4k than Tab. 3.2 summarizes.

3. Though it has been experienced nin modern times by Mexico, Argentina, Brazil, and Chile within Latin America (though without comparable movements in vital rates except for recent CDR increase in Argentina); also in Africa by the coloured and white populations of South Africa, Egypt, Kenya, and Tanzania and in Asia by China, India, Pakistan, Bangladesh, Myanmar, Indonesia and three small neighbors of the East Indies, the Philippines, and Thailand--though known CBR’s and CDR’s in those populations do not extend much backward in time

(Harris 2001).

4. Jan de Vries 1984, 171, and his Ch. 8 more generally.

5. These rates are calculated from .03 (times 10 for graphing here, as in 300 per 1,000) at the zero year of the fitted curves. The growth trends are graphed and fitted in Vol. I (Harris 2001, 150-51).

6. Though they did again very recently, in the 1990s.

7. And E-type growth of population resulted instead from the lag between decline in death rate and decrease in birth rate.

8. Tab. 3.2 and, more inclusively, Tabs. 2.1a and 2.1b and 2.3a and 2.3b.

9. For example, Livi-Bacci 1992, 103; Keyfitz 1985, 24; Chesnais 1992, 27. The presentation here, however, specifies the *same C shape of curve* for both vital rates. This is the reverse in time of the forward-slanting asymmetric arithmetic ‘S’ pattern of G.

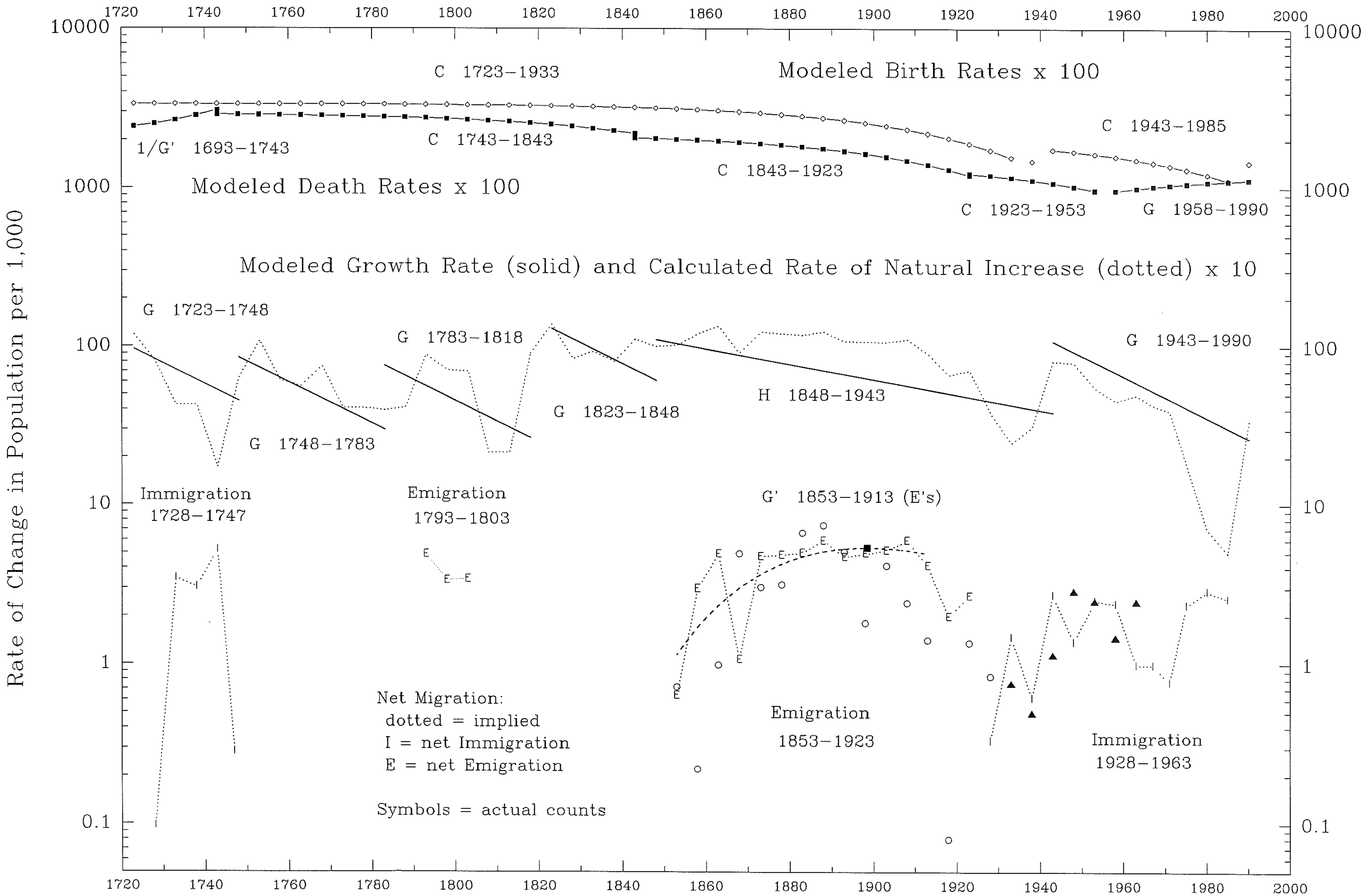
10. Later discussion returns to England to illustrate some G-based relationships of economic and social development with historically common demographic changes such as this.

11. In Japan from the 1870s to World War I (part E of Tab. 3.2) the G rise of the CDR somewhat *preceded* the G of the CBR.

12. Considering the advance of total fertility from the 1940s into the later 1960s, in spite of the campaign of the early 1960s (Coale and Chen 1987, 25; Lee and Wang 1999, 85).

Figure 3.1a

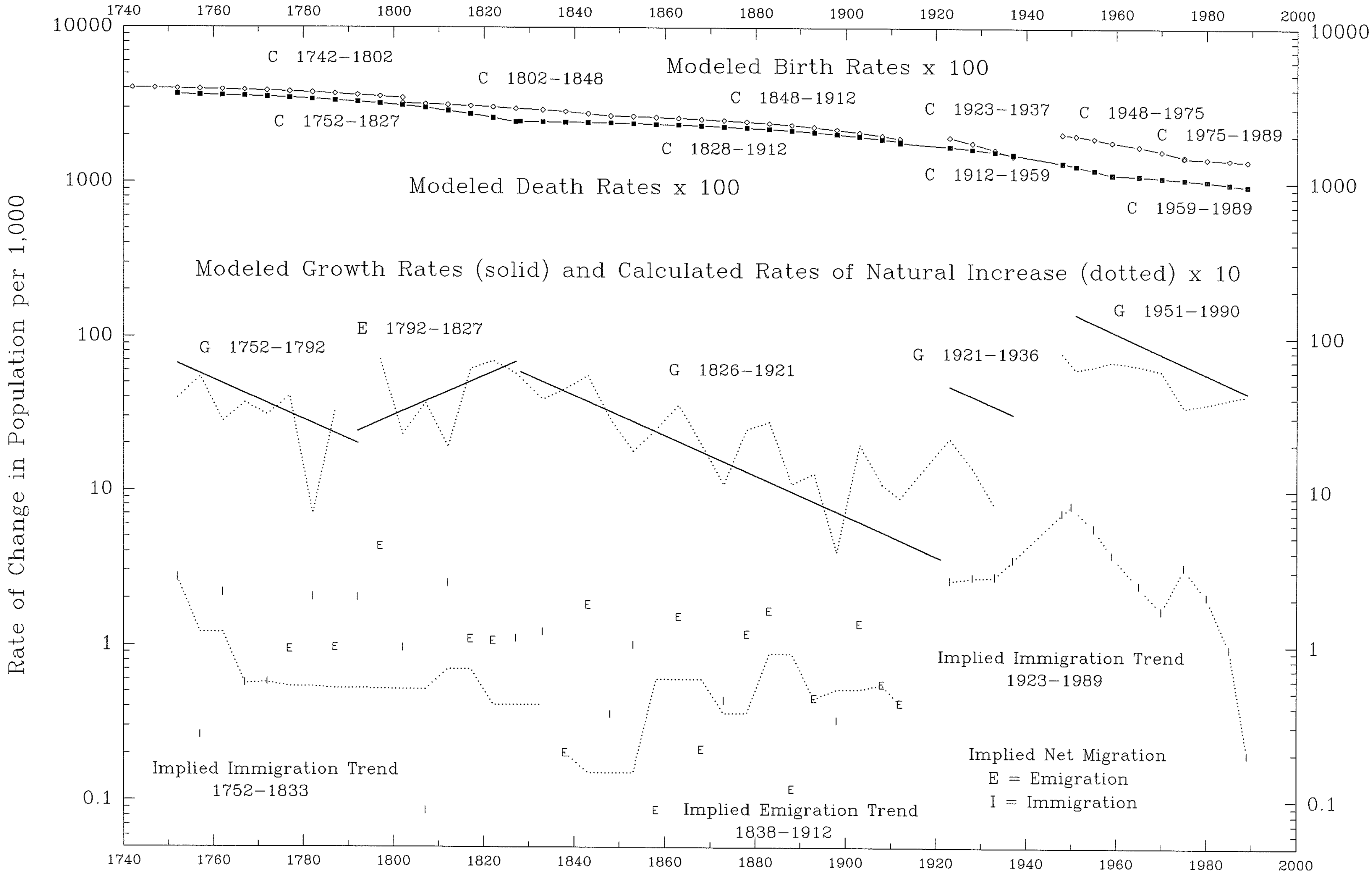
The Interplay of Birth and Death Rates with Population Growth and Net Migration: Sweden



Sources: Figures 2.1a and 2.2a; Harris 2001, 150–51; Harris 2003, 26.

Figure 3.1b

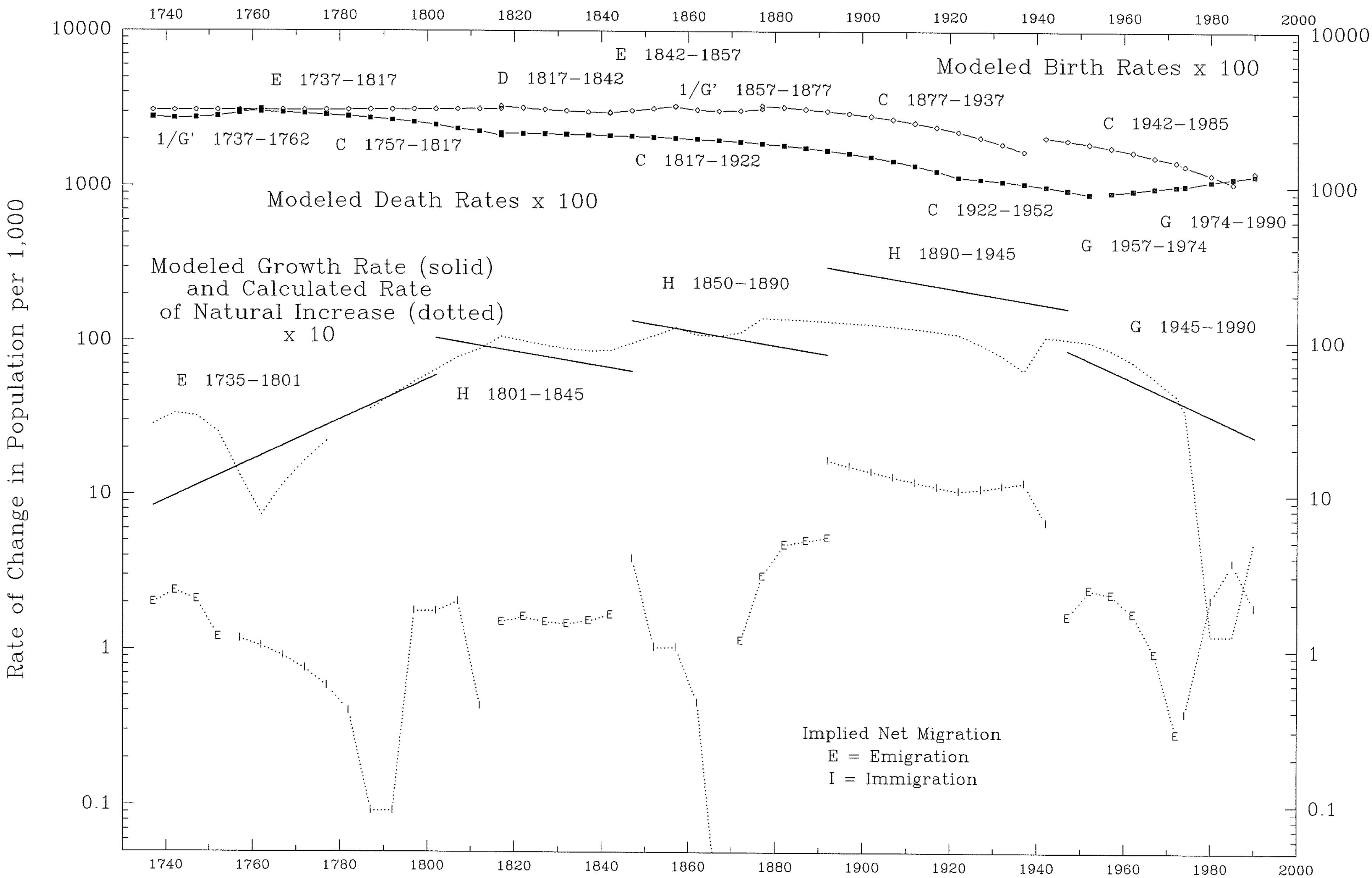
The Interplay of Birth and Death Rates with Population Growth and Net Migration: France



Sources: Figures 2.1b and 2.2a; Harris 2001, 152.

Figure 3.1c

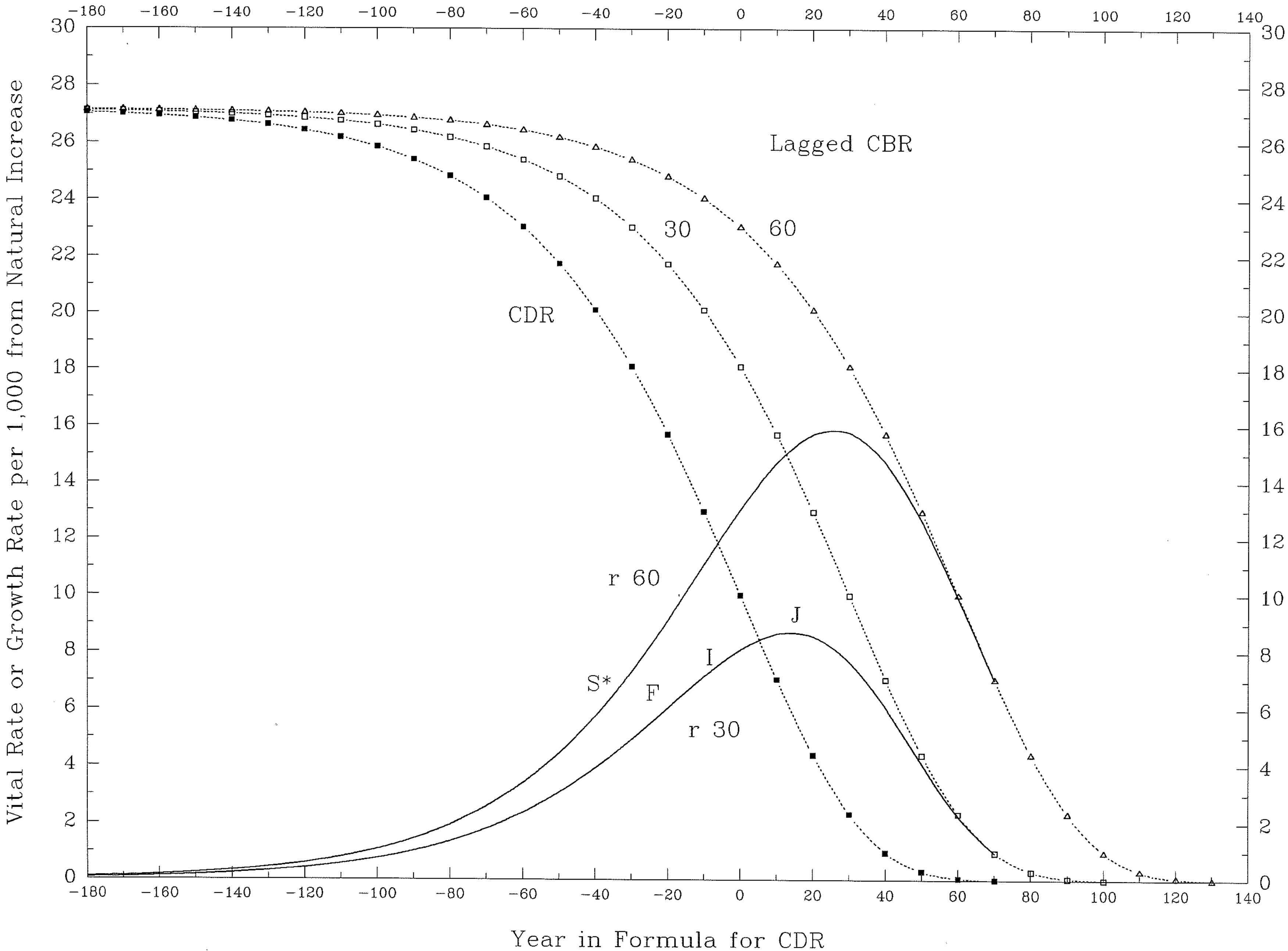
The Interplay of Birth and Death Rates with Population Growth and Net Migration: Denmark



Sources: Figures 2.1a and 2.2f; Harris 2001, 153.

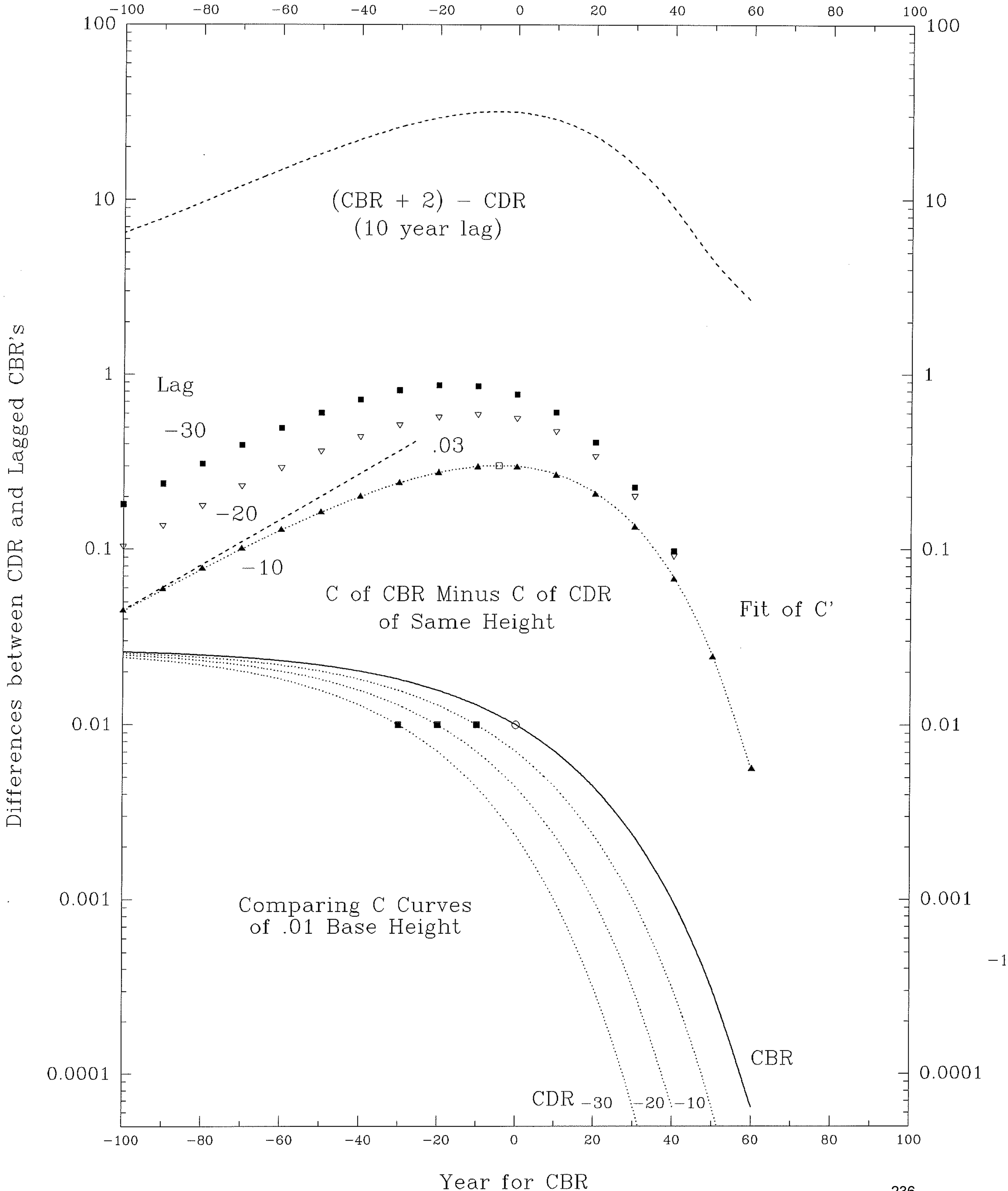
Figure 3.2a

C–Shape Birth Rates Lagging C–Shape Death Rates, and Consequent Growth Rates: Arithmetic Scale



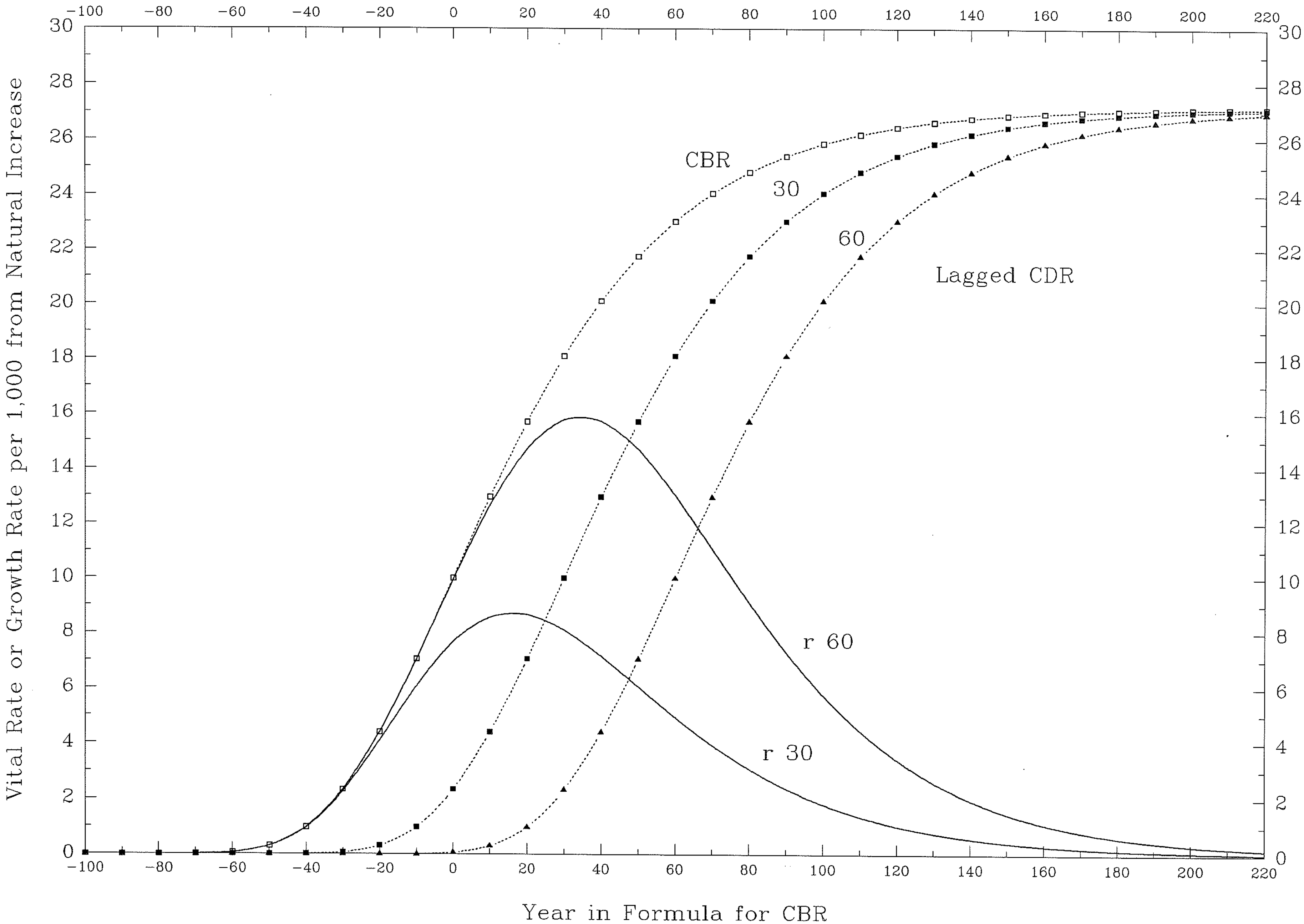
Sources and Explanations: See text.

Figure 3.2b
C-Shape Birth Rates Lagging C-Shape Death Rates, and Consequent Growth Rates: Semi-Logarithmic Scale



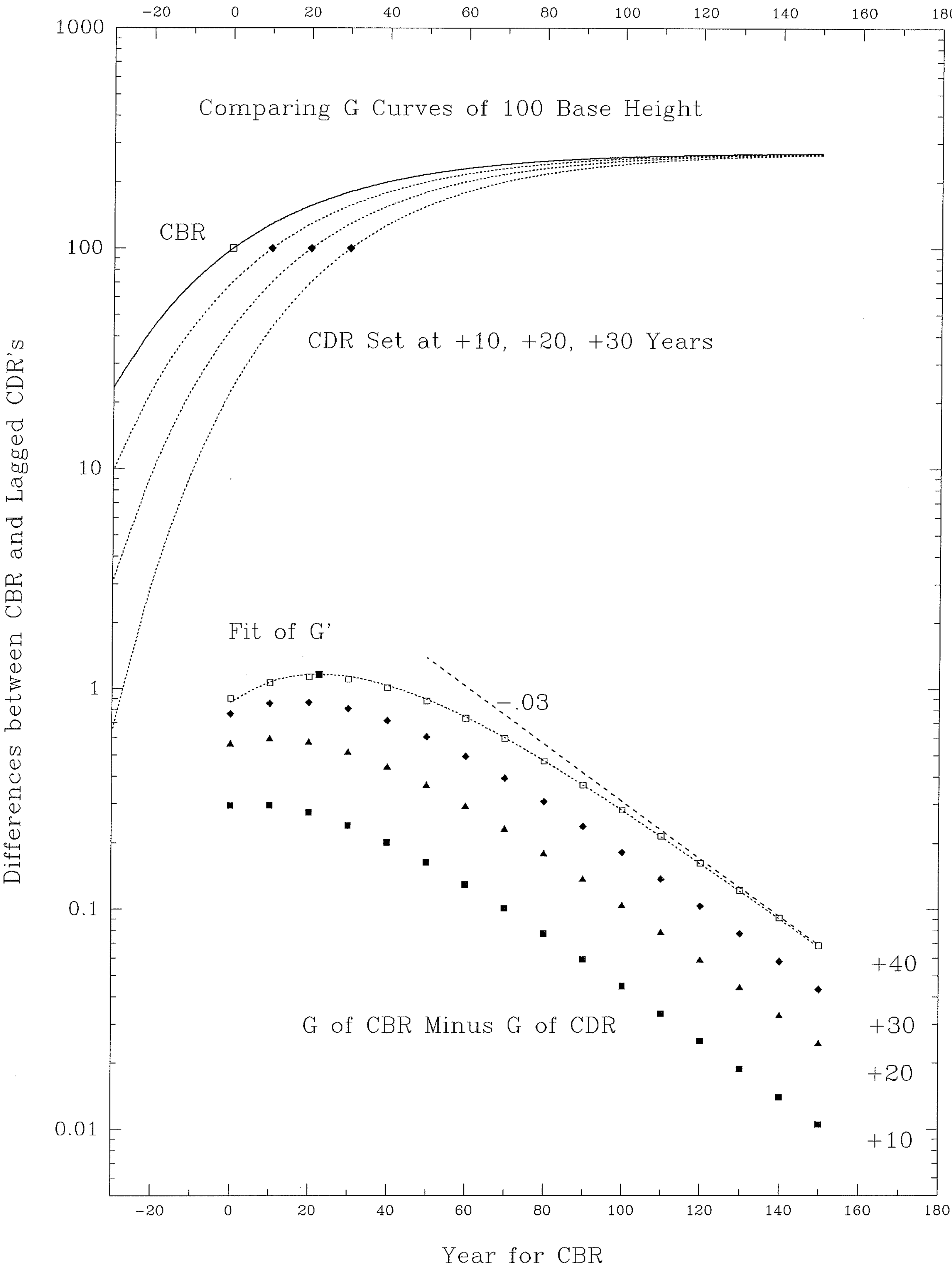
Sources and Explanations: See text.

Figure 3.3a
G–Shape Death Rates Lagging G–Shape Birth Rates, and Consequent Growth Rates: Arithmetic Scale



Sources and Explanations: See text.

Figure 3.3b
G–Shape Death Rates Lagging G–Shape Birth Rates, and Consequent Growth Rates: Semi–Logarithmic Scale



Sources and Explanations: See text.

Table 3.1

Tentative Combined Birth and Death Rate Groupings for Surveyed Populations

Crude Birth Rate Type:	Crude Death Rate Type: A-1	A-2	B-1	B-2	C
A-1:	England Scotland? Denmark Netherlands Germany Switzerland?		Belgium Imp. Austria	No./All Italy	
A-2:	Hungary				
A-3:		Romania		Portugal Japan	
A-4:		Philippines[a]		All/So. Korea[a] Singapore[a] Sri Lanka[a] Cyprus[a]	Taiwan[a]
			Panama[b]	Hong Kong[b]? China[b]? Puerto Rico[b] Mexico[b] Costa Rica[b] Venezuela[b] Guyana[b]	Malaysia[b] Mauritius[b]
		Russia[c]		Chile[c] Egypt[c]	Reunion[c]
B-1:	Sweden Norway		Luxemburg		
B-2:	Czech Lands	Finland Bulgaria Greece		France	
B-3:	Yugoslavia Argentina	Poland Uruguay		Spain	
B-4:				Brazil India	Pal./Israel
C:			Austria[1] U.S.A.[2] Canada[2]		
			Australia[3] New Zealand[3] Jamaica[3] Trin.-Tob.[3]	Ireland[3] No. Ireland[3]	
		Fiji[4]		Albania[4]	

Superscript letters and numbers refer to subcategories by timing of CBR classifications A-4 and C. See Tables 2.2 and 2.4.

Sources: Tables 2.1a, 2.1b, 2.3a, 2.3b.

Table 3.2

Comparing Trends of Population Growth and Birth and Death Rates in Selected Countries

A. A North-Sea-to-the-Alps European Zone of Demographic Change

I. Population Growth

England	Scotland ?	Denmark	Netherlands	Germany	Switzerland ?
1541-1556 G 1507			1500-1620 G 1471		
1561-1656 H 1461					
1656-1686 D 1587			1620-1750 G 1574		
1686-1726 H 1492					
1726-1806 E 1822	1755-1821 E 1839	1735-1801 E 1856	1750-1839 E 1866		
1816-1861 H 1758	1811-1871 H 1741	1801-1845 H 1706	1815-1869 H 1728	1816-1864 H 1743	1837-1888 H 1712
1861-1939 H 1794	1871-1911 H 1779	1850-1890 H 1775	1869-1889 H 1799	1864-1910 [E] 1923*	1880-1910 [E] 1934*
		1890-1945 H 1833	1899-1947 H 1849	1910-1950 [E] 1977*	1910-1970 [E] 1995*
1951-1991 G 1899	1891-1975 G 1896	1945-1990 G 1906	1947-1990 G 1906	1939-1990 G 1905	1970-1990 G 1901

II. Crude Birth Rate

England	Scotland	Denmark	Netherlands	Germany	Switzerland
1556-1661 C 1710					
1656-1751 G 1602					
1726-1816 E 1862		1737-1817 E 1936	1808-1823 E 1842	1775-1805 E 1854^{loc}	1737,1795 ?E 1856^{loc}
1816-1846 D 1779		1817-1842 D 1760	1823-1853 D 1767	1817-1857 D 1761	1807,1827 ?D 1770^{loc}
		1842-1857 [E] 1903*	1848-1878 [E] 1938*	1852-1877 [E] 1925*	
		1857-1877 G' 1868			
1851-1933 C 1933	1862-1937 C 1943	1877-1937 C 1944	1878-1938 C 1950	1877-1932 C 1929	1872-1937 C 1942
1933-1990 C 2032	1947-1984 C 1995	1942-1985 C 1987	1948-1979 C 1973	1937-1985 C 1994	1947-1984 C 1989

III. Crude Death Rate

England					
1556-1681 E 1722					

1681-1731	1/G'	1704															
						1737-1762	1/G'	1747				1755-1795	1/G'	1772			
1736-1831	C	1880				1757-1817	C	1846	1808-1913	C	1919	1795-1845	C	1906			
1831-1923	C	1936	1857-1922	C	1943	1817-1922	C	1935	1913-1937	C	1945	1867-1932	C	1929	1872-1932	C	1930
1923-1948	C	2030	1922-1957	C	2008	1922-1952	C	1981							1922-1957	C	1991
															1957-1975	C	2016
1948-1978	G	1840	1962-1984	G	1860	1957-1974	G	1913	1953-1990	G	1899	1952-1975	G	1902	1975-1990	G	1917
1973-1991	C	2044				1974-1990	G	1944				1971-1990	C	2051			

[loc] = local evidence; parentheses, brackets, and asterisks highlight distinctive trends.

Sources: Harris 2001, 148-49; Tables 2.1a, 2,1b, 2.3a, 2.3b.

Table 3.2 (cont.)

B. Northern Scandinavia and Francophone Europe

I. Population Growth

Norway			Sweden			Finland			France			Luxemburg			Belgium		
1665-1735	H	1512	1570-1720	H	1447				1675-1700	D	1566						
			1721-1748	G	1685	1723-1748	G	1702	1700-1752	G	1650						
1748-1818	H	1632	1748-1783	G	1706	1748-1793	G	1742	1752-1792	G	1702						
			1783-1818	G	1737	1793-1808	G	1772	1792-1827	[E]	1876*						
1818-1893	H	1758	1823-1848	G	1795	1808-1833	G	1801	1826-1921	G	1774				1815-1866	(H)	1717*
1893-1948	H	1797	1848-1943	(H)	1757*	1838-1873	G	1809				1839-1867	G	1796			
						1873-1908	G	1860				1895-1915	G	1868	1876-1910	(H)	1790*
						1908-1943	G	1878	1921-1936	G	1862	1922-1939	G	1889	1920-1947	G	1874
1948-1990	G	1917	1943-1990	G	1909	1943-1989	G	1911	1951-1990	G	1925	1947-1970	G	1908	1947-1990	G	1897
												1970-1989	G	1918			

II. Crude Birth Rate

Norway			Sweden			Finland			France			Luxemburg			Belgium		
1743-1773	G'	1758	1693-1933	C	1941	1723-1738	G'	1742									
1748-1813	C	1869				1753-1808	C	1854	1742-1802	C	1859						
									1802-1848	C	1895	1842-1857	C	1908	1847-1872	[E]	1922*
1818-1923	C	1959				1808-1938	C	1952	1848-1912	C	1944	1857-1942	C	1944	1872-1942	C	1945
									1923-1937	C	1945						
1948-1985	C	1992	1943-1985	C	2001	1943-1973	C	1972	1948-1975	C	1992	1942-1987	C	2014	1947-1985	C	2001
						1973-1988	C	2051	1975-1989	C	2054						

III. Crude Death Rate

Norway			Sweden			Finland			France			Luxemburg			Belgium		
1743-1773	1/G'	1758	1693-1743	1/G'	1716	1723-1763	1/G'	1724									
1738-1823	C	1860	1743-1843	C	1881	1763-1878	C	1929	1752-1827	C	1853						
1823-1933	C	1948	1843-1923	C	1941	1873-1953	C	1959	1828-1912	C	1951	1842-1932	C	1947	1815-1922	C	1935
1933-1958	C	1987	1923-1953	C	1983				1912-1959	C	1974	1932-1987	C	2046	1922-1988	C	2038
1958-1990	{G}	1918+	1958-1990	{G}	1912+	1958-1988	{G}	1882+	1959-1989	C	2030						

Table 3.2 (cont.)

C. Hapsburg and Southwestern Europe

I. Population Growth

Czech Lands			Austria			Hungary			Italy			Spain			Portugal		
									1550-1625	G	1499	1540,1589	?G	1496	1500,1636	?G	1425
									1625-1675	D	1566	1589,1648	?D	1563			
												1648-1768	(H)	1527*	1636-1768	(H)	1547*
			1700,1774	?G	1663				1700-1771	G	1696						
			1774-1828	G	1694	1793-1817	G	1753	1771-1821	G	1717	1768-1797	G	1718	1768-1835	G	1726
1818-1851	G	1790	1821-1857	G	1786	1817-1880	G	1808	1821-1861	G	1790	1797-1887	(H)	1680*			
1851-1890	(H)	1739*	1850-1880	[E]	1910*	1880-1910	(H)	1811*	1861-1936	(H)	1755*				1841-1890	[E]	1920*
1880-1910	[E]	1945*	1880-1910	[E]	1934*							1887-1920	[E]	1952			
1910-1930	[E]	2004*	1923-1961	G	1847	1910-1941	[E]	1977				1920-1960	(H)	1829*	1920-1970	G	1897
1947-1990	G	1913	1961-1990	G	1897	1949-1990	G	1897	1952-1990	G	1910	1960-1990	G	1932	1970-1990	G	1938

II. Crude Birth Rate

Czech Lands			Austria			Hungary			Italy			Spain			Portugal		
1787-1837	C	1885							1770-1800	[E]	1870*						
			1822-1847	D	1778				1825-1855	D	1778						
			1847-1872	[E]	1951*	1867-1887	[E]	1947*							1843-1878	[E]	1959
1837-1937	C	1943	1872-1912	C	1952	1882-1937	C	1938	1862-1942	C	1955	1859-1932	C	1966	1877-1897	C	1942
															1892-1922	[E]	2002*
															1922-1942	C	1955
1942-1990	C	2008	1908-1932	C	1917	1937-1990	C	2002	1942-1989	C	1986	1936-1975	C	2024	1942-1962	C	2045
			1932-1967	{G}	1897+							1975-1988	C	1971r	1962-1988	C	1979r
			1962-1985	D	1960												

III. Crude Death Rate

Czech Lands			Austria			Hungary			Italy			Spain			Portugal		
1787-1812	1/G'	1787							1770-1815	G	1715						
1817-1932	C	1939	1832-1932	C	1934	1887-1932	C	1934	1820-1912	C	1935	1867-1957	C	1946	1887-1957	C	1966
1942-1957	C	1952				1932-1957	C	1966	1912-1952	C	1955						
1962-1980	{G}	1944+	1932-1990	C	2043	1967-1988	{G}	1949+	1952-1989	C	2080	1957-1982	C	2015	1957-1988	C	2028

Table 3.2 (cont.)

D. Some British 'New World' Colonies

I. Population Growth

U.S.A.			Canada			Australia			New Zealand			Jamaica			Trinidad & Tobago		
1607-1675	G	1673	1650-1670	G	1672							1650-1700	G	1693			
1675-1850	F	-	1680-1730	F	-												
			1730-1770	H	1728							1700-1770	H	1698			
			1790-1824	G	1811	1790-1815	G	1834				1787-1844	G	1769			
1850-1930	H	1853	1824-1901	G	1851	1810-1830	G	1856									
									1858-1886	G	1894	1861-1891	G	1842	1844-1861	G	1832
			1901-1941	G	1903	1830-1911	G	1881	1896-1945	G	1899	1891-1921	G	1868	1861-1931	G	1883
						1911-1946	G	1904									
1940-1997	H	1888	1951-1990	G	1948	1954-1983	G	1950	1945-1983	G	1943	1940-1960	G	1929	1946-1990	G	1948
												1970-1990	G	1953			

II. Crude Birth Rate

U.S.A.			Canada			Australia			New Zealand			Jamaica			Trinidad & Tobago		
1800-1850	C	1883				1822-1847	G	1793	1857-1877	[E]	1939						
1862-1902	C	1928	1871-1901	C	1929	1847-1897	C	1941	1847-1897	C	1889						
1907-1937	C	1940	1901-1937	C	1960	1912-1937	C	1938	1892-1937	C	1950	1902-1942	C	1982	1902-1932	C	1979
1937-1952	{G}	1932+	1937-1952	{G}	1933+	1937-1952	{G}	1932+	1937-1952	{G}	1935+	1947-1962	{G}	1933+	1932-1947	{G}	1920+
1952-1975	C	1977	1957-1974	C	1959	1952-1977	C	1992	1957-1985	C	1985	1962-1988	C	1990	1947-1988	C	1993
1975-1990	{G}	1936+	1974-1988	C	2043	1977-1989	C	2037									

III. Crude Death Rate

U.S.A.			Canada			Australia			New Zealand			Jamaica			Trinidad & Tobago		
1863-1930	C	1944 (M)							1862-1887	C	1909	1885-1912	[E]	1961*			
1903-1923	C	1936	1856-1916	C	1928	1902-1932	C	1957	1887-1932	C	1984	1912-1932	C	1937	1911-1937	C	1950
1923-1953	C	1986	1922-1967	C	1991							1932-1962	C	1953	1942-1962	C	1944
1953-1990	C	2045	1967-1982	C	2043	1937-1982	C	2010	1937-1977	C	2017	1966-1988	C	1990	1967-1982	C	2025

(M) = Massachusetts; + = rising modern trend in birth rate.

Table 3.2 (cont.)

E. Examples from Asia

I. Population Growth

Korea	Philippines	Singapore	Ceylon/Sri Lanka	India	Japan
				1800-1881 G 1766	1792-1852 G 1719
			1850-1891 G 1848	1881-1921 G 1834	1872-1885 [E] 1925*
	1876-1918 G 1897	1871-1901 G 1883	1901-1921 G 1879		1885-1915 [E] 1935*
1910-1944 [E] 1954*	1918-1948 (H) 1899	1911-1931 G 1921		1901-1970 [E] 1972*	1915-1935 [E] 1952*
	1939-1960 [E] 1956*		1921-1963 [E] 1957*		1920-1945 G 1902
	1960-1980 F -				1945-1965 G 1931
1955-1990 G 1957	1975-1990 G 1976	1947-1985 G 1960	1963-1990 G 1956	1961-1990 (H) 1947	1965-1990 G 1939

II. Crude Birth Rate

Korea	Philippines	Singapore	Ceylon/Sri Lanka	India	Japan
1912-1927 [E] 1953*	1903-1927 [E] 1980*	1912-1937 [E] 1957*	1902-1927 [E] 1990*	1886-1953 C 1996	1877-1912 G 1855
1927-1953 C 2003	1922-1955 C 2009		1927-1947 1/G' 1939		1912-1989 C 1977
1957-1988 C 1971	1953-1987 C 2007	1952-1977 C 1955	1952-1989 C 1995	1958-1989 C 2006	

III. Crude Death Rate

Korea	Philippines	Singapore	Ceylon/Sri Lanka	India	Japan
					1872-1922 G 1839
1913-1948 C 1946	1922-1962 C 1949	1902-1962 C 1933	1907-1962 C 1944	1896-1953 C 1962	1917-1957 C 1942
1948-1978 C 1956				1953-1973 C 1973	
1978-1988 C 2021	1962-1987 {G} 1908+	1967-1981 C 2014	1962-1989 C 2003	1973-1989 C 1985	1962-1977 C 2004

Table 3.2 (concl.)

F. Examples from Latin America

I. Population Growth

Mexico (W. C. to 1780)			Costa Rica			Guyana			Chile			Argentina			Brazil		
1548-1620	D	1573	1522-1622	D	1504												
1620-1650	D	1585													1585-1660	G	1593
1660-1720	[E]	1729*															
1710-1740	(H)	1697	1700-1751	G	1685										1690-1823	(H)	1710
1740-1780	F	-															
1803-1831	G	1746	1778-1824	G	1773				1802,1813	?G	1764	1778-1809	(H)	1709			
1831-1873	(H)	1740	1835-1864	G	1826	1841-1861	G	1838	1813-1833	G	1813	1809-1839	(H)	1764	1823-1872	(H)	1806
			1864-1892	[E]	1886*												
1873-1910	(H)	1819	1883-1930	G	1893	1861-1891	G	1854	1843-1907	(H)	1813	1857-1895	F	-			
1921-1960	[E]	1952*	1920-1963	[E]	1946*	1891-1931	G	1836r	1907-1960	[E]	1960*	1895-1970	(H)	1905	1900-1940	(H)	1885
															1950-1970	F	-
1940-1990	F	-	1963-1990	G	1973	1946-1985	G	1949	1970-1990	G	1960	1970-1990	G	1959	1970-1990	G	1972

II. Crude Birth Rate

1897-1917	C	1953															
1912-1952	[E]	2026*	1887-1957	[E]	2005*	1902-1942	[E]	2010*	1897-1947	C	1978	1872-1937	C	1947			
						1942-1952	[E]	1944*r									
1952-1972	C	2027	1957-1972	C	1964	1952-1967	C	1973	1957-1977	C	1971	1937-1967	C	2014	1937-1987	C	2002
1972-1988	C	1988r	1972-1989	C	2007	1972-1982	C	2004	1977-1989	?[E]	2056?	1967-1988	boomlet?				

III. Crude Death Rate

			1887-1912	G	1821				1880-1907	G	1833						
												1872-1932	C	1926	1872-1897	C	1931
1897-1962	C	1951	1917-1977	C	1952	1922-1962	C	1944	1907-1957	C	1948	1932-1952	C	1962	1902-1972	C	1970
1962-1981	C	1971				1962-1982	C	1990	1962-1977	C	1968	1957-1977	{G}	1883+	1977-1987	C	2013

r = retroactively timed trend of same shape; + = rising modern trend in death rate.

Table 3.3

Trend Sequences in the North Sea-Alps Group, Northern Scandinavia, and France

A. The North Sea-Alps Cluster of European Demographic Change

England

Growth Pattern			Birth Rate			Death Rate		
1541-1556	G	1507						
1561-1656	H	1461	1575-1665	C	1731	1556-1681	E	1722
1656-1686	D	1587	1665-1755	G	1608			
1686-1726	H	1492				1681-1731	1\G'	1704
1726-1806	E	1822	1725-1795	E	1867	1736-1831	C	1880
1816-1861	H	1758	1795-1845	D	1779			
1861-1939	H	1794	1851-1933	C	1933	1831-1923	C	1936
1951-1991	G	1899	1933-1990	C	2032	1923-1948	C	2030
						1948-1978	G	1840+
						1973-1991	C	2044

Denmark

1735-1801	E	1856	1737-1817	E	1936	1737-1762	1/G'	1747
						1757-1817	C	1846
1801-1845	H	1706	1817-1842	D	1760	1817-1922	C	1935
1850-1890	H	1775	1842-1857	E	1903			
			1857-1877	G'	1868			
1890-1945	H	1893	1877-1937	C	1944			
1945-1990	G	1906	1942-1985	C	1987	1922-1952	C	1981
						1957-1974	G	1913
						1974-1990	G	1944+

Netherlands

1500-1620	G	1491						
1620-1750	G	1574						
1750-1839	E	1866	1808-1823	E	1842	1808-1913	C	1919
1815-1869	H	1728	1823-1853	D	1767			
1869-1889	H	1799	1848-1878	E	1938			
1899-1947	H	1843	1878-1938	C	1950	1913-1937	C	1945
1947-1990	G	1906	1948-1979	C	1973	1953-1990	G	1899+

Germany

			1775-1805	E	1854 (local)	1755-1795	1/G'	1772
1816-1864	H	1743	1817-1857	D	1761	1795-1845	C	1906
1864-1910	E	1923	1852-1877	E	1925			
1910-1950	E	1995	1877-1932	C	1929	1867-1932	C	1929
1939-1990	G	1905	1932-1985	C	1994	1952-1975	G	1902+
						1971-1990	C	2051

Table 3.3 (cont.)

B. Northern Scandinavia and France

Norway

Growth Pattern			Birth Rate			Death Rate		
1665-1725	H	1512						
1748-1818	H	1632	1743-1773	G'	1758	1743-1773	1/G'	1758
			1748-1813	C	1869	1738-1823	C	1860
1818-1893	H	1758	1818-1923	C	1959	1823-1933	C	1948
1893-1948	H	1757				1933-1958	C	1967
1948-1990	G	1917	1948-1988	C	1992	1958-1990	G	1918+

Sweden

Growth Pattern			Birth Rate			Death Rate		
1570-1720	H	1447						
1721-1748	G	1685	1693-1933	C	1941	1693-1743	1/G'	1716
1748-1783	G	1706				1743-1843	C	1881
1783-1818	G	1737						
1823-1848	G	1795				1843-1923	C	1941
1848-1943	H	1757				1923-1953	C	1983
1943-1990	G	1909	1943-1985	C	2001	1958-1990	G	1912+

Finland

Growth Pattern			Birth Rate			Death Rate		
1723-1748	G	1702	1723-1738	G'	1742	1723-1763	1/G'	1724
1748-1793	G	1742	1753-1808	C	1854	1763-1878	C	1929
1793-1808	G	1772						
1808-1833	G	1801	1808-1938	C	1952			
1838-1873	G	1809						
1873-1908	G	1860				1873-1953	C	1959
1908-1943	G	1878						
1943-1989	G	1911	1943-1973	C	1972	1958-1988	G	1882+

France

Growth Pattern			Birth Rate			Death Rate		
1675,1700	?D	1566						
1700-1752	G	1650						
1752-1792	G	1702	1742-1802	C	1859	1752-1827	C	1853
1792-1827	E	1876	1802-1848	C	1895			
1826-1921	G	1772	1848-1912	C	1944	1828-1912	C	1951
1921-1936	G	1862	1923-1937	C	1945	1912-1959	C	1974
1952-1990	G	1925	1948-1975	C	1992	1959-1989	C	2030
			1975-1989	C	2054			

+ = modern rising trend in death rate.

Source: Table 3.2.

CHAPTER 4

Components of Modern Fertility Transition in European Countries

What ensures that populations replace themselves, and does most to make them grow, is the rate of reproduction for women. Do trends in more precise measures of fertility than crude birth rates also take G-related forms? Is the origin of the ubiquitous G-based movements that have been observed in so many areas of population history perhaps generated by some characteristic of human fertility?

The more specific that analyses of demographic behavior are made, the smaller the pool of historical evidence becomes. Precise, reliable measurements of fertility that are more fundamental to reproduction than crude birth rates are generally modern--mostly since the middle of the 1800s--and historically predominantly European. This makes for a bias in the kind of demographic experience for which there is insight: namely, types of change that populations have been undergoing quite recently. The English and some other examples have already demonstrated, however, that various G-related forms of trend in the birth rate that modern peoples have been experiencing have also appeared in considerably earlier times, and well beyond the confines of Europe. One should at least consider the possibility that the more specific processes of reproduction that are shown to have been shaping recent CBR trends in G-based forms lately may have done the same for birth rate movements of comparable shape in earlier eras and other populations for which the more detailed evidence is not, and is likely never to be, available.

The analysis begins with a reexamination, employing the new framework of G-based patterning, of the largest and richest historical corpus on international fertility available--the research of Ansley J. Coale's Princeton group on European countries from the middle of the 1800s into the middle of the 1900s, an era during which fertility decline associated with demographic transition spread across that continent. In subsequent chapters, other insights from earlier and more local findings, and evidence from outside Europe, are then brought to bear upon the emerging reinterpretation of where, and when, and in what patterns fertility changed.[1]

What role did fertility, and the nuptiality that enabled it, play in generating and perpetuating the ubiquitous demographic trends connected to the G curve that emerge from the historical evidence? Was the nature of the human reproductive process somehow the source of the closely related, small set of recurrent G-based shapes in demographic change? Or did movements in fertility or nuptiality instead acquire such forms from some other dynamic operating in populations? Are, on the other hand, patterns of this G-based type perhaps simply irrelevant once one digs down to explore reproductive processes more basically and precisely than via crude birth rates?

THE GROWING ROLE OF ADJUSTMENT IN MARITAL FERTILITY FROM THE 1800s INTO THE 1900s

The outstanding feature of the modern 'fertility transition' has been the rising significance for demographic change of reproduction within marriages in place of the once leading role of the frequency and duration of marriages. In a capstone volume for the Princeton studies of modern historical change in fertility (Coale and Watkins 1986), an essay by Coale and Treadway made conclusions about trends in fertility for 26 European countries. It summarized and interpreted periodic evidence on four indicators of reproduction:

Marital fertility (I_g) refers to the number of legitimate births in a population per married female age 15 to 50. In the Princeton approach, the index is set with 1.0 being the supposed maximum rate for *homo sapiens*. This is estimated from North American Hutterite levels in the 1920s, a familiar standard from a well-recorded special human population that practiced no measures to reduce fertility. Overall fertility (I_f), in contrast, relates all births to *all* women of fertile age, against the same historical standard for a likely maximum. Illegitimate fertility (I_h) measures, comparably, the reproduction of unmarried women 15 to 50; and the index of proportion married (I_m) denotes the extent to which the share of females of child-bearing age were currently 'at risk' in wedlock. Together, these measures provide several insightful perspectives on the dynamics of reproduction in those populations that can be sufficiently documented.

The main contributors towards determining overall fertility (I_f) are the proportion of potentially reproductive women who are in marriages (I_m) and the rate at which these females reproduce (I_g). In most historical circumstances that are currently documented, the rate of child-bearing outside marriage (I_h) did not play a substantial part--though changes in this behavior through time throw useful light upon how patterns for marriages and for births have been shaped historically by factors such as the ups and downs of economic opportunity and the vicissitudes of tradition and social control. The crude birth rate (CBR), on the other hand, still further incorporates influences on the denominator population from patterns of mortality and of age structure that is shaped by interaction of both the way births add people and the manner in which deaths subtract them.

{Please note that the Figures and Tables referenced in Chapter 4 are not interleafed in the text but appear after the text (notes). MSW 31 July 2015}

As Tables 2.3a and 2.3b and Figures 2.2a through 2.2f have previously shown the crude birth rate to move, all of these fertility rates for the 26 European populations that the Princeton group studied display G-based patterns. Given limited space, mostly just the data by country are analyzed in the present discussion. For those who would like to test any argument or patterning that is made here at the level of societal populations in finer geographical detail, however, Coale and Treadway also summarize the four indices for hundreds of “provinces” within these two dozen nations (1986, 80-152).[2]

In modern demographic contexts, overall mortality mostly has little intervening effect between overall fertility and the crude birth rate. This is demonstrated, for example, by how parallel the C trends of European CBR in Chapter 2 are with contemporary' patterns for I_f, as shown by Table C.1 in Appendix C. Similarly, during demographic transition in Europe since the middle of the 19th century, change in the marriage rate of populations has mostly had little impact upon overall fertility (though international differences in the *level* of total fertility have been sensitive to the level of the marriage rate). In an age during which contraception and other methods for controlling births became widely available and utilized, the key movement was in the rate of child-bearing *within* marriage, as repeatedly close parallels of trends in I_g (solid squares) and I_f (hollow circles) in Figures 4.1a through 4.1f demonstrate (again summarized in Tab. C.1).[3]

The figures plot these largely similar trends for marital fertility and overall fertility in the countries of Europe, clustered by geographical location, from the mid-1800s to the late 1900s. For some populations the evidence is only recent and fragmentary, and it becomes necessary to splice rates for rather different territorial units--as for pieces of the former Austro-Hungarian Empire before and after World War I. Though those more knowledgeable about local particulars may well make improvements--including exploring the patterning further, into the beginning of the 21st century--certain fruitful generalizations emerge from the data.

First of all, for both overall fertility (I_f) and its principal driving engine of reproduction in marriage (I_g), the C curve (G reversed with respect to time) repeatedly captures the way that rates came down in Europe during the basic long-term fertility decline from the 19th into the 20th century. In most cases, further patterns of this shape also appear in change that has occurred since the temporary increases in births that immediately followed World War II, movements that--on the fertility side of the interaction, at least--lend support to the contention of John C.

Caldwell (2000, 311-14) that demographic transition (in response to the shift from agricultural to industrial economies) is still in progress, not some new phase of change. The literature has not yet recognized the distinctive G-related C shape of this repeated form of trend, or its generality across the modern decline of fertility in Europe. Different countries obviously saw reductions commence from different levels and follow different timings; but the *shape* of the trends has been very much the same everywhere. Table 4.1 summarizes and organizes these movements for marital fertility in 26 countries of the continent by the timing of the applicable C curve and the presence or absence of a particular *alternative* shape of change in I_g.

That is, for several decades of its course past the zero year the G’ curve of the first derivative of the G function declines almost identically along with the C trend of G reversed with respect to time as this approaches its own t_0. The patterning for marital fertility (the solid squares) for the Netherlands in Figure 4.1a illustrates this point. The fitted curves for 1879-1930 of C (medium dash) and G’ (short dash) are virtually indistinguishable. Marital fertility in Belgium from about 1860 to 1910 displays alternative trendings that are only slightly easier to tell apart. For several countries plotted in Figures 4.1a through 4.1f, in fact, fertility changes for substantial periods of time might equally or even better be fitted with such a segment of the G’ curve rather than via C.

One could think that encountering fairly frequent alternative G’ patterns weakens the argument that the C curve has a quite general international role in the modern reduction of reproduction. To the contrary, the finding strengthens and expands the interpretation by adding two kinds of fruitful insight.

First of all, as one moves from marital fertility through overall fertility to consider the even more complexly determined crude birth rate (as in Ch. 2), the G’ alternative becomes less useful with each step. The CBR measure--which, with the death rate, ultimately determines how populations grow--widely takes simply the C form. And, as Figures 4.1a through 4.1f indicate, change in overall fertility (*If*), which is tempered by the rate of births out of wedlock (increasingly important recently in many societies) and by what happens to the proportion of potentially child-bearing women who are ‘at risk’ to reproduce in a formal union or other relationship, adheres to the C pattern somewhat more consistently than that in marital fertility (*Ig*). From observing the alternative trending that is present in one series but becomes progressively less evident in the others, a sense emerges of how specific changes in marital fertility that take G’ form contribute to C patterns of more general and compounded reduction in total fertility and, most steadily and comprehensively of all, C shapes of decline in crude birth rates.[4]

Second, the presence of likely G’ trends in some populations but not others confirms and clarifies the ways that, say, 19th century industrialization or social and economic changes after World War II provided first somewhat strengthening, only then weakening, stimulus for fertility response in some countries but not the rest. International and inter-regional relationships in historical demographic change, the contrasts or comparisons involved, and their likely sources, are suggested.

Populations across Europe since the 1800s have tended to group geographically according to their patterns of change in *marital* fertility. Drawing from Figures 4.1a through 4.1f, Table 4.1 compares and contrasts developments at the elemental level of births within marriage (I_g) for the 26 societies covered in the Princeton summary of Coale and Treadway. It lists the chronological range, zero year, and proportion of the Hutterite standard that would be reached at t_0 for C shapes of trend fitted to the data--both for the fundamental recorded local movement of this type from the 1800s into the 1900s and for any more recent pattern of that shape. “None” indicates that data for this stage exist but the C form does not, from the available evidence, appear to be appropriate. Where there seems also to be a G’ trend in the series, the zero or maximum year for such a fitted curve is given in the second column of the table. A dash (-) in this column signifies that no G’ alternative seems likely. Austria and Hungary each occupy two lines: the upper for the larger “Austrian” or “Hungarian” divisions of the Hapsburg Empire before World War I, the lower for the smaller countries that bore these names after Versailles. Bohemia is used as a surrogate for Czechoslovakia before 1919.[5] As the vertical spacing of the table indicates, four sets of countries tend to cluster in terms of the behavior of their marital fertility during the European era of decline between the middle 1800s and middle 1900s.

From Britain through the Low Countries and Denmark into central Europe seven or eight populations display C trends in I_g that began (or are first documented) between 1860 and 1881 and then extend into the inter-war period. The timings by base year for these curves come between 1914 and 1941, on average in the early 1930s. The value of I_g at the zero year for these fits ranges from .30 to .39, with a mean of approximately .34. Back about three-quarters of the way through the 19th century, where the C pattern was quite flat for this cluster of populations , the level average of marital fertility ran at about .78 of the hypothesized human maximum. In all of these countries except Scotland, however, the G’ form seems to capture the movement as accurately, or more accurately, for the same or even longer local time spans (Figs. 4.1a through 4.1d). In these instances the G’ shape, though close to the behavior of the applicable C curve, offers a somewhat better (more precise and/or more inclusive) characterization of the evidence. These G’ patterns, moreover, cluster even more tightly in their timing by zero year than their C counterparts. The most representative, generally shared pattern for marital fertility in this group of countries (except Scotland), in other words, between the 1860s and the 1930s is in fact G’ with zero year near 1877.[6]

Largely comparable was the behavior of marital fertility across a northern arc fringing Europe from Iceland to Finland.[7] In all, in this northern zone of four countries (including the 1860-1900 trend in Sweden), the C-shape decreases in I_g seem to have headed for zero years around 1952, on average some two decades later than the patterns of the first group of populations above them in Table 4.1. With a mean target level of about .31 at the t_0’s of their curves, however, they were in the process of falling only slightly lower (compared with .34) from a starting plateau that lay at about .75 near 1870--just a little under the .78 of the populations in previous region of Europe considered.

While the evidence from Sweden, Finland, and Norway seems to lend itself to alternative G' patterning, the data of Iceland do not.[8] Northern Scandinavia, however, shared having alternative G' patterns with Denmark and the other populations of the first cluster of nations on the list--though these peaked on average about a decade and a half later (1886 vs. 1870). In all, except for that difference in timing, movements of marital fertility in this second array of four extremely northern European countries were generally very similar to those of the group stretching geographically from Britain to Bohemia.

Within western Europe, from Luxemburg through France southwestward to Spain and Portugal and southeastward into Italy stretches a region of five countries with C trends for I_g that have, on *average*, timings comparable to those of the northern Scandinavian group just examined. Among them, however, Luxemburg and France display t_0's for their C trends as early as the Britain-to-Bohemia group while Italy, Portugal, and Spain, in contrast, have C curves of about a generation later.[9] Notable among this romance-speaking cluster of populations in western Europe, however, is the wide range of *levels* along which chronologically parallel C-form decline took place underneath an average of .30 for the five curves, with Luxemburg unusually high and France exceptionally low.[10]

In fact, the extended French data (Fig. 4.1a) show that as early as the *1830s* (perhaps even sooner) fertility in marriage there had been lowered this far. The international lead of the French people in reducing fertility has long been recognized. The maps of Coale and Watkins (1986, Maps 2.1 and 2.2, back pocket), for example, show how *all* the localities of Europe that had by the authors' definition experienced sustained decline in marital fertility by 1830 lay within just this one country. So did *all* zones where I_g was under .530 as of 1870. There is, however, a limit to this French exceptionalism that needs to be understood: As of the middle 1800s *further* change in marital (and overall) fertility in France unfolded in the *same* pattern as among neighboring populations--along a typically timed C curve. The early demographic change that for a while set France apart was already *over* and in place by 1830 (or earlier).

Meanwhile, it seems unlikely that before the 1930s marital fertility for France as a whole ever rose then fell away in G' form.[11] The absence of an alternative pattern in this shape was shared by Portugal, Spain, and Luxemburg as well as Ireland, Iceland, and Scotland. Though marital fertility in Italy, might *possibly* be said to have moved in a G' way, that interpretation depends primarily on the calculation for just the one time-point of 1921 (Fig. 4.1e). In other words, the G' pattern for change in marital fertility seems characteristically to have been a phenomenon of northern and central Europe without the outer Atlantic fringe of Ireland, Scotland, and Iceland. Except for contiguous Belgium, in countries south and west of the Rhine and the Alps it was absent.

Patterns for eastern Europe strengthen this impression, though they extend the zone of likely G' movements that has been identified somewhat further into the heart of the continent. Bohemia and Austria, next to Germany and Switzerland, are joined by Hungary in displaying probable trends of G' shape. Change of marital fertility in five other countries of eastern and southeastern Europe, in contrast, seems to take C form without that G' alternative, though the data are sparse in several instances. Bulgaria at present simply cannot be trended in G-related terms. The C-type movements for eastern Europe, furthermore, generally lasted three-quarters of the way through the 20th century, well past World War II: along with that of Ireland, all the fitted curves--not unlike those of Portugal, Spain, and Italy--head toward zero years only from about 1960 into the early 1970s. Broadly speaking, 'transition'-era C trends in I_g tended to dive deeper while they accelerated only later and later as fertility reduction progressively diffused across the continent.[12]

These country-by-country trendings obtained by looking at the data through the new lens of G-related *shapes of movement* to a considerable extent provide temporal and spatial results concerning fertility transition in Europe that are similar to the interpretations of the Princeton group. Coale and Treadway, for example, by their criterion of where 10 percent or more reduction leading to sustained decline in marital fertility occurred, identify as laggards Ireland, Russia, Romania, Albania, southern Greece, southern Italy, Spain, and Portugal: “Ireland and the southern and eastern periphery of Europe” (1986, 40). The timing of the C curves in the left half of Table 4.1 shows late change--with zero years from 1959 through 1979--for each of these countries (except for Albania, which is not documented sufficiently) but also for Hungary, Yugoslavia, and Poland. Coale and Treadway, it should be remembered, based their regionalizing conclusions upon more localized provincial data from within countries, a finer instrument for classification than the national entities that are employed here for simplicity in demonstrating the historical significance of the new G-based trendings for the history of fertility.[13] The comparison of C-curve timings shown in Table 4.1, meanwhile--both for these later countries and across the rest of the continent--also fits the general conclusion of Watkins (1986, 448) that fertility decline began in northwestern Europe and, as Knodel and van de Walle put it (1986, 411-12), from there diffused to place after place and from group to group within locales.

While findings via the C and G’ curves of Table 4.1 tend to indicate timings of this dissemination that are similar to the picture drawn by the Princeton group of analysts, they go further to provide additional information:

1) Instead of a one-time cut-off measure such as when 10 percent decline was achieved, the C (sometimes G’) curves capture a *common* shape of *continuous* change that was *shared* all across Europe as fertility rates descended from quite varied pre-transition conditions and levels that had been established by local cultures (Knodel and van de Walle 1986, 392). The new modeling provides a more precise and more comprehensive way of following and comparing the timing of fertility change, an objective stressed by Watkins for undertaking further study since research so far has mostly stressed levels (1986, 446).

2) From the perspective of the new method, the timings of the trends of decline were not as clustered or focused as has been claimed (Knodel and van de Walle, 411-12). The distribution is generally bi-modal, with 12 zero years falling between 1914 and 1947 and 15 coming from 1953 though 1979,[14] composing two groups with medians at 1933 and something like 1963, which respectively contain the countries of the north and west (less Iceland and Ireland) and those of the south and the east beyond Finland, Germany, and Switzerland--approximately the classic Trieste-to-St. Petersburg line proposed for European marriage patterns by Hajnal (1965, 101).

3) While Watkins (1986b, 443-44) has noted that in some parts of Europe fertility *rose* in the 19th century before the 10 percent drop that is stressed by the Princeton group (increases which she attributes to practices such as reduced breast feeding rather than a desire for more births), the new analysis here (Figs. 4.1a through 4.1f) has identified almost all of these lifts as being part of fairly long-lasting G' trends of change. These tendencies to rise, in other words, appeared mostly as an early integral part of the curve along which, once t_0 was passed, sustained reduction in marital fertility took place (as in Belgium, for instance). Sometimes, though, increase occurred as the upward tail (following the bottom point) of a 1/G' *depression* in I_g that is evident just before the long 'transition' decline took place (as evident in France, likewise in Fig. 4.1a, but also in Denmark, Italy, and Portugal show Figs. 4.1a, 4.1c, and 4.1e).[15]

4) The up-then-down G' movements, in the 12 nations that display them in Table 4.1, are much more clustered in timing than their C alternatives. Of the peaks indicated by fitted G' curves, no less than 10 of 12 arrive in just the sixteen years from 1874 through 1889 with Belgium (1863) and Finland (1894) constituting early and late outliers. Whatever phenomenon caused the transition of marital fertility in part of Europe to take such an alternative form, this close-to-C segment of the G' path was indeed a chronologically "focused" form of change, though the pattern appeared in only about half the countries of the continent. What might have generated such common movement for fertility in one connected region of Europe but not

others? Was it shared economic change, some common cultural phenomenon, or more strictly demographic in origin? In the end, any claim for a European generality of timing and shape of change in marital fertility applies to these two halves separately, not the whole.

SPACE

Though data beyond what was available to Coale and Treadway in 1986 may change the picture, the later-20th-century behavior of marital fertility in Europe seems less smoothly captured by C and G' patterning than is the case for the preceding era. Extended G' humps probably do appear in France, Belgium, England and Wales, Scotland, and perhaps Denmark from the fertility trough around 1930 to about 1980 (possibly longer, later evidence may indicate).[16] These movements reflect systematic 'baby booms,' some of which, it should be noted, commenced *before* World War II (or at least during it), not awaiting peace, and crested rather early by conventional perceptions of the postwar period. Elsewhere, more abrupt upward shifts in marital fertility instead occurred following World War II. Sometimes these seem to have led to new C trends; sometimes they do not, initiating movements that with the evidence presently at hand apparently cannot be assigned either C or G' shape. Data for the 1990s and the early 2000s should help produce more definitive patterns; but that effort must be undertaken elsewhere.

During a rebound from the Depression, accentuated first by the departure of young men to a second world war and then by their return with aspirations for normal life, a surge in marital fertility requires little explanation. Some cases in which a smooth G' shape was not taken in this period, furthermore, most probably result from readily understandable idiosyncratic local circumstances at very focused points in time. A notable example is the massive loss of young men for Germany and Russia from 1942 through early 1945.

Local analysts should be able to identify the causes of these variations in post-World-War-II pattern. Some evidence would seem to support the argument that the long-term demographic transition was still being completed. Other patterns do not.

What, however, might have generated the G' movements of marital fertility that are observed in several countries to peak about three quarters of the way through the *19th* century? The upswing is shorter and much less substantial than the subsequent slide down; but the G' shape is generally very clear even if it appears only in *some* European populations, not others. The forces at work to produce G'-type rather than C-shape trends in reproduction within marriage this way need to be explored. Were, for example, the dissemination of attitudes and methods of family limitation in a later-19th-century era of cultural and political liberalization more likely to have produced such very parallel international G' movements in marital fertility than a diffusion of the economic benefits of industrialization?

CHANGES IN NUPTIALITY DURING THE EUROPEAN FERTILITY TRANSTION

Accompanying marital fertility in determining overall patterns of reproduction was the proportion of potentially fertile women who currently had men in their lives. Figures 4.2a through 4.2f plot trends in I_m for the 26 European populations covered by Coale and Treadway. From the middle 1800s (or wherever national records begin) into the early 1900s, Table 4.2 demonstrates how in 13 of these countries the proportion of women of potentially fertile age who were in marriages was rising in G form. The gains were flattest--had the earliest t_0's--in France (but with *two* G trends already before 1901), Norway, Sweden, Scotland, and England and Wales, as part A of the table summarizes. In Ireland and Iceland early temporary G' humps are evident instead. In each case, a rather late-set G trend (with zero year about 1850 rather than 50 to 100 years earlier) then followed. This movement was paralleled in its t_0 by the third or 1901-1960 G trend in France and second G surges in Portugal, the Netherlands, Belgium, and also by what was probably a secondary movement of that shape in Luxemburg, though the data there are available only at two points in time.[17]

The second movement that is evident in Switzerland, on the other hand, is apparently unique: a 1/G' dip, which suggests some temporary impediment to marriage at work there across the first half of the 20th century that bottomed in the middle of the 1920s. What might that have been? England with Wales and also Scotland, meanwhile, stand out together by having the slow-starting but upwardly accelerating E form of trend in nuptiality between 1891 and 1931. What could have generated this exceptional phenomenon in Britain across the opening decades of the 20th century? Other European countries, for instance, also lost heavily in World War I without experiencing this unusual pattern in I_m during the first third of the 1900s.

In a second group of perhaps 11 European populations, from the 1800s down to or into the early 20th century the percentage of females 15 to 50 years of age currently in marriages seems to have *declined* via C instead of rising via G. The patterning of this sort suggested for places like Poland, European Russia, Yugoslavia, and Romania is only a possibility that is *allowed* by data at two points of time; but C the trends hypothesized on that minimal basis fit in with those from better-documented neighboring countries like Finland, Hungary, and Greece--as well as clearly substantiated C-shape patternings for Spain, Luxemburg (in terms of all females 15 or more), and Italy. Then, across the latest years documented by Coale and Treadway, in the period since the Great Depression, only Finland and Poland (and perhaps Luxemburg) among the countries of part B of Table 4.2 show I_m movements of G' form, though one would be possible for Russia from 1926 through 1959. Most of these populations, in other words, apparently experienced accumulating G trends of rising nuptiality in the later 20th century instead of the up-and-down 'marriage booms' that represent important features of the populations inhabiting part A of the table in this period.[18]

In European populations where the proportion married was rising in G fashion in the late 19th and early 20th centuries, moreover, the *level* of I_m tended to be lower toward the end of the 1800s than in countries where the percentage fell via C. As of 1900, for instance, the indices for the 'A' group in Table 4.2 ranged from .32 in Ireland (less than a third of women 15 to 50 currently in unions) to .54 in France while in the ‘B’ group the spread was from .46 in Luxemburg to as much as .81 in Yugoslavia (Coale and Treadway 1986, 80-152). Across a northwestern fringe of Europe from Iceland to Ireland and Scotland and over the North Sea to Norway and Sweden, the average was .39 compared with .46 for England and Wales, Denmark, the Netherlands, Belgium, Switzerland, and Portugal, and .52 for France, Germany, Austria, and Bohemia at the high edge of the group of populations in part A of Table 4.2. In eastern Europe, in contrast, the average for seven countries from Poland and Russia south to Greece was .70. Finland and Luxemburg, from part B of the table, show levels comparable to those of Denmark and her peers; Italy and Spain as of 1900 display, like France at the top of the table, proportions situated at the margin between the nations of part A and part B. The conventional “imaginary line” from Trieste to St. Petersburg (Hajnal 1965, 101; Coale and Treadway 1986, 47), which purported to distinguish later marriage and lower proportions ever marrying to the west of this divider, captures *some* of the difference in the base levels from which modern European nuptiality evolved, but tells only *part* of the story. It fails to identify both substantial regional variation in the *levels* from which developments started and the *shapes* of the trends along which change then flowed.

In general, conditions of the later 1800s and early 1900s allowed populations in which marriage had been curtailed at the beginning of the era to loosen the limiting restraints somewhat. At the same time, peoples with comparatively high initial rates of exposure to pregnancy in marriage began slowly but increasingly to have less of their females between 15 and 50 in unions. Maps 2.6 through 2.9 of Coale and Treadway (Coale and Watkins 1986, back insert) demonstrate these opposite tendencies for their “provinces” within European countries as well as whole national populations.

Table C.1 of Appendix C shows, meanwhile, how--from Finland through Poland on its listing (including also Luxemburg, Italy, Spain, Russia, Romania, Hungary, Yugoslavia, and Greece)--in the ten populations in which the proportion of women aged 15 to 50 who were in marriages fell away in C fashion rather than increasing in G form from the later 1800s into the early 1900s--the C curves for I_m had their zero years generally not far behind the t_0's of the C trends for marital fertility, overall fertility, and the crude birth rate. In these countries, all four indices very much came down together via C, with the proportion of potentially fertile women currently involved in marriages on average typically lagging the other measures by about 20 years.[19] For these particular populations, in other words, lessening participation in marriage trailed in time falling fertility within marriage. Did, perhaps, the daughters of mothers who had begun to control fertility within marriage then feel less inclined to marry or remarry as a heritage of their mothers' experience and/or teaching? Or does some other mechanism such as cultural resistance to family limitation explain how reduction of nuptiality in these populations echoed C trends in marital fertility with a lag of about 20 years? Some fruitful research in currently developing countries seems indicated, especially using living subjects from whom some sense of motivation can be directly ascertained. In all, though, a quite general constriction of reproduction in C fashion was under way in these populations, not the *increasing* involvement in marriage that blossomed alongside reduced fertility in other countries where more frequent and earlier marriage, or remarriage, was one dimension of the improved life chances brought to women by the ability to control fertility. The likely role of contraception in these national contrasts is highlighted--though the familiar, persisting Irish solution via severely limited marriage also stands out.

As Figures 4.2a through 4.2f indicate, conditions following World War II mostly eliminated restrictions on marriage, on the one hand, and freed the act of entering into marriage from having to calculate so carefully the pressures of having children. As Coale put it (1986, 28), the traditional European tendency to late marriage was widely "abandoned" in the period from 1930 to 1960. Prior to transition, practices of late marriage and a high proportion of women never marrying were general throughout much of Europe (Knodel and van de Walle 1986, 393; Hajnal 1965). And it was variation in marriage that had made the pace of overall fertility quicken or slow down, having perhaps twice the effect of fertility within marriage upon total reproduction (Watkins 1986b, 430; Coale and Treadway 1986, 48). Then between 1870 and 1930 I_m changed very little and, instead, I_g powered transition in overall fertility (Watkins, ibid.).

In contrast, as a consequence of changes after 1930 or so, in 23 of the 26 countries covered--the next to last column of Table 4.2 shows--I_m at 1970 ranged only between .58 and .72 (Coale and Treadway 1986, 78; though for Iceland at 1960, 120). On average, now just 36 percent of females between 15 and 50 were *not* yet married or were widowed, separated, or divorced without currently being re-married. The highest rates of nuptiality still characterized Romania and Bulgaria in the Balkans; but England and Wales and Belgium joined Hungary in also having ratios over .70. Ireland, not unexpectedly, was the most notable exception with proportion married there still falling below half, at .49. On the whole, however, 'marriage booms' following World War II--half taking G' form, half in non-receding G shape (Table 4.2)--tended to *equalize* I_m across Europe much more than conditions at the opening of the 20th century.[20]

Like the presence and absence of probable G' movement in marital fertility that is displayed in Table 4.1, furthermore, patterns for the countries of parts A and B of Table 4.2 delineate a certain distinctive regionalism in the history of European fertility since the middle 1800s--a grouping of countries that is partly familiar but also rather different from the conventional classification. The regional clusterings of the two tables, however, are not identical. Each is also not entirely clear-cut: overlaps exist among the regional groupings. Nevertheless, a picture begins to emerge that should help to organize in more useful ways the effort to interpret how fertility was changing spatially across this comparatively well-documented continent during the modern transformation of populations, and to probe how a few G-related shapes of demographic change were so common.

INFANT LOSS AND MARITAL FERTILITY

Marital fertility, as Table C.1 and previous discussion indicate, generally determined across Europe the ubiquitous C trends of the later 19th and early 20th centuries that total fertility and the crude birth rate would also follow. In these countries and during this historical era of transition, changes in proportion married--the G, C, and other movements of Table 4.2 and Figures 4.2a through 4.2f--had comparatively little effect. They just altered somewhat the *timings* of the C curves for overall fertility relative to those for reproduction within marriage; they did not generate patterns of change in a different form. What, then, might have caused the decisive component of marital fertility to have altered so uniformly in C or near-C (G' alternative) shape?

Studies of modern reproduction have shown that as effective means become available and accepted, couples often adjust the timing or the total of their births so that they are confident of having a desired number (and/or sex) of children survive to adulthood. In these conditions, parents trade off an interest in having "enough" offspring--to do family work, to support and care for them as they age, and to perpetuate the family line--against the offsetting costs of maintaining and training the young. When one shifts the perspective from the family to the broader, collective community (Coale 1986, 23-27), populations confront an inescapable calculus according to which, in order to stay within a certain rate of expansion (for instance, to avoid strain upon resources of food and shelter and threats to social order), somehow births must be reduced as the survival of children improves.

Before the stage of 'transition'--before couples were widely aware of, and willing to try, limiting births as an option--no strong relationship should be expected between infant or childhood mortality and marital fertility. With the dissemination of birth control--its knowledge, and its acceptance--however, theory posits that under the influence of reduced mortality for the young there will occur, with some lag, a response of marital fertility to the heightened chances that infants and children will in fact survive (F. van de Walle 1986, 203). Once infant mortality and I_g are both low, however, there will be little further connection (ibid., 218).

In the Princeton analyses even Knodel, who stressed the lack of aggregate relationships between child loss and fertility in the transition-era 19th century German villages he studied, found significant adjustment of this sort by *couples* within these local populations who had themselves lost children (1986, 384-85). From surveying the accumulated international evidence, however, he and É. van de Walle concluded, like the prevalent theory, that prior to the fertility transition Europeans did not control their reproduction in a way related to infant or child mortality, though they argued that the abandonment, abuse, and neglect that historical studies have revealed served in a substantial way to get rid of unwanted children in times before the fertility transition (1986, 402, 405). This last finding raises the possibility that the rate of death among the young could be a *consequence* of fertility rates, not just the other way around. In the end, though, Watkins concluded in her summary essay for the Princeton studies that, in spite of difficulties in demonstrating the causal connection, lowered infant mortality was indeed one feature of European regions that led the transition in fertility (1986b, 440).

What then, through the lens of the new G-framed perspective on how demographic change has unfolded, was happening to the loss rate among infants as European fertility rates came down via long segments of C shape? And how might these tendencies be connected with trends that have been observed in marital and overall fertility or movements in nuptiality?

Chapter 2 has previously demonstrated that, during the epoch of modern demographic transition, mortality more broadly--as measured in crude death rates covering all ages--fell across Europe (and other parts of the world) in the same kinds of C patterns as have been identified for transition-era birth rates, overall fertility, and reproduction within marriage. Jean-Claude Chesnais has summarized conveniently what happened specifically to *infant* mortality (labeled M_i here for brevity) across this phase of demographic history (1992, 580-97). His data for 24 European countries are trended in Figures 4.3a through 4.3f.[21]

What the figures show is that *everywhere* in Europe from the later 19th century to the middle of the 20th infant mortality declined for a substantial period of time in C form. What is more, Table C.1 in its first two columns demonstrates how similar these trends usually were in span of years and timing of the curve to the C patterns found in marital fertility (I_g). In short, for the most part the reduced reproduction of married women in European countries over the century from 1850 through 1950 followed the same shape of decline as that found in how many babies (live births) were typically being lost in their first year, and came down rather closely in time along with that decrease in early mortality.

Though there are some significant variations in the relative datings of the two categories of C trends that must be explored, did the origin of the C *shape* of change, at least, then reside in how trends of deaths among the young were generated? Is the analysis one step closer to where the ultimate source of G-related forms may be found--in the behavior of *mortality*?

Table 4.3 in its first two columns simplifies evidence of Table C.1 concerning these largely parallel movements in marital fertility and infant mortality during the transition era for Europe, a phase of demographic history over which a significant relationship between the two variables has been suggested. For brevity, it just compares the zero years for the C trends involved. Except for Hungary--and her neighbors Austria and Bohemia/Czechoslovakia, for whom no C pattern in I_g is at present clear--the countries are listed by dates of the base years of their C trends in marital fertility. The average t_0 for marital reproduction for the 12 populations from Belgium through Norway is 1932. From Italy through Ireland, the mean base year for C movement in I_g, in contrast, falls 35 years later--at 1967. This significant lag is one feature that familiarly separates the fertility transition in northern and western Europe (save Ireland) from regions to the south and east.

In the chronology of C trends for rates of infant mortality, meanwhile, there is also a typical distinction between these groups of countries. For populations from Norway upwards, in col. 2 of the table the average zero year is 1930 compared with 1940 for the contiguous central European cluster of Austria, Bohemia/Czechoslovakia, and Hungary but as late as 1958 from Italy through Bulgaria down the bottom half of the list. In spite of an early exception in Italy, in other words, another, comparably geographically dividing dimension of regionalism for demographic change in Europe from the later 1800s through the first half of the 1900s is constituted by differences in how infant mortality declined--not in the shape of the trend, which appeared universally across all 24 recorded countries, but in the *timing* of the C curve that was so generally followed.

Column 3 of Table 4.3 relates the national target or zero year for the C in marital fertility to that in infant mortality. A positive number means that the t_0 for the trend in I_g came *after* that for M_i. Belgium and Romania present unusual instances (meriting further investigation) in which, over significantly different ranges of time during the 20th century, fertility in marriage declined well *in advance of* infant mortality. For most countries, to the contrary, the two C trends are set at about the same time or somewhat later, suggesting that curbing marital fertility was a response to the loss of fewer babies, as some demographic theory argues (Kirk 1996, 367-69). England and Wales (-4), Sweden (-5), and Scotland (-6), however, display short lags in the opposite direction from what that theory projects, while Portugal (-1), France (0), and Denmark (+1) saw the two changes take place in parallel fashion. In 13 of 21 countries with the necessary evidence, nonetheless, there were delays of from 6 to 28 years--averaging about 16 years--according to which the C curve of change in marital fertility *trailed* that in infant mortality. Though not totally supportive, the weight of the evidence, at least at this national aggregate level, is on the side of theory that expects I_g, whether lagged or relatively contemporaneous, to have followed I_m down as the processes of fertility transition progressed. The negative or mostly synchronous cases, furthermore, are--with the one exception of Romania--for some reason all clustered geographically within northern and western Europe: Scotland, England and Wales, Sweden, Denmark, Belgium, and France, along with Portugal further south down the Atlantic coast. In contrast, the most protracted lags in the direction called for by the theory chiefly occurred in southern and eastern Europe, where fertility decline took place reluctantly and later: Spain, Italy, Yugoslavia, Greece, Hungary, and Poland. For some reason these countries were accompanied in their longer intervals by Ireland, the Netherlands and Switzerland. Meanwhile, national populations with only a relatively short lag--Norway, Finland, European Russia, and Germany--tended to lie close to those with no lag or a small reversal in order.[22]

In all, furthermore, populations with *early* C-shape decreases in marital fertility had shorter delays following reductions in infant mortality. Broadly speaking, historically delayed reduction in infant deaths was accompanied by slower response in births.[23] The international distribution of lags between reduction in infant mortality and marital fertility, in other words, tends to add another dimension to the groupings of countries emerging in Table 4.3.

What do these various geographical clusterings by direction, dating, and duration of lag between C-shape reduction in infant mortality and comparable decrease in marital fertility suggest about the dynamics of fertility transition? Highlighted, given pressure from the survival of more babies, are dissemination of knowledge concerning family limitation, attitudes allowing or supporting it, and methods for executing such a choice in an acceptable way. The change, it has been established in the Princeton research and elsewhere, was a complicated one. Much of the fertility transition, for instance, was in fact achieved via withdrawal and abstinence before modern contraceptive techniques and safer and more dependable abortion were widely available. Certain methods had been employed in limited social circles for centuries (for example, Livi-Bacci 1986, whose findings are reexamined in Ch. 5). It was knowledge and acceptance of them by more and more *ordinary* people across the era of demographic change that gave the fertility transition its building momentum. The geographical patterns of lag encountered here would seem to offer some help in the ongoing process of identifying the ways that the relevant knowledge and attitudes spread across Europe in the later 19th and early 20th centuries in the face of pressure--for both family and community--coming from the survival of more and more babies into later stages of life.

A profitable step in advancing understanding of the fertility transition, now it would seem, is to relate systematically G-based trends that exist in marital fertility for the many

European provinces that are covered in the Princeton project to whatever comparable regional evidence is available concerning local movements in infant and/or childhood mortality. Do the linkages between these two variables that are evident in Table 4.3 for two dozen national populations appear, and yield insight into the nature of adjustment in the much more numerous *regional* data sets within and across countries that can be studied?

The geographical groupings of Table 4.3 by I_g and M_i for the era of transition, finally, bring to mind international clusterings of other sorts that have previously been encountered. In the first place, as col. 4 of the table indicates from evidence presented in Figures 4.1a through 4.1f and Table 4.1, among the 10 countries from Italy down through Bulgaria not a single C trend of marital fertility in the transitional era could fruitfully be replaced by a modeling in G' shape. From Belgium through Hungary above in the listing, to the contrary, for 12 out of 16 societies a G' alternative fit provides an equally good, frequently even more effective trending. The exceptions come from France and Luxemburg, on the one hand, and Scotland and Iceland, on the other. The latter two countries in this respect join in the behavior of Ireland on the far northwestern fringe of Europe. What type of phenomenon with a G' imprint might be involved in the way that some populations, but not others, responded to falling infant mortality by slightly increasing then markedly reducing their marital fertility in G' fashion during this period? What type of G' impulse might have affected certain European peoples simultaneously this way during the later 19th century to set off serious fertility control? Movements in industrialization, urbanization, and related migration are of course prominent suspects. But so is what might be called a 19th-century international 'liberalization' of values, both religious and secular.

Second, Figures 4.2a through 4.2f and Table 4.2 have demonstrated that across the later 1800s and the early 1900s, while in some European countries the proportion of females between 15 and 50 years of age who were married at any given time rose in G fashion (combined with a few G' and E movements, which have been discussed), elsewhere this fraction declined in C shape instead. Column 5 of Table 4.3 categorizes the forms of trend for I_m that appeared in each country in this transitional period. From Hungary through Ireland in the lower portion of the list, 8 of 10 populations for which trends could be established display definite or potential C-type contractions in the proportion of females 15 to 50 currently married. In all of these countries except Hungary, moreover, there is no significant possibility that a G' pattern might capture change through time in marital fertility (I_g). Above Hungary on the list, meanwhile, only Finland displays an I_m trend of C form and 11 of 15 nations show possible G' movements in I_g.

In short, participation in marriage tended to contract in those populations appearing in the bottom half of Table 4.3, a group of countries whose reductions in marital fertility lagged more behind the local C decline in infant mortality than was characteristic elsewhere. The pre-modern method of population control, by curbing nuptiality, remained a significant factor. Less early, lengthy, and continuous participation in marriage was a collective price paid for not reducing fertility in marriage promptly as more babies survived. In all, G-related trendings clarify in several aspects how different dimensions of fertility altered across Europe from the middle 1800s to the middle 1900s in ways that jointly distinguished the experience of one group of national populations from that of another.

In the later era that followed the Great Depression and World War II, the nature of trends in infant mortality again set apart some European populations from others, as Table 4.4 demonstrates. Several countries (in part C of the table) have experienced only C patterns.[24] In others (part B), there perhaps occurred some decline for a while in the downwardly concaved D form instead, though just the bend of the joint between the trend for the early 20th century and the distinct C that appears in these cases after World War II may approximate this shape. In ten populations (counting both West and East Germany), however, D movements--sometimes two of them shows part A of Table 4.4--have occurred since the 1940s in the proportion of live-born infants who died in their first year. And in these countries no C alternative is justified.

Table 4.4 raises some questions that invite further inquiry. What might have generated decline in infant mortality that took D rather than C shape? Why have other European populations not experienced it? Through comparison with Table 4.3, furthermore, it is evident that these national groupings after World War II differ significantly from those of the preceding era of demographic transition in Europe. The D shape represents rapid change that slows down. The C curve, in contrast, captures slowly starting decline that accelerates with time. Do the divergent patterns perchance reflect distinctions in how soon and by what means health care for infants (and pregnant women) emerged, was promoted, and spread? Or did other national developments shape these movements?

Categorizing countries for the period since the 1930s or 1940s by shapes of trend for marital fertility, for the proportion of fertile women currently engaged in marriages, and for infant mortality together, meanwhile, proves more elusive than the kind of generalization about shared national clusterings from one dimension of fertility change to another that is possible in Table 4.3 for the earlier, 'transition' period. This is the case in spite of the fact that, separately, Figures 4.1a through 4.1f indicate potentially insightful but distinctive country groupings for recent trends in fertility within marriage. Four populations (in Belgium, England and Wales, Denmark, and France) across the second half of the 20th century saw C trends in I_g that could be matched by G' alternatives. Scotland and Hungary produced the G' shape without the C. Luxemburg, Germany, Austria, Sweden, Finland, Spain, Portugal, and Italy experienced decline in C shape without any G' alternative. Movements of marital fertility in the other twelve countries of Europe since the Depression, however, without more data simply cannot be trended in G-related forms.

Similarly, recent changes in I_m can be usefully categorized spatially, but along their own distinctive lines, which are not linked to the distribution of movements in I_g or M_i. The British Isles, the Low Countries, Scandinavia, Austria, Poland, and Russia (early, between 1926 and 1959) had 'marriage booms' of up-and-down G' shape. The other populations of Europe saw I_m, from the 1930s or 1940s forward expand in continually rising, if decelerating, G form instead. These relatively recent national patternings for marital fertility and proportion married should encourage further investigation as to what determined overall fertility here or there in Europe across the later post-‘transition’ decades of the 20th century even if their divisions do not accompany each other, and movements in infant mortality, as much as Table 4.3 indicates for the preceding era of demographic change from the middle of the 1800s into the middle of the 1900s.

EXTRAMARITAL FERTILITY IN EUROPE AFTER THE MIDDLE OF THE 19TH CENTURY

Fertility outside marriage, I_h, did much less to affect overall reproduction than fertility for married women, I_g. Its behavior over time across the countries of Europe, nonetheless, provides further valuable insight into the demographic and socioeconomic processes at work during the era of fertility transition and in the years that have followed.

In the first place, Figures 4.4a through 4.4f and Table 4.5 demonstrate the ubiquity of G’ surges and declines in extramarital fertility across Europe. Whereas this up-and-down pattern of change provides an alternative to C trends of I_g, or fertility within marriage, in just 12 of 26 countries of the continent, potentially *every* population displays an I_h pattern of G’ form advancing from the middle 1800s into the early or middle 1900s. In England and Wales, Scotland, and Denmark two--in France no less than three--G’ movements occurred by the 1930s.[25] Several populations then saw fertility outside of marriage again take G’ form in the years following World War II, though others experienced more erratic surges at this time, and a few had G’ trends continue into the postwar period that had begun appreciably before (Italy, Spain, Hungary, Portugal, and Ireland).[26] In Ireland at a very low level and in Portugal with a rather high rate of illegitimate fertility (Fig. 4.4d), on the other hand, quite definite *inverted* trends of 1/G’ shape appear before the usual G’ transition pattern takes over. Apparently a development *restricting* extra-marital fertility could pass through a population in the same way that the consequences of a stimulus *encouraging* it first emerged then faded away.

Though, as seen in the first two columns of Table 4.5 (part A), the timings of G' movements in extra-marital fertility could vary twenty years or more from those for fertility in marriage (I_g), mostly the respective peaks occurred closer to each other.[27] And, as part B of the table shows best, most European populations--quite a variety of them--had their rates of extra-marital fertility come to a G' crest between the mid-1860s and the mid-1890s. Ireland, Portugal, Luxemburg, Poland, and Yugoslavia appear to have experienced only later manifestations of this phenomenon. France, England and Wales, and Scotland, in contrast, display 19th-century G' surges in I_h that maximized early, by 1850.

What might have caused fertility outside of marriage to have peaked and fallen off this way so generally, and mostly so contemporaneously, across virtually all the European countries recorded? Did this perhaps reflect an international patterning according to which young people across the continent were uprooted from traditionally restrained agricultural settings to work and live in urban centers and mining or factory towns that imposed less control upon their sex lives? Volume II has demonstrated, for example, that specific migrations, including those to cities, have generally taken the G' form historically (Harris 2003, Chapter 3). And the growth of cities, though displaying G-shape expansion instead, was--like elevated extra-marital fertility--universal and generally simultaneous across Europe in the middle of the 19th century (Harris 2001, 312-18, for large cities individually; but contrast Harris 2003, Ch. 4, for patterns of urbanization more broadly).[28]

In response to this new urban and largely industrial experience, was the frequency of pregnancies--particularly those outside of marriage--at first driven up by social reorganization? Then, however, did that chronologically focused phenomenon of increase in city living and related socioeconomic change in turn induce women and couples from a variety of cultural heritages to accept methods for preventing conception or live birth, procedures that had been known for some time but by the later 1800s were becoming broadly familiar and available? Once favored, such practices--as they were employed more and more--could then for some time power continuing declines of fertility down the post-peak path of the G' curve, which tends to parallel for a substantial period the C shape of change as that form of trend approaches t_0. Perhaps there is a present-day analogy in how rising energy prices might eventually inspire significant and continuing conservation.

In this interpretation, marital fertility accompanied extramarital fertility in rising somewhat then falling off via G' in one half of the countries of Europe, but not the other, principally because of the uneven way that nations urbanized and industrialized during the 19th century. Cultural heritage, for instance the tendency for populations below Scotland and Iceland in the left column of Table 4.5 to be Catholic or Orthodox in religion, was only indirectly or partially relevant for generating G' movement also in marital fertility, as the trends of Belgium and Bohemia, Austria and Hungary, and Scotland and Iceland attest. Yet part A of Table 4.5 suggests that in the end even in culturally more conservative populations extramarital fertility waxed and waned with the socioeconomic change that was permeating Europe, albeit less in their territories than elsewhere, while fertility within marriage instead remained resistant to such influences there.

Possible socioeconomic and cultural causes for advanced or delayed reduction in fertility are continually debated in the literature. The national relationships of G' and C trendings in marital and extra-marital fertility offered here, however, would seem--particularly if they hold up when taken to the many regions within countries for which data are available--to help clarify what was at work where, and how the diffusing changes passed through or were taken up by populations comparably or differently. The broad national findings suggest further, more local, more specific cultural and economic investigation which could fruitfully exploit the abundant provincial data provided by the Princeton group that Coale and Treadway summarize and evidence produced by various other regional studies .

The *level* that the rate of extra-marital fertility achieved from country to country adds still another perspective to the accumulating picture. In Hungary (.139), Austria (.119), and Bohemia (.104) during G' peaks in the 1880s, Table 4.5 shows, I_h crested at about twice the rate averaged by most of Europe. If the phenomenon is not just one of how the Hapsburg Empire kept records, why did this central region of the continent experience the most illegitimate fertility in the 19th century? The only rival is, for some reason, to be found way out in the middle of the Atlantic--in Iceland (.094). What Table 4.5 reveals is that among twelve societies in which G' is a plausible alternative trend for *marital* fertility, these three Austro-Hungarian populations had three of the *lowest* peaks for such a surge in I_g while reaching the *highest* levels of I_h. Does this inversion represent some kind of collective trade-off, which was mediated by the way marriage worked in these particular societies? In Ireland (about .012), Greece (.017), the Netherlands (.024), Luxemburg (.023), Switzerland (.030), and Romania (.028), in contrast, the index for fertility outside of marriage in the later 1800s reached only about *one half* the level for most European countries. What might have given these populations distinctively low levels of I_h? More hostile and punishing environments for unwed mothers and their partners, stronger internalization of norms against pre-marital indulgence, a greater frequency of non-coital sexual practices, more developed prostitution (thus involving more "professional" control over pregnancy and live birth), and perhaps simply differences in recording would all seem to be possibilities worth probing.

In the later years of the 20th century, the rate of extramarital fertility surged in many countries. In England and Wales, Scotland, and Norway (Fig. 4.4a) levels shot back up to what had been characteristic in the middle of the 1800s. In Iceland (ibid.), I_h as of 1960 roughly tripled the already high crest attained there during the 1870s by means of a new G' swelling. In Sweden after 1950 and Finland after 1970 (Fig. 4.4c) the non-marital fertility rate apparently jumped markedly, a movement also evident in Denmark and the Netherlands (and perhaps Hungary) but most pronounced in Ireland, though that country in *comparative* terms still displayed a very low level for Europe. In France, the G’ trend through the era of World War II mostly sustained levels that had been characteristic of this population since the 1830s, though some upward shift in non-marital fertility seems to have begun in the 1970s. G’ movements of the later 20th century in Germany, Greece, and--rather more substantially--Switzerland fell well short of bringing I_h back to its levels of a century before. In Belgium, Italy, Spain, Portugal, Austria, Poland, and probably Czechoslovakia, meanwhile, *no* signs of fresh increase in fertility outside marriage appear in the 1950-1980 period.

These G’ movements observed in non-marital fertility carry further forward an understanding of G’ and 1/G’ pulses in the history of European reproduction, phenomena first observed as exceptions since the middle 1800s in I_g and I_m. They add to a general picture of how particular stimuli or shocks can appear in G’ or 1/G’ form and be absorbed as contributions to more persistent G-based trends like G, C, or D as the ongoing, interacting, aggregate processes of fertility evolve for a population. Such a relationship of specific surges to more comprehensive and long-term movements has previously been observed in Volume II for migrations (international and internal, such as urbanization), which tend to be rooted in the same types of upheavals that periodically elevate extramarital fertility.

It is mostly young adults who relocate this way. Some evidence bearing on the reproduction of young women in the population and of all females who lived in cities exists to help evaluate this type of interpretation.

Figures C.3a and C.3b offer, often quite tentatively, some possible trends for the percentage of women 20 through 24 who were married. Table 4.6 compares these with patterns of extramarital fertility in the same countries. Generally, first of all, there appear to have been more signs of surges in the nuptiality of these younger females than for older females or all women of fertile age.

In England and the Netherlands, furthermore--and possibly in Belgium and Germany--the G' bulge in young nuptiality (Fig. C.3a) for the most part lagged the widely experienced movement of that shape in extramarital fertility (I_h).[29] In France, the frequency of marriage for women 20 through 24 rose only very slighty between 1831 and 1901 (as extramarital fertility largely remained level, shows Fig. 4.4d), while in Sweden, Scotland, and Italy opposite 1/G' dips occurred. For Portugal, the trend for female nuptiality 20 through 24 largely resembled that of France, though some G' rise could have appeared between 1864 or sooner and 1890 while I_h exceptionally sagged in 1/G' shape. In post-famine Ireland, young nuptiality contracted in D form as extramarital fertility dipped via 1/G'.

While the evidence is insufficient to be definitive, there is at least a hint that in the earliest and furthest industrializing and urbanizing countries of northwestern Europe, the bulge in illegitimacy was before long followed by a surge in opportunity for young women to marry, while elsewhere little or even opposite consequences of extramarital fertility for early nuptiality appear. Young marriage could in effect be curbed rather than facilitated in the wake of a surge in I_h and the dynamics that produced it. In the early 20th century G' movements in nuptiality for women 20 through 24 were even more common, and more contemporaneous, in northern Europe--now including Scotland and Sweden (Tab. 4.6). Their relationship to similar surges in extramarital fertility, however, had mostly disappeared.

Declines in infant mortality rates have been seen to do much to shape decreasing fertility. For Sweden, the other countries of northern Scandinavia, and parts of Germany, rates of infant mortality in cities have been compared with those for rural areas (F. van de Walle 1986, 217).

Ratios of urban to rural rates of M_i that had been about 1.5 near mid-century in Sweden and Norway, 1.2 to 1.25 in Prussia and Finland, and just over 1.0 in Bavaria fell to levels below 1.0 by the 1930s (Fig. 4.5). In Sweden, Bavaria, and Prussia the decline most clearly took C shape. Possible C trends receive some support in Norway between 1895 and 1935 and perhaps

Finland from 1905 to 1935, though there the G' shape best suits both this time span and the evidence for 1885. In Sweden and Norway the C trends for decline in the ratio of urban to rural infant mortality are almost exactly parallel with C-type declines in the crude death rate (Tab. 4.7; Tab. 2.1a). The fact that the C movement for the CDR in Germany as a whole comes down earlier than the comparable movement for infant mortality in cities relative to rural areas (with a t_0 at 1929 rather than the 1956 for Bavaria and the 1946 for Prussia) probably reflects the fact that these two recorded areas of the nation were slow in undergoing social and economic changes of the 19th and the early 20th centuries compared with regions in more western areas, particularly the Rhine watershed from Switzerland to the Netherlands. Why the CDR came down appreciably later than the ratio of urban to rural infant mortality in Finland must be left to others.

Most certainly in Finland, but also possibly in Norway and Sweden, the relationship of urban to rural infant mortality may alternately have taken a G' path through the later 1800s and early 1900s. During certain phases the two curves, C and G', bend very much the same way. In each of these three Scandinavian countries, the maximum for the G' alternative arrives at 1894 or 1895; and one might identify similar movement with t_0 also at about 1894 in the Bavarian data of 1890-1925 (not graphed) while for Prussia an 1876 to 1900 G' movement peaks rather earlier, at 1879. In Sweden and Finland such G' swings in relative infant mortality rates for cities parallel surges of this shape in extramarital fertility (Tab. 4.7). For Germany as a whole, meanwhile, the G' for I_h peaked at 1881 compared with 1879 for the ratio of urban to rural infant mortality in Prussia. In three of the four countries documented, in other words, the G' pulse of illegitimacy was accompanied by contemporaneous G' surging in the ratio of urban to rural infant mortality. In the exception, Norway, the peak of illegitimacy for some reason preceded that for urban relative to rural infant mortality by about two decades. This, however, for some reason is about when the comparable crest came in Germany as a whole (1881).

In all, a picture begins to emerge of how 19th-century urbanization and the lifestyle that accompanied it loosened the tie between marriage and fertility but simultaneously created higher infant mortality. The socioeconomic change taking place at first tended to generate a G' rise in extramarital fertility, which in more rapidly developing countries was accompanied by overall marital fertility, thanks to more frequent early marriage and reproduction. With time, however, improving urban health services reversed the balance into the 1930s, making infants safer in the city than in the countryside; and the social disorganization of urbanization and industrialization ameliorated. As seen in other demographic changes, temporary G' pulses in the ratio of urban to rural infant mortality that occurred were mostly absorbed into the more inclusive and persistent C trends that marked the decline of mortality in general, as evidenced by the largely parallel movements indicated for crude death rates in the nations involved.

NEW PERSPECTIVE ON FERTILITY TRANSITION IN EUROPE

As economic and accompanying social changes, which had been pioneered in a few countries (or parts of them) in the later 18th and early 19th centuries, diffused more generally across most of Europe during the later 1800s and the 1900s, employment and other life chances drew population, especially young adults, to urban centers and away from the traditional structures of rural society, which imposed collective restr aints upon reproduction, chiefly through limited opportunity to marry. When such socioeconomic change took place, rates for extramarital fertility tended to increase somewhat everywhere but then fall off markedly--all in G' fashion. So did marital fertility in more rapidly developing countries as the new living conditions--their strains, their risks, their opportunities, and their shifting cultural climate--made popular various methods of family limitation during the later 19th century. At first, these were mostly crude, only partially effective, and long-known measures that required little new "technology" or expense. Still, they had considerable aggregate effect.

Responding to the challenges that the new socioeconomic context posed for sexual unions and reproduction, *unmarried* women everywhere apparently seized upon the available chances to keep their lives under control (Tab. 4.8, col. 1). For *wives,* however, matters were at once less pressing and yet more complicated. Child labor was in demand and could significantly assist family income. In urban and industrial life (unlike agriculture) ownership of, or access to, land did not have to be divided, dragging assets below the critical mass for effective production. Youths in transition to adulthood could live at home and contribute earnings there while preparing themselves toward establishing their own families as they coped with what passed for security of employment at that time. Meanwhile, the love child conceived in the less socially controlled and more anonymous urban context could more readily than in a rural community be passed off as that of the husband. Under the new conditions of social and economic change, whether to limit one's offspring for *married* women remained more sensitive to the culture of the family. Traditional religious views or other communal values were relatively more important for determining the fertility of wives, and any input of husbands into family planning. *Marital* fertility (Tab. 4.8, col. 2) thus did not so ubiquitously increase somewhat then fall off in G' fashion under the widespread 19th-century stimuli of urbanization and industrialization. It did so only where these processes advanced the fastest and furthest, against the least effective cultural restraints. Eventually, nonetheless, it declined everywhere (generally in C form), driven in large part by demographic pressure that was generated by shrinking rates of infant mortality.

Total nuptiality, meanwhile, changed only in fairly stable, long-term patterns--some G-type increase in the most rapidly developing countries but C-shape decline where reduction in marital fertility only partially counteracted C-type decrease in the death rates for infants. Temporarily elevated nuptiality for *young* females, moreover, occurred in some populations parallel with the widespread surges of extramarital fertility that appeared across Europe in the later 19th century. Such moves added in G' shape to overall marital fertility in these more rapidly developing countries because young wives typically have more children than older ones.

New urban and industrial employment, accompanied by escape from rural restraints on marriage and reproduction that were exercised through inheritance and intimately enforced social norms, made young marriage easier in several societies that had been known for historically high average age at the time of first union.

How, then, were patterns previously established in Volumes I and II for overall population growth, the proportion of people who lived in cities, and emigration--and what is known of contemporary social change and economic development--associated with the movements in fertility, nuptiality, and infant mortality observed? Across Europe, two particular patterns of diffusing, related demographic increase and urbanization from the 1700s into the 1900s have been identified: via E and via H (Harris 2001, 148-49; 2003, 275, 277, 286). These are recapitulated in columns 5 through 8 of Table 4.8. Column 4 reviews the patterns of emigration found for European countries (Harris 2003, 24). Table 4.9, meanwhile, summarizes from Table C.3 in Appendix C certain combinations of trends in death and birth rates found to have accompanied E and H patterns of growth historically.[30]

As Chapter 3 has reviewed, according to the theory of 'demographic transition' lags between decreasing mortality rates and reductions in fertility for a time generate accelerating rates of increase in population size. Given C-shape shifts that involve comparable starting levels and amounts of change, this growth surge starts out increasing at a rate of $e^{.03}$ but rapidly slows as the CBR and CDR re-approach equality (Fig. 3.2b). Among 25 surveyed populations of Europe since the 1700s (the middle column of Table 4.9) only 8 actually display such a combination of C-type death rate, C-type birth rate, and E-shape pattern of growth: France, early and briefly, for a generation after the markedly secularizing Revolution of 1789; then Spain and a cluster of 6 central European countries in the late 19th century and early 20th, also mostly for just about 30 years. Within Europe, at least, historically the typical depiction of 'demographic transition' was principally a late 19th-century phemomenon that was present in at most a third of populations that have been sufficiently documented.

In contrast, in several countries that display E-type population increase *early* in the modern developmental process, starting during the formative 1700s (England, the Netherlands, and Denmark, and probably also Ireland, Scotland Germany, Belgium, and Switzerland, where national trends for death and/or birth rates are unknown this early, but not France, where they are) rather than declining in C fashion, the crude birth rate probably *rose* via E (the first column of Tab. 4.9; Tab. C.3).[31] In these countries, population could, and did, expand in E trajectories for much longer periods of time than for France and other territories that later conformed to the 'transition' model in the middle column of Table 4.9, because fertility increase in E shape kept growth along the $e^{.03}$ trajectory necessary for the E-type trend of population increase past where the simple 'transition' lag of C-shape CBR decline behind such decrease in the CDR would have let expansion begin to slip below this path (Fig. 3.2b). Adding to the effects of an almost exactly opposite contemporary C-shape decline in infant mortality (Fig. 4.3b), an upward thrust in total fertility, generated by a parallel E trend in nuptiality, is clear for England (Fig. 1.4). Elsewhere, such fertility increase is inferred from the crude birth rate, in which E movement is similarly found early for Lombardy, in northern Italy, but without resulting E-type growth for the country as a whole (Tab. C.3). The phenomenon of E-shape increase in birth rates is also observed later, after the middle of the 19th century, in Austria, Romania, and Portugal.[32] In these cases, it likewise contributed to demographic expansion in E form. Judging from the English evidence, in the era of the 18th century and the early 19th, the handful of countries that led the economic changes of this early modern developmental epoch seem to have found their populations growing progressively faster as falling infant mortality and total fertility, rising with nuptiality, simultaneously added people.[33]

During the 18th century and the early 19th, in an era of agricultural improvement, in the first-developing countries of Europe (located generally in a zone stretching from the northern Atlantic and the North Sea southeastward to the Alps) rising crude birth rates that followed E paths more and more rapidly pushed surplus population, typically young adults and teenagers, out of farming into the urban labor market. In England and the Netherlands, and perhaps France after 1750, more likewise entered non-agricultural employment in the countryside (Harris 2003, 232). Such 'protoindustrial' growth is also evident elsewhere in several other regions of northwestern and central Europe.

The domestic demographic pressures that so affected economic development also set off surges (of G' form) in emigration. These began in the 18th century from Ireland, Germany, and England (Harris 2003, 60, 67) and in a flow of foreigners willing to go overseas for the Dutch East India Company (ibid., 449).

In the first half of the 19th century, however, declines in birth rates for England, Denmark, the Netherlands, and Germany took D shape while death rates came down along the gradual early stages of C trends (Tab. C.3). In Belgium, CBR decrease following the 1820s may have taken D form, but cannot be confidently trended (Fig. 2.2f). Sufficiently early evidence for Scotland, Ireland, and Switzerland is not readily available.[34] The D trend starts downward more rapidly, then decelerates. The C trend begins slowly and picks up speed. The temporary narrowing of discrepancy between CBR and CDR that occurred thanks to the two different patterns of reduction cut into the tendencies of those populations to continue to have accelerating growth, tipping their further expansions over into slowly slowing H trends, a form of increase shared among European nations during the first half of the 19th century only by Norway and Russia, where a preceding E pattern in population did not occur, but earlier H movement instead (Harris 2001, 148-49).[35] Urbanization, however, continued to take E shape broadly across Europe into the middle of the 1800s, where an equally general surge of emigration out of northern and central countries helped shift it into a decelerating H path for the remainder of the 19th century and the early 20th. To what extent were the D-form declines in the birth rates of what were probably the most rapidly changing societies of this era, steeper than their C-type counterparts for death rates, themselves a product of the emigration of young or middle-aged adults with families, who have formed a relatively larger portion of the *early* stages of G' surges of some historic migrations than of later ones?

In column 8 of Table 4.8, England and Wales stand out for having a likely transition from E-type to H-form increase in urbanization in the early 1800s, while elsewhere H trends--though virtually universal across Europe--commence only in the middle, even later, 19th century. In contrast, while 15 of 25 European countries probably did not, Ireland, Scotland, Norway, Denmark, the Netherlands, Belgium, Germany, Switzerland, Bohemia, and one geographical outlier, Spain, did share with England *population increase* of H form during the first half of the 1800s (though only Norway with as late a base year--as steep a trend--as England). Though England may or may not prove to be an exception among developing countries during this period, some particulars are known about her economic evolution which suggest that interpretation of the demographic interactions at work there is probably also relevant for some other countries and regions (Ch. X).

In the middle of the 19th century with the more complete blossoming of industrialization, national trends of urbanization in Europe, which other than in England had so far continued to follow accelerating E-type paths, also shifted into decelerating H tracks even though the growth of the largest centers advanced significantly (Harris 2001, 311-18). The fastest emigration occurred just when G' surges in marital and extramarital fertility in the more rapidly developing nations crested together and young women were most likely to be married (Tabs. 4.8, 4.6). That, however, was approximately when emigration also peaked and began to recede in *most* European countries. Underlying this loss of momentum, did foreign 'magnets,' which had evolved to draw from population surpluses in the first-developing European nations, begin to lose their 'pull' as former immigrants demographically nativized, curbing opportunity for subsequent arrivals--a process demonstrated for both free and slave migrations in Volume II? Or did the fruits of industrialization and related socioeconomic change to some extent improve fairly much everywhere at once across Europe, reducing the 'push' pressure at this time?

As in England, population growth in Scotland, Denmark, the Netherlands, and Belgium took fresh H shape during the second half of the 19th century and the early decades of the 20th. Increase in other countries of Europe that had shared E then H demographic trends related to economic development in Europe between the middle of the 1700s and the middle of the 1800s did not, even though their pattern of urbanization followed comparable H paths. In the special case of Ireland, exploitation to advance English economic interests led to over-dependence upon the potato to sustain working families, which with the blight of the 1840s resulted in famine, and generated massive depopulation in D form (facilitated by landowners who wished to shift from grain to more profitable livestock). This decline lasted from 1850 past 1950. For Germany in the 1860s, Switzerland and the Czech lands in the 1880s, and Hungary on the eve of World War I, on the other hand, the pattern of demographic expansion reverted to E shape rather than a new H. One such trend occurred in Hungary. Two successive ones appeared in the other three countries. In addition to the path of urbanization, though, these four populations shared with England and other early developers of the 1750-to-1850 era G’ reductions in marital fertility that came down from peaks in the 1880s and--except for much later increase in Hungary--also emigration surges of G’ shape that crested together in the later 19th century and began to recede. It was among this group of populations, however, that the simple lags between decline in death rates and curtailment of birth rates that are called for by ‘transition’ theory now took place, without the added boost of E-type gain in CBR (Tab. 4.9, “C-C-E”).

What made the manner in which their populations now expanded different? They shared these E movements of growth with neighboring Austria, Romania, and large portions of western Russia (Harris 2001, 220-21) but also Spain and Portugal. Were these the territories where the kind of industrialization based upon cheap labor that had flourished in northwestern and central Europe during the later 1700s and early 1800s, and perhaps interacted with demographic change in the way that the English evidence suggests (Ch. X), now moved as more advanced forms of demonomic development evolved in the original sites--a type of international shifting well known in the ‘globalization’ of the present time? ‘Transition’ lags during this later period in these countries supplied the accelerating increase of extra workers. Did they also do this earlier, for French economic development and military build-up during the first decades following the Revolution?

Fom the middle of the 19th century forward, meanwhile, the populations of Sweden, Serbia, and Italy acquired their first H patterns of increase, while Norway and Russia (as a whole) started new ones. In the late case of Spain, the H appears only after late E-type expansion to 1920. Though involving lag-driven growth rather than birth rates rising in E form, the 20th-century Spanish sequence may reflect a delayed manifestation of the demonomic transformation from early to later modes of development (including a G’ surge in emigration aimed, until the 1920s, to crest only around 1938), that had been characteristic of much of northern and central Europe about a century before. All these countries likewise shared the H pattern of urbanization that was characteristic for most of Europe during this era and emigration surges in G’ form which, however, except in Norway crested appreciably later than those in nations of Table 4.8 examined so far. Sweden and Norway also experienced G’ movements in marital fertility and gain of G shape in nuptiality along with the early-developing block of European populations. Italy, Spain, Russia, and Serbia did not.

In Sweden, from the middle of the 19th century forward, fertility went up mostly because a higher proportion of *young* women married (Fig. C.3a). How might they do that? An H trend for the *ratio* of youthful fertility to total fertility in fact mirrors the H movement in Swedish urbanization. Apparently, as hypothesized internationally, better life chances and weakened social supervision during the general shift from countryside to town of this era allowed young people to wed and to have children with a freedom not previously possible.

Over the first third of the 1900s, as the delayed upper or birth-rate arm of the envelope of ‘demographic transition’ for Sweden (Figures 2.2a and 3.1a) swung downward, the C-shape decline for fertility among women 20 to 24 dropped away more tardily than that for the overall rate of reproduction (Fig. C.8). Now, with modern contraception available and the appeal of higher standards of living and chances for employment outside the home, older women took more advantage than younger ones of opportunities for family limitation as the loss of infants and children to early death declined. The tail of child-bearing years into middle age was compressed more than the young end of the reproductive range. That difference allowed the proportion of all births that was provided by females 20 to 24 to keep rising along the same H path it had taken since the early 1880s. In this later phase of Swedish fertility adjustment, too, urban opportunity continued to make reproduction by the young relatively more important, even if the population of Sweden meanwhile enlarged from the 1840s into the 1940s in appreciably flatter H form, with zero year back at 1757 (Harris 2001, 150-51), more slowly than trends also of the H shape that have been found for the same period in urbanization and the weight of reproduction by women 20 to 24 within total fertility (t_0's at 1842 and 1825).[36]

In contrast, neither E nor H trends of population increase seem to have appeared in France after 1827, Luxemburg, Finland, Poland, Bulgaria, and Greece (Tab. C.3). France, as often noted, constituted an exceptional demographic case. An historical succession of E then H movements in urbanization, resembling those in Belgium and in England and Wales is evident, but just a brief early E and no H in population growth, which followed a G path from the 1820s into the 1920s (Harris 2001, 148, 152).[37] The combination of a low *level* of emigration (though displaying the usual G’ surge), yet also some simultaneous gain for nuptiality in G fashion, was made possible by the exceptionally low rate of marital fertility that the French population had attained already by the middle of the 19th century. France is also distinguished by having grown economically more through smaller, local or regional enterprises than England (Habakkuk ??). How that developmental mode might have interfaced rather differently with demographic change is worth further careful exploration.

The E-to-H sequence for urbanization that was so common across Europe during the 19th and early 20th centuries also appeared in Romania, while the H path possible for Poland since

1800 resembles those found in Ireland, France, Italy, Spain, and Russia. Regarding emigration, meanwhile, evidence for Russia and Austro-Hungary includes some of the territories more finely listed in Table 4.8. These empires, however, produced notably late G' surges of emigration along with Italy, somewhat trailing even Portugal and Spain. In Finland, where G' decline in marital fertility occurred but patterns of urbanization and emigration are subsumed within Russia, and in all the countries below Portugal in Table 4.8, furthermore, nuptiality contracted in C fashion as opposed to the G-type expansions found in earlier-developing populations. As in Hungary, it remained a factor in reducing overall fertility.

On the whole, where development arrived last, decrease in marital fertility alone did not suffice to link the patterns for demographic increase, for urbanization, and therefore presumably for economic growth. nuptiality had to decline as well. Of note, all the countries in Table 4.8 from Luxemburg down through Bulgaria had primarily Catholic or Orthodox religion. Possessing such traditional institutions resistant to reproductive change did not *prevent* countries from reducing fertility to the point where nuptiality could expand (viz. uniquely secular post-revolutionary France, but also Portugal, Austria, and the Czech lands); but they were present almost everywhere that this exchange did not happen.

The demographic expansions in H fashion during the later 19th and early 20th centuries mostly involved very parallel C-shape declines in CDR and CBR (Tab. C.3). So, however, did virtually *all* growth patterns of this era. How, then, did H trends of increase in population occur rather than those of E or G shape?

One possibility is that, different degrees of discrepancy between birth rates and death rates as the H trends of this era *began* shaped patterns of growth that resulted from the margin. Tables B.1a and B.2a allow rough comparison as of about 1870. At this point, the level of CDR had fallen least relative to CBR for (in order) Ireland, Norway, Scotland, England, Denmark, Sweden, Germany, Belgium, Finland, the Netherlands, and Yugoslavia (reaching from 44 to 29 percent lower than the birth rate). Ireland has been noted as an exception, with demographic decline due to the special severity of net emigration there. Germany and Finland, with E and G patterns instead, unlike their neighbors failed to have H-shape demographic expansion during this later period. The smallest proportional gaps between birth rates and death rates around 1870, in contrast, existed in France and Greece (both only about 7 percent) and in Spain, Italy, Austria, Greece, Hungary, Switzerland, Russia, the Czech lands, Luxemburg, and Romania (from 15 to 27 percent). In Italy, Hungary, and Russia, however, contemporary H trends for population size *did* appear. Disregarding the exceptional collapse of the Irish population, with 5 misfits among 21 adequately measured populations (absent Portugal, Poland, Bulgaria, Greece, and Albania) between the top and bottom halves of these rankings, there seems to be some association between proportional divergence between CBR and CDR at the beginning of the era and H-form expansion in population during it. Ranked by the initial absolute difference between vital rates (simple subtraction), Russia and Hungary rise into the top half, while Belgium and Yugoslavia drop into the top third of the bottom half of countries.[38]

The timing of surges in emigration, moreover, may have affected the populations that did not conform to this bifurcation by degree of difference between CBR and CDR as of about 1870. All of the low-ranked countries with H trends--Italy, Hungary, and Russia--had G' thrusts of emigration that, if not interrupted by the Great Depression and anti-immigrant legislation, would have peaked only between 1938 and 1947. This delay relative to the emigration surges of the remainder of Europe (except Spain) reduced any 'safety valve' effect for most of the second half of the 19th century, which would encourage domestic population increase to have accumulated more (as in the H mode) rather than being flatter (as via G, or the early stages of an E trend.

This analysis of comparative demonomic development among two dozen European countries between about 1750 and 1950 is obviously limited and largely suggestive. Frequently the requisite population data are absent, or provide only few and widely spaced, sometimes not very reliable, observations through time. The socioeconomic connections with these demographic movements, except for England/Britain (Ch. X), are mostly inferred from general historical context, even there relying upon broad impressions of economic development and social and cultural change: industrialization and the development of related commerce and services, wealth and welfare, the growth of middle classes and their institutions, and type of religion or degree of secularization. And the considerable variety of ways in which populations altered demographically (especially from the middle of the 19th century forward) as socioeconomic development, urbanization, and emigration disseminated across Europe, makes it hard to classify countries simply.

Nonetheless, identifying the recurrent--sometimes comparable, sometimes contrasting--G-related trends in fertility, nuptiality, and mortality sharpens, corrects, and clarifies previous international depictions of demographic changes across Europe during this two-century era. The new understanding of the G-based nature of the trends taking place from region to region makes it easier to relate movements in these basic demographic variables to each other, to patterns of change in population size, migration, and urbanization identified in Volumes I and II of this study, and to certain much-discussed aspects of historical socioeconomic development (as illustrated through the English experience in Ch. X).

Though partial and imperfect, the new interpretation should suggest to the inquiring reader further, fruitful analyses (where data will permit) beyond the scope of this present study[39] that will advance still further our understanding of the processes observed in Europe in the shaping of the modern world on a full international scale. Many of the developments identified are hardly unique to this one continent. Simultaneously, world-wide population changes and their connections with other aspects of human life can scarcely be expected always to fit uniformly into European patterns.

The next steps here are twofold. First, before moving on to other parts of the globe it is profitable to mine certain further, more narrow but nonetheless insightful historical studies that clarify and amplify what the national European data suggest, and also extend understanding of demographic change there back in time before the middle of the 18th century. Next, it is essential to ascertain what the trends and relationships among them have been world-wide. Though usually not so full in coverage or historical depth, there exist--as already illustrated by modern international birth and death rates in Chapter 2--valuable materials for beginning to make more world-wide conclusions about both the generality and the diversity of human demographic experience.

Notes

1. Continuities or changes during the past decade or two, however, are left for others to analyze.

2. A recent reevaluation of Coale's indices by Charles Wetherell indicates that some improvement may be introduced by a better grasp of the actual age-specific Hutterite fertility that is employed as the standard for comparison. Those more accurate, slightly higher, real Hutterite levels will somewhat reduce indices of total and marital fertility for other populations. The main improvement appears among women over 40, toward the end of their reproductive cycle. Most of the conclusions about historical change that have been drawn from employing Coale's indices, Wetherell states, will nonetheless remain generally unchanged, though future analysis can be made more precise.

The topic most sensitive to his proposed correction in method will be the chronological patterning of fertility control since, historically, older women have tended to adopt such behavior earliest (2001, 602, 593). The effect of recalculating according to Wetherell's advice would most likely be to lower slightly all curves of I_f and I_g proposed in the present study. Somewhat earlier timing of fertility declines since about 1800 (where family limitation increasingly becomes a factor) is also possible, but not inevitable or especially significant, given the nature and scope of the corrections that he presents.

3. Though Fig. 4.1b shows how an increase in proportion married narrowed the gap between I_g and I_f in England and Wales or--even more--Scotland, between about 1930 and 1960. Contrast this to almost no change in the comparative levels for France (Fig. 4.1a). Before the interwar years of the 20th century, the C trends for I_g and I_f across Europe were generally more parallel than they have been recently, though Belgium (Fig. 4.1a) provides an illustration of considerable strengthening input of I_g (convergence of the two trends) while in Spain (Fig. 4.1e) significantly expanding intervention of the marriage rate between I_g and I_f is evident in the divergence of the comparable curves.

4. A similar perspective on how G' responses to stimuli in parts of a demographic system interact to produce more prolonged, non-reversing G, D, C, or E trends at more aggregate or composite levels has been encountered in Volume II of this study in the relationship between local or otherwise more specific

cases of migration, whether free or forced, and more composite or compounded historical flows of relocation of which they have been part.

5. Moravian fertility remained higher longer. Germany without Alsace-Lorraine is employed from 1867 through 1933. The summary by regions for Italy is used (Coale and Treadway 1986, 80, 113, 122).

6. In Switzerland the C curve fits a somewhat longer span of data, but does not capture the 1880-1930 stretch as well.

7. The Coale and Treadway evidence for Sweden is infrequent, because data were desired from all counties of the nation. Countrywide estimates from John Knodel and Étienne van de Walle (1986, 397), however, help establish more continuous C and G' trends for Swedish I_g (the filled upward triangles for this country in Fig. 4.1c). Between 1860 and 1900, decline for marital fertility in Sweden approximately paralleled (t_0 at 1962 vs. 1970) a preceding C-shape change that is evident from 1800 through 1850, but did so at a slightly higher level (.273 compared with .257). To simplify presentation, only the 1800-1850 trend is shown in Figure 4.1c. Then it took up a steeper, retroactively timed C path that resembled contemporary movements in Belgium and Germany into the 1930s.

8. The latter country joins Scotland and Ireland (further down in Tab. 4.1) on the far northwestern Atlantic periphery of Europe in lacking support for such shape of movement.

9. The Coale and Treadway data for Luxemburg at just 1900 and 1930 suggest a t_0 of 1920, almost as early as that of Belgium. Governmental data that simply relate the number of annual births to females 15 through 49 (Luxembourg 1990, 54), however, from 1871 through 1947 follow a C trend with t_0 of about 1943. Though this measure is more like I_f than I_g, it supports the hypothesis that a C trend does represent reliably the movement of marital fertility in Luxemburg between and around the two dates from Coale and Treadway.

10. The Luxemburg data, for example, imply a starting level at as much as .97 of the Hutterite standard, the French evidence only .47.

11. A 1/G' sag between 1841 and 1871 seems most likely (Fig. 4.1a). A preliminary regional exploration of marital fertility across departments (employing Coale and Treadway 1986, 94-107),

however, identifies what should be an insightful minority of locales in which French movements did resemble the trends found in neighboring countries such as England, Belgium, and Germany though the national pattern did not.

Ten departments of France in fact display G’ patterns in marital fertility that top out in the 1870s. Four of these were in Brittany (Finisterre, Côtes du Nord, Morbihan, and Ille et Vilaine). Three ranged from Seine Inférieure, probably including Pas de Calais, to Nord--in other words, along the Channel from the area around Rouen to the region contiguous to the western half of the Belgian border. Beyond this long band of seven departments along the north coast of France and the Belgian border, two other G’ exceptions, Haute Loire and Lozère, lay together near the Cevennes mountains west of the Rhône. The final G’ pattern appears in Hautes Alpes, east of the Rhône and next to the Piedmont border of Italy west of Turin.

What might explain G’ movements of marital fertility in these 10 areas of France but not some 80 others? Though Nord contained Lille and Seine Inférieure included le Havre and Rouen, the growth of a substantial city did not--within France, at least--of itself generate this shape of 19th century trend in I_g. Seine (Paris), Rhône (Lyon), Bouches du Rhône (Marseilles), and Gironde (Bordeaux) lack this form. Did, however, the type of industrialization and commercialization experienced by France--conventionally thought to take place frequently in smaller, more scattered firms--distribute in a fashion that might help the interpretation?

Clearly, meanwhile, the evidence shows that departments with relatively high fertility as of 1831 could experience *either* C or G’ shapes in I_g. Did a history of strong demographic *curtailment* before 1831, however, mean that little systematic increase could occur thereafter? Apparently not. Calvados and Eure, lying in rural Normandy between the 4 departments of Brittany that display G’ trends and the 3 north of the Seine along the Channel, shared the lowest departmental levels of marital fertility by the second quarter of the 19th century along with Seine, Seine et Oise, and Oise stretching inland across the Paris basin. Yet they also display some systematic 19th-century increase in marital fertility (in G rather than G’ form) while the three other more inland areas with especially low I_g by 1831 do not. What, then, might almost all the departments near the north coast from southern Brittany to the Belgian border have shared with each other, and with the three inland areas of the South that also show G' trends? Not isolation, judging by Nord and Seine Inférieure, but perhaps strong regional identity and attitude toward change?

12. The targeted levels for the t_0's of the trends for southeastern Europe average .26, lower than the .30, .31, and .34 for earlier-timed movements in the three groups above them in Tab. 4.1 respectively.

13. Very early fertility decline in certain parts of Hungary, for example, is masked by the national total. Ch. 5 contains discussion of this regional phenomenon.

14. Among the zero target years for the transition era C curves in Tab. 4.1, 1 is projected in the 1910s, 4 in the 1920s, 4 in the 1930s (including what is probably a secondary, post-1830 C movement for France), 3 in the 1940s, 3 in the 1950s, probably 7 in the 1960s (including Austria and Czechoslovakia, for which meager data exist), and perhaps 5 in the 1970s (making comparable assumptions about what happened in Bulgaria and Albania relative to neighboring territories).

15. These movements are discussed in the next chapter as part of the pre-transition behavior of European fertility.

16. In Switzerland (Fig. 4.1d) a G' trend may exist for 1940 through 1960, but the rate at 1970 clearly breaks below the pattern. Hungary (Fig. 4.1f) might have had a later G' movement, too; but the evidence so far covers a very short period, only after 1960.

17. The proportion of all women 15 and over (not just 15 through 49) in Luxemburg who were married, for which more regular though not exactly comparable evidence is available (Luxembourg 1990, 18), rose from 1900 through 1922 in G form with base year around 1843, very much like contemporary movements in Ireland and Iceland (part A of Tab. 4.2). Then from 1922 to 1980, omitting the low of postwar 1947, the percentage rose along a new G path with zero year coming between those for the 1901-1960 G trend of I_m for France and the 1925-1939 G for Germany. The other exceptional G pattern in part B, for Italy between 1921 and 1951, is closely parallel to the 1901-1960 trend in France and that of 1900 to 1930 (or 1900 to 1922) for Luxemburg.

18. With the exceptions of unclear patterns in Germany and France, and of Portugal, Switzerland, and

Czechoslovakia, where nuptiality kept rising in G fashion into the 1980s rather than falling back via G'.

Figs. C.1a and C.1b and Tab. C.2 (App. C)--with perhaps insightful exceptions--show a tendency toward increased regional variability within countries as a part of overall national G-shape gains in nuptiality, while populations with falling I_m correspondingly had less "provincial" variation.

Figure C.2 trends crude marriage rates for England, France, and Sweden. Besides the long-term G and C movements, which can be identified well before the era of 'demographic transition,' of interest are the apparent G' patterns in England between 1751 and 1781, in France from 1772 through 1807, and in Sweden about 1803 to 1833 (with t_0's in the vicinity of 1767, 1790, and 1805 respectively). What might have made the crude marriage rate surge this way successively in these three countries?

19. For probable or possible C curves fitted for these ten populations in Figs. 4.2a through 4.2f, the averages are 1964 for I_g (excluding thinly documented Luxemburg), 1954 for I_f (including estimation for Luxemburg), and 1981 for I_m (with Luxemburg). Finland has early C's for both overall fertility and proportion married relative to the other nine countries of the group; Hungary and Poland show comparatively early other C's relative to their birth rates.

20. For apparent trendings in the *variability* of nuptiality among provinces *within* countries see Tab. C.2 and Figs. C.1a and C.1b in Appendix C.

21. Lacking Luxemburg and Iceland, which Coale and Treadway (1986) include in their European overview. Fig. 4.3a indicates that for Finland data from 1753 through 1833 lie somewhat above a backward projection of the 1843-1967 C trend but clearly parallel it. For Sweden, meanwhile, the series from 1818 through 1863 comparably partners, in this case at a somewhat lower level, a C curve fitted to 1753-1813 and 1868-1888. Local investigators should be able to identify the causes and the significance of these particular shifts.

22. A recent study of infant mortality and related matters in 36 towns of England between 1865 or 1875 and 1905 indicates that, in aggregate, births per woman age 15 through 44 declined in C form toward a t_0 located about 1918 (Millward and Bell 2001, 713; trend estimated). This compares with an 1871-1931 C path for overall fertility in all of England and Wales with a base year at 1929 (Table C.1). Decline in C

fashion, furthermore, appears to be characteristic for all 8 of the different sub-groups of towns that the authors examined: textiles, ports, mining, mixed industrial, seaside, middle class/suburban, farming, and other miscellaneous centers. Textile and mining towns started with the highest levels of fertility; but the rate fell first and steepest in textile centers along with seaside towns.

Trends for infant mortality reported by Millward and Bell study are less clear, in large part because values at 1895 all seem high. Making allowances for this, however, it seems that even then, as in the relative timing for England and Wales as a whole likely or possible C trends for infant mortality came down more *tardily* than those for fertility in every type of center. Textile towns and those with mixed industry began with the highest levels of infant loss. Farming centers saw improvement in M_i first; seaside communities, ports, and mining towns adjusted last, and display the greatest "wrong-way" lags between their fall in fertility and their decline in infant mortality, though there was some delay in all 8 kinds of towns--mostly rather more time than what Tab. 4.3 shows for the country as a whole.

23. In the 12 countries of Tab. 4.3 from Belgium down to Norway, which had the earliest C curves of decline in marital fertility, only 2--Switzerland and the Netherlands--show lags of more than 10 years behind C-shape change in infant mortality. Among the 9 nations from Hungary through Ireland with later I_g transformations, in contrast, 6 display intervals of 14 years or more behind the movement of M_i, while European Russia has a delay of 9 years.

24. Though recent evidence on Spain and Italy indicates D shapes since the 1970s (Smil 2005, 606)

25. Fig. 1.4 in Ch. 1 displays G' surges for I_h in England alone from 1758 to 1783, 1783 to 1828, and 1833 to 1873. The last of these movements crests in 1858 compared with 1848 for the 1851-1901 trend of England and Wales in Fig. 4.4a.

26. Also Luxemburg, if the 1877 through 1958 G' path for percentage of births that were illegitimate, with crest around 1916, is an indicator of the likely trend in I_h (Luxembourg 1990, 54).

27. In England and Wales *two* G' humps in I_h occurred, bracketing the 1874 t_0 in I_g with peaks 26 years earlier and 23 years later. The data of Wilson and Woods (Fig. 1.4), on the other hand, indicate a G' surge for the year from 1833 through 1873 that crested at 1858. In Scotland, two G' trends of extra-marital

fertility that were virtually identical with the English ones appeared without any such movement for fertility within marriage. In Denmark, a bracketing similar to the English one has a 17 year lead and then a 14 year lag, while France displays two G' rises in I_h that are almost perfectly contemporaneous with those of Denmark, but no such movement in I_g.

28. For instance, for 17 leading cities in 14 countries--from England to Greece, from Portugal to Finland and Russia--across the later 19th century and into the early 20th the number of inhabitants expanded in G form with t_0 between 1864 and 1905 (Harris 2001, 312). The zero years for these growth trends (and therefore their G' derivatives), in other words, are distributed by date very much like the crests of the national G' surges in I_h that appear in the second and last columns of Tab. 4.5.

29. For Germany, I_m has to be used as a crude indicator. For Belgium, such movement has to be hypothesized for the rise between 1856 and 1900 without intervening evidence.

30. Drawing upon Vol. I (148-49) and Tabs. 2.1a and 2.3a, Tab. C.3 displays the connections for virtually all of Europe, unlike Tabs. 3.2 and 3.3, which selected 18 and 8 examples respectively. Tab. 3.2 was organized to stress international comparisons of separate trends in population, births, and deaths, not how the three components fitted together during each period in each nation.

31. The Belgian population pattern is estimated from the provinces of Antwerp, Brabant, and East Flanders (Klep 1991, 505, 498). In five communities of western Germany, birth rates rose in E fashion between 1755 and 1805, while the population of Württemberg expanded this way from 1759 through 1802 and that of Mark, northward down the Rhine, between 1722 and 1780 (Tab. 2.3a; Harris 2001, 206, 208, 327). In the Swiss canton of Solothun, south near Basel, meanwhile, growth from the 1790 through the 1820s that has been represented by a succession of G trends, could well have taken E form (Harris 2001, 335). It is possible that in Poland, east of Germany, population expanded in E form between 1700 and 1800 with t_0 in the vicinity of 1779 (de Vries 1984, 36; CBR and CDR are not known this early).

32. I_f before 1880 is known only for Portugal, where it rose in accelerating fashion from 1864 through 1890 (Fig. 4.1e).

33. The French population, exceptionally, already met falling infant mortality with *reductions* in marital

fertility while holding nuptiality steady (Figs. 4.3a, 4.1a, and 4.2b).

34. A D trend for the crude birth rate in Lombardy and Tuscany, though, appears from the 1820s through the 1850s, following an E movement for Lombardy between 1770 and 1800 (Fig. 2.2b). *Northern* Italy has a long history of economic development and urbanization.

35. Under rather different circumstances of fundamental economic change, in the Low Country provinces of Antwerp, Brabant, and perhaps East Flanders, in the Dutch maritime province of Holland, and in Germany (with its mining riches and overland routes of trade from the south of the Alps), growth in this H manner appeared probably by about 1500, as the economic activity of Europe, and its urbanization, shifted from the Mediterranean to northern regions (Fig. D.2; Harris 2001, 148, 200; Harris 2003, 258, 252). In England and Sweden it followed suit from the later 1500s into the 1600s (Harris 2001, 148-49). The H trend of population increase for England during the last half of the 1500s and the first half of the 1600s, followed relatively flat G-type growth over the preceding years and was stimulated by a marked drop in death rates in the 1560s with considerably less decline in birth rates (Ch.1, Figs. 1.1 and 1.2).

36. Similarly, the G for population growth from 1943 through 1990 had a zero year of 1909, earlier than that for the apparent G for the relative fertility of the young between 1943 and 1967, or later.

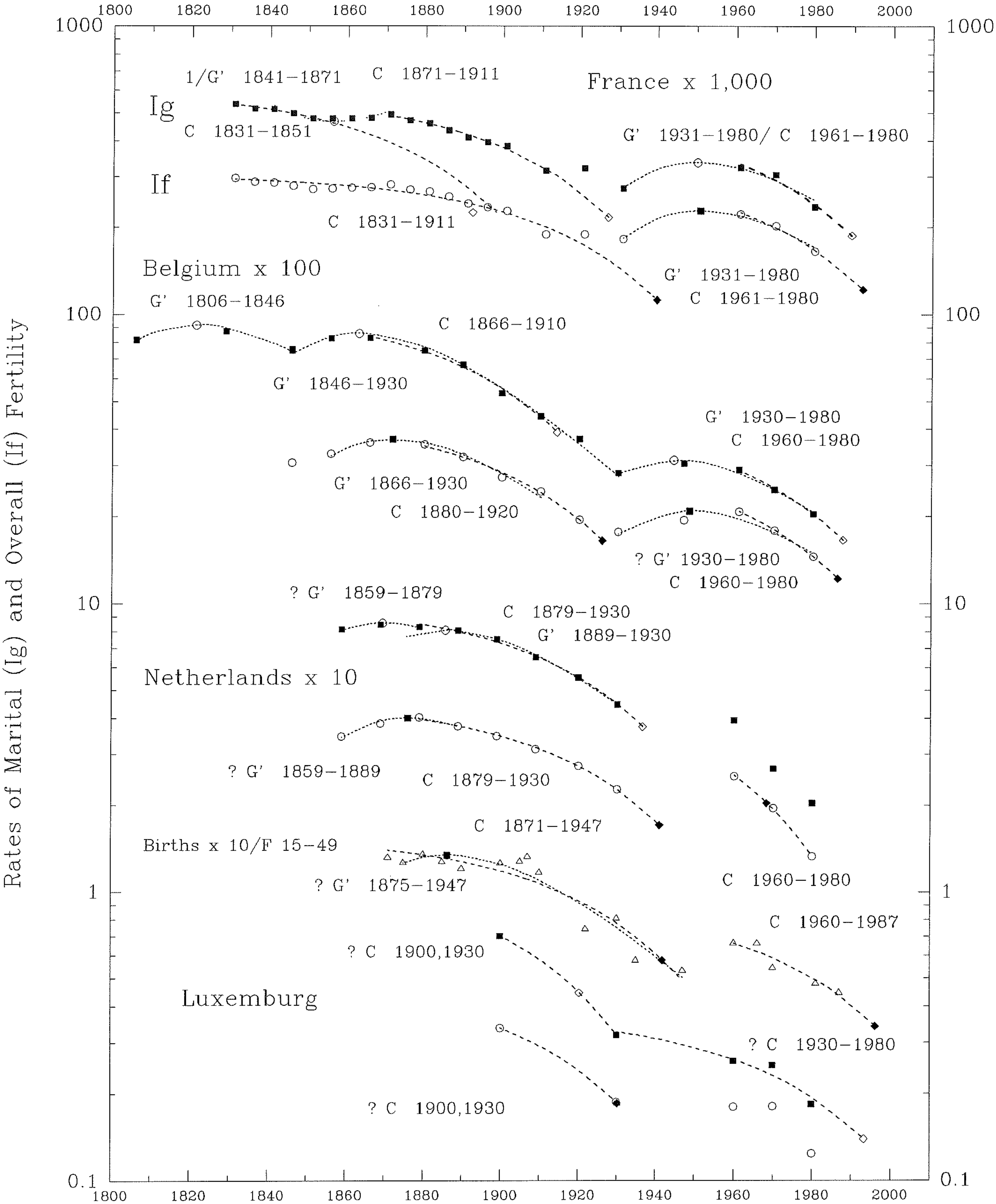
37. Though, as this analysis hypothesizes for regions with robustly developing economies, H-type demographic increase did occur in Nord (the heavy industrial department around Lille), between 1851 and 1911 as well as from 1801 to 1851, and perhaps also in Seine (the department of Paris) between 1831 and 1931, but not in the environs of Lyon, Marseilles, or Bordeaux (Harris 2001, 199). The same holds for Lower Austria, the site of Vienna, alone among the regions of that country (ibid., 213).

38. Ranking simply by the level that CDR had reached by 1870 provides a weaker match with the appearance of demographic growth in H form during the later 19th century.

39. Including what has happened since World War II.

Figure 4.1a

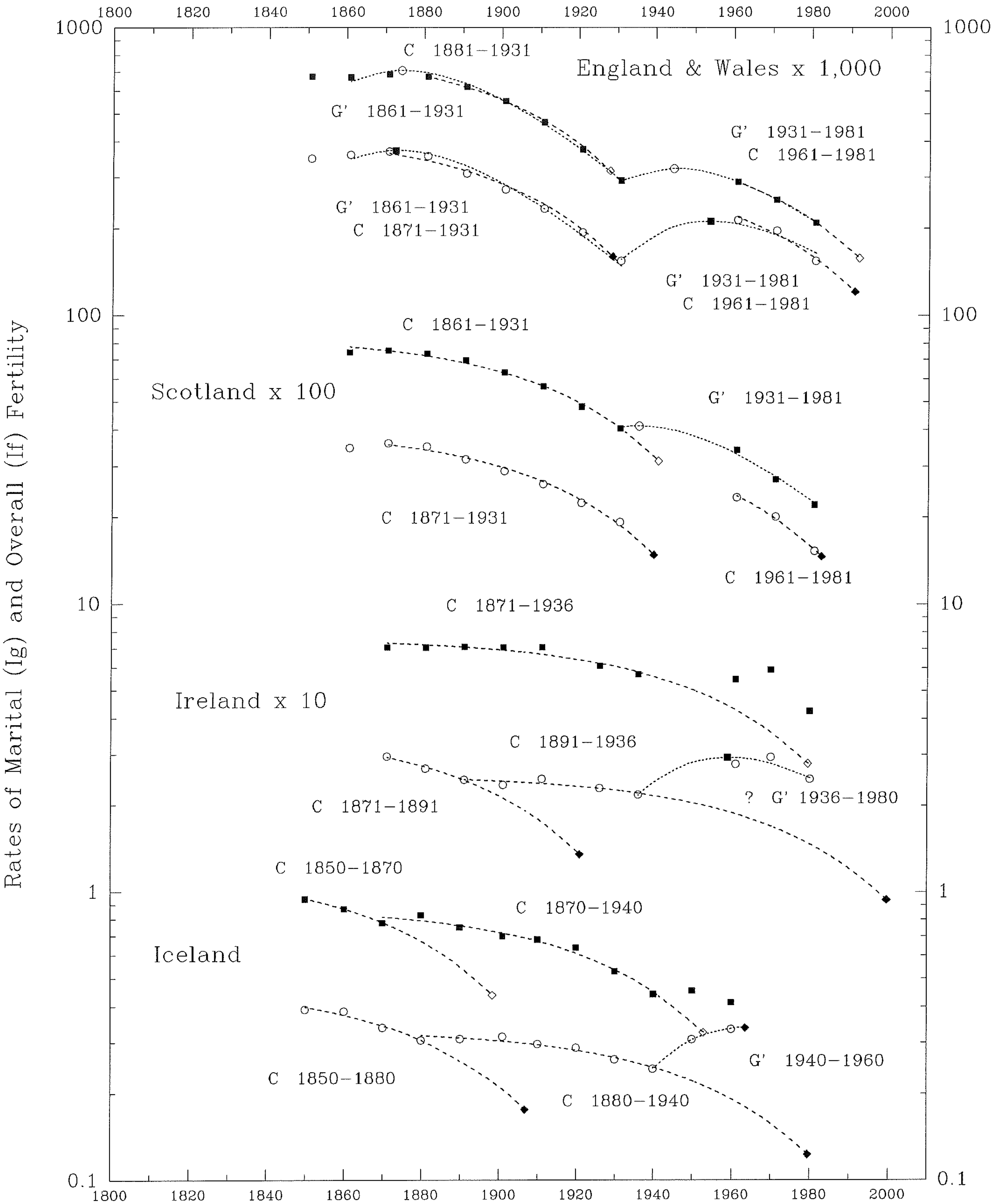
European Trends of Marital and Overall Fertility: France, Belgium, the Netherlands, and Luxemburg



Source: Coale and Treadway 1986, 78, 80–152; Deprez 1979, 272; Luxembourg 1990, 54.

Figure 4.1b

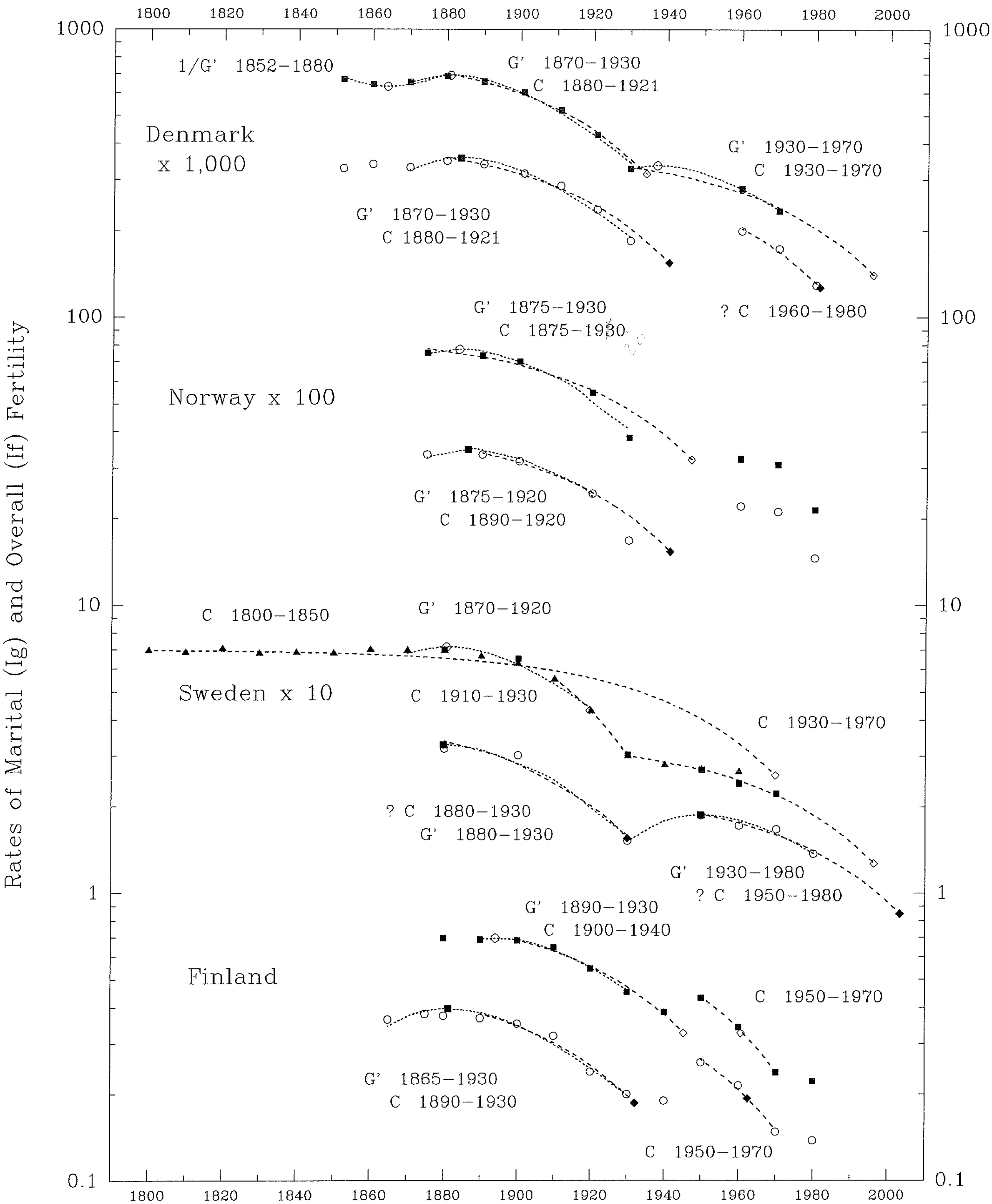
European Trends of Marital and Overall Fertility: England and Wales, Scotland, Ireland, and Iceland



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.1c

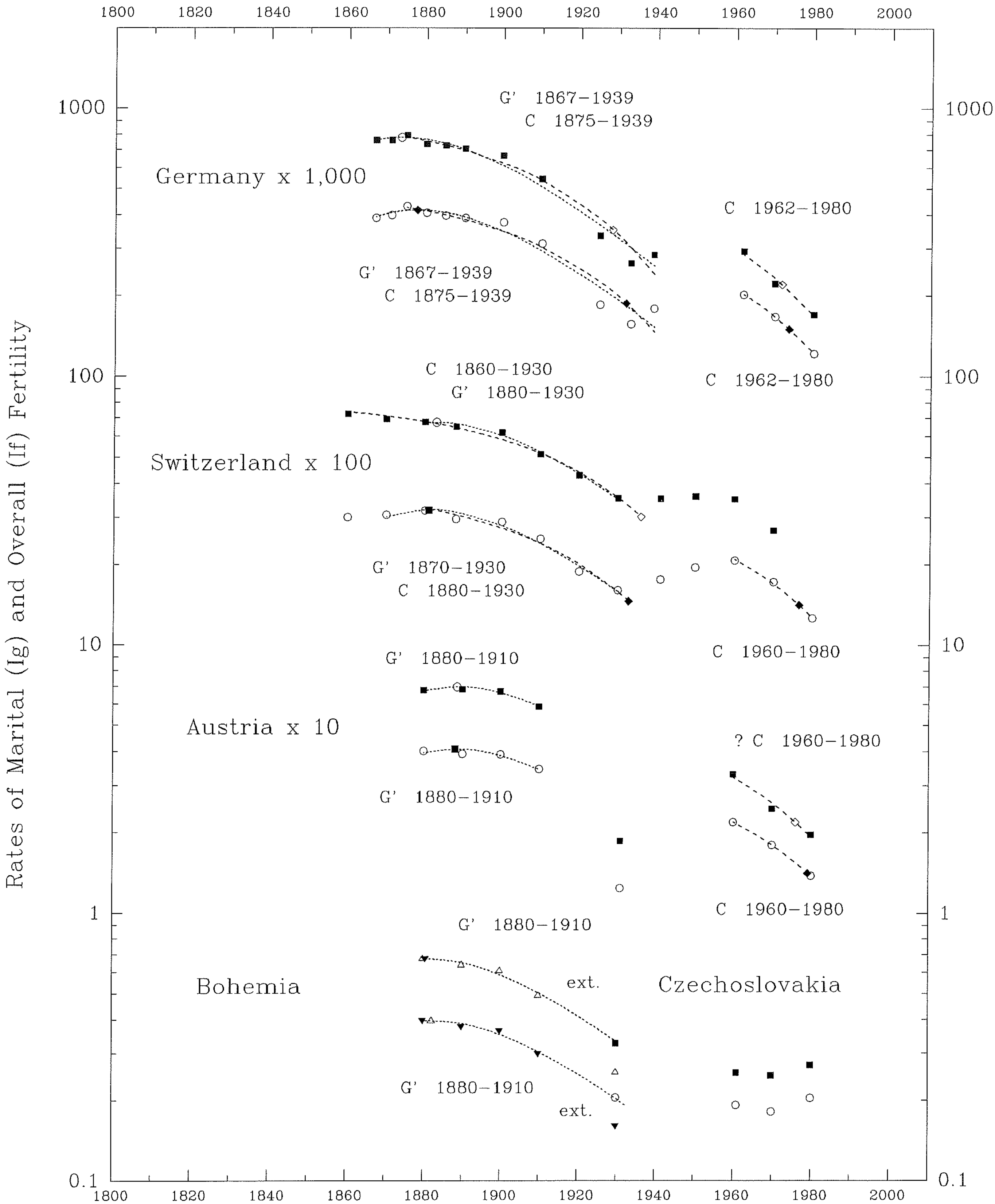
European Trends of Marital and Overall Fertility: Denmark, Norway, Sweden, and Finland



Source: Coale and Treadway 1986, 78, 80–152; Knodel and van de Walle 1986, 397.

Figure 4.1d

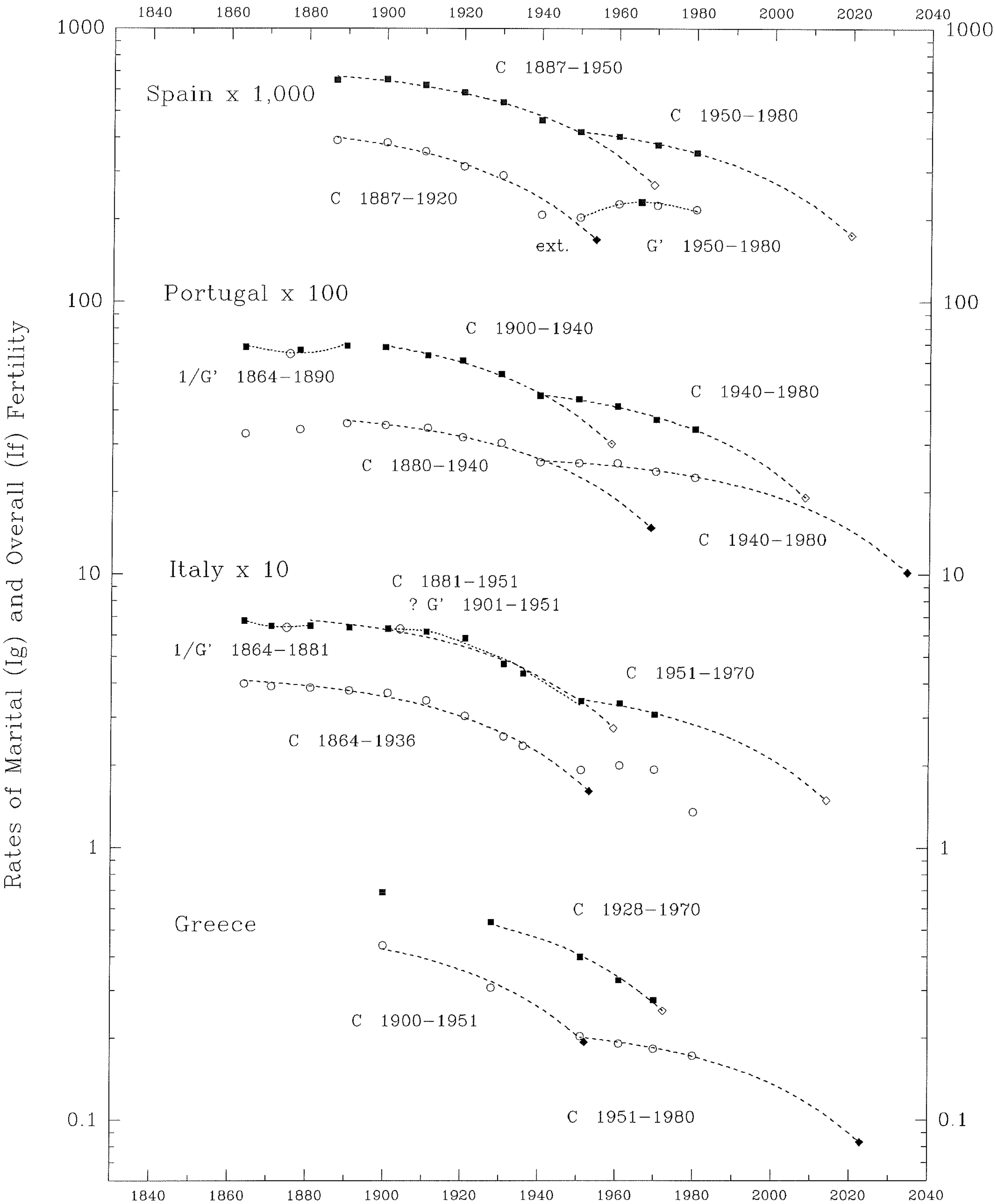
European Trends of Marital and Overall Fertility: Germany, Switzerland, Austria, Bohemia, and Czechoslovakia



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.1e

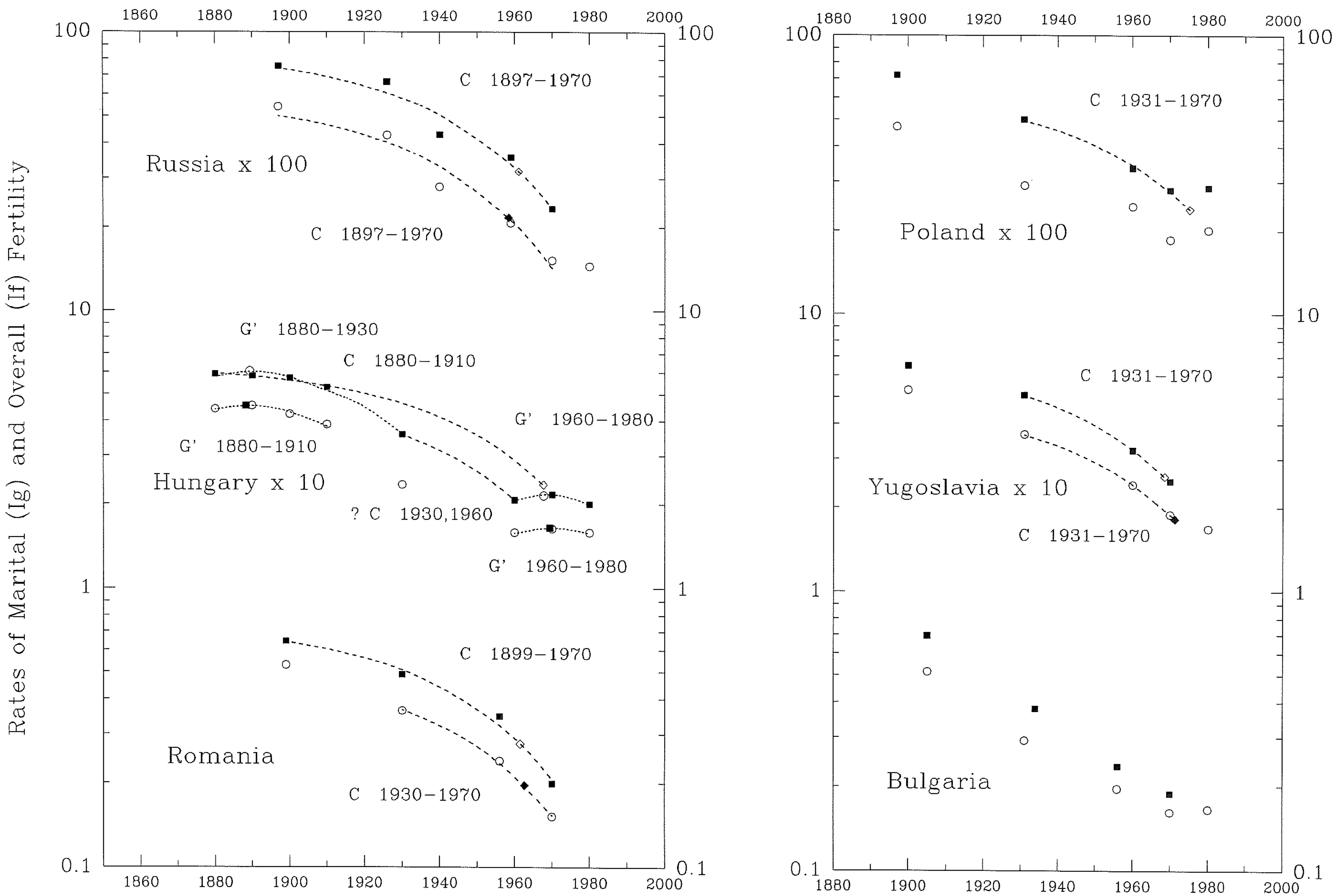
European Trends of Marital and Overall Fertility: Spain, Portugal, Italy, and Greece



Source: Coale and Treadway 1986, 78, 80–152.

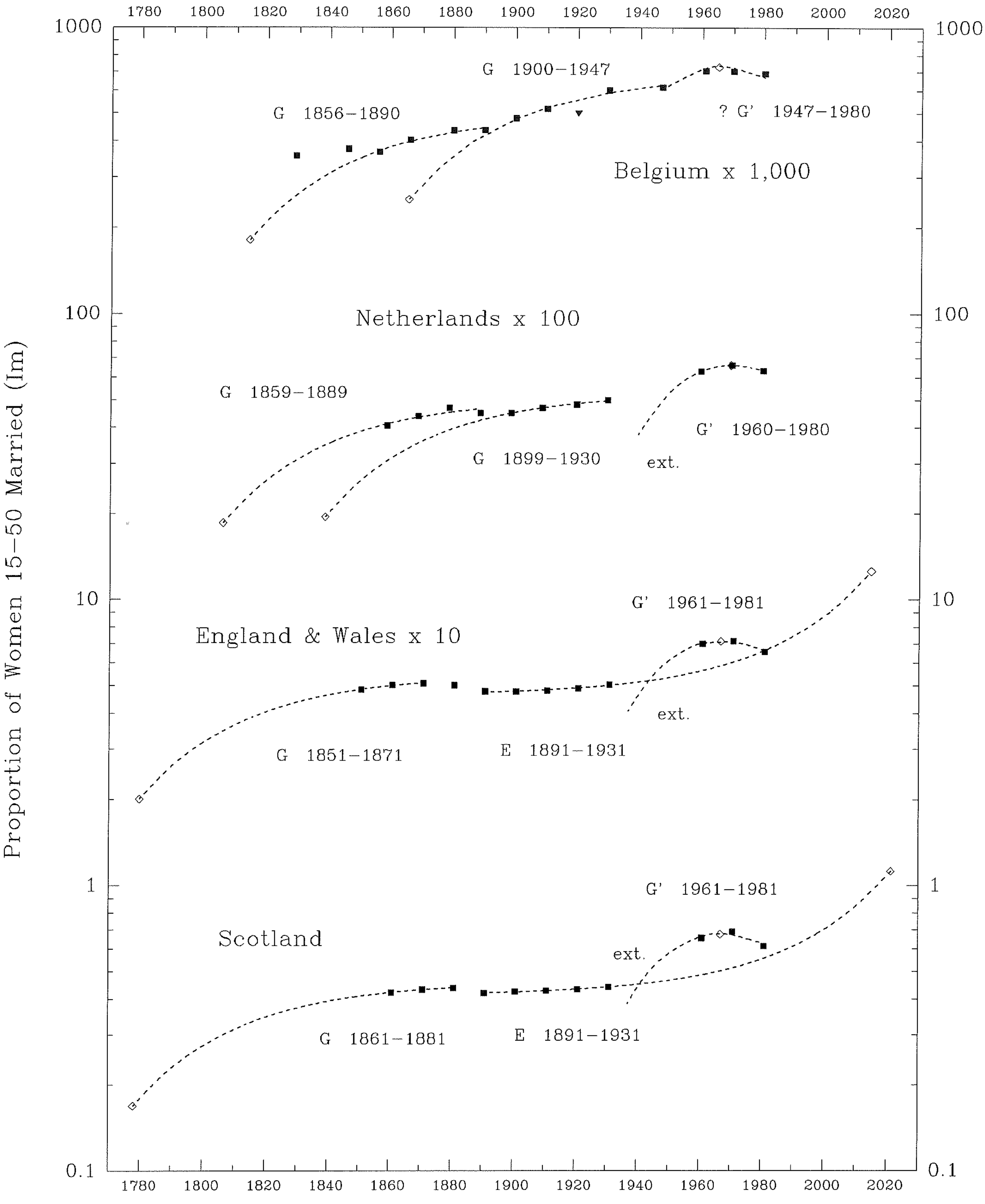
Figure 4.1f

European Trends of Marital and Overall Fertility:
Russia, Hungary, Romania, Poland, Yugoslavia, and Bulgaria



Source: Coale and Treadway 1986, 78, 80–152.

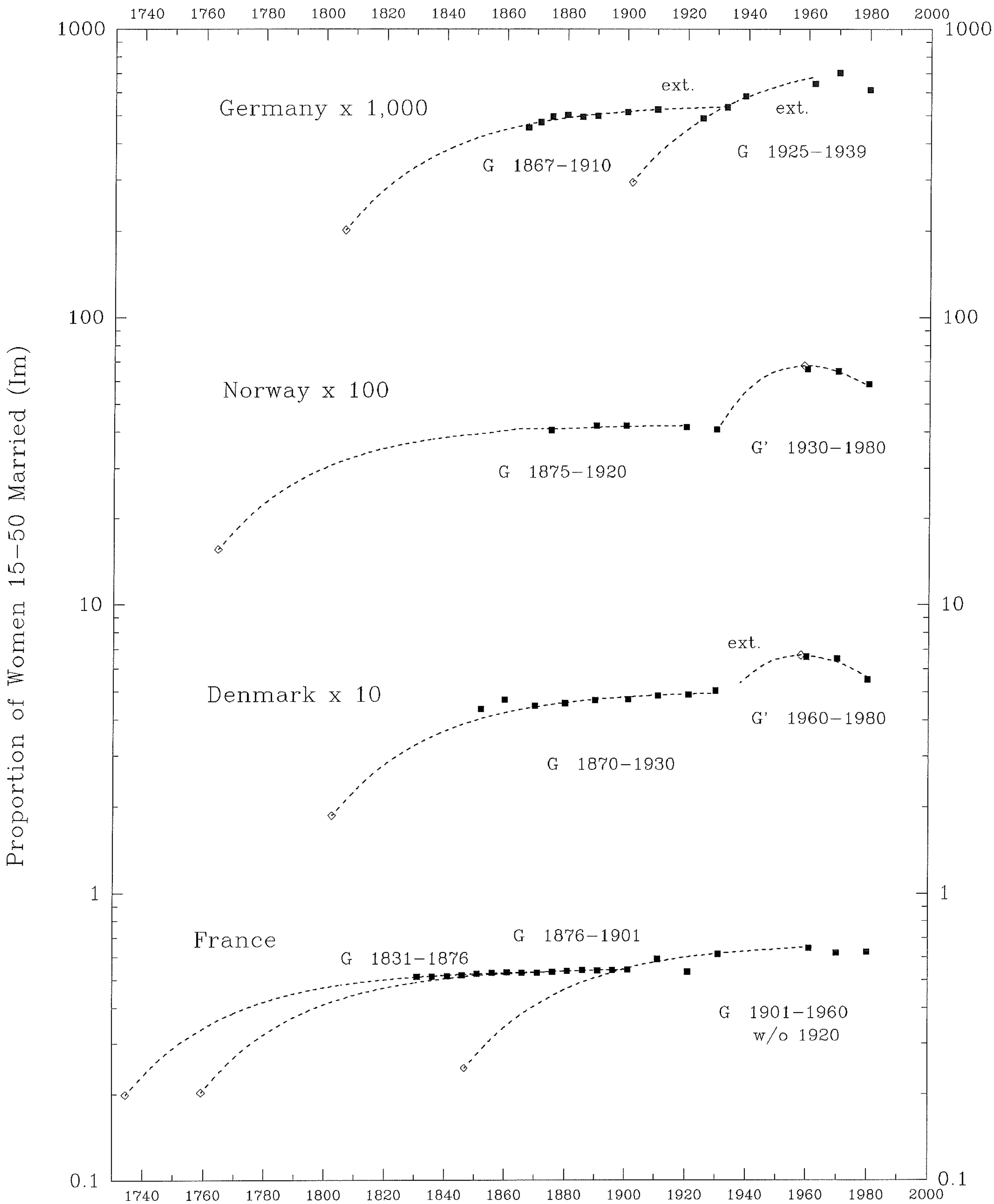
Figure 4.2a
Proportion of European Females 15–50 Married:
Belgium, the Netherlands, England and Wales, and Scotland



Source: Coale and Treadway 1986, 78, 80–152; Deprez 1979, 270.

Figure4.2b

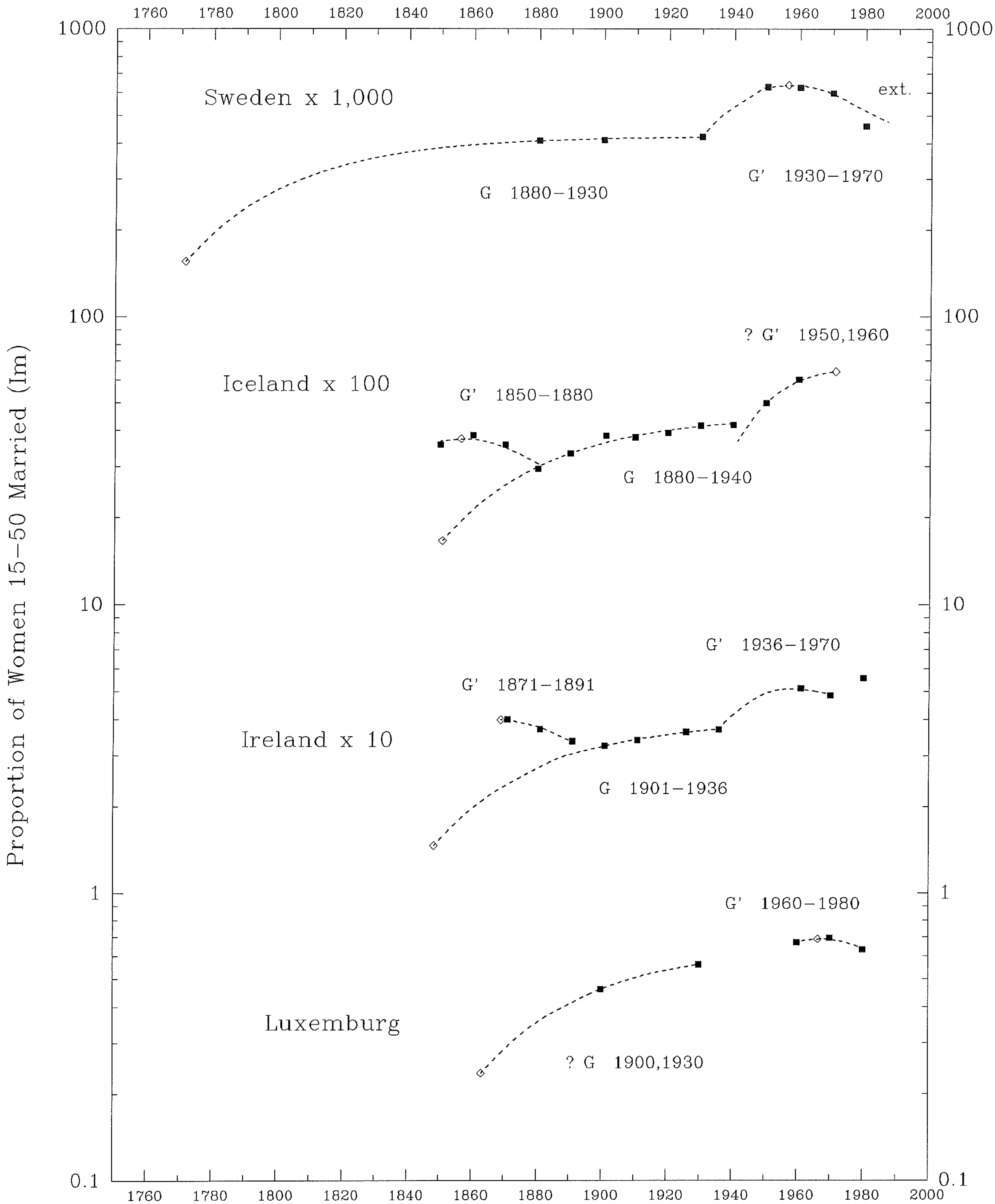
Proportion of European Females 15–50 Married: Germany, Norway, Denmark, and France



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.2c

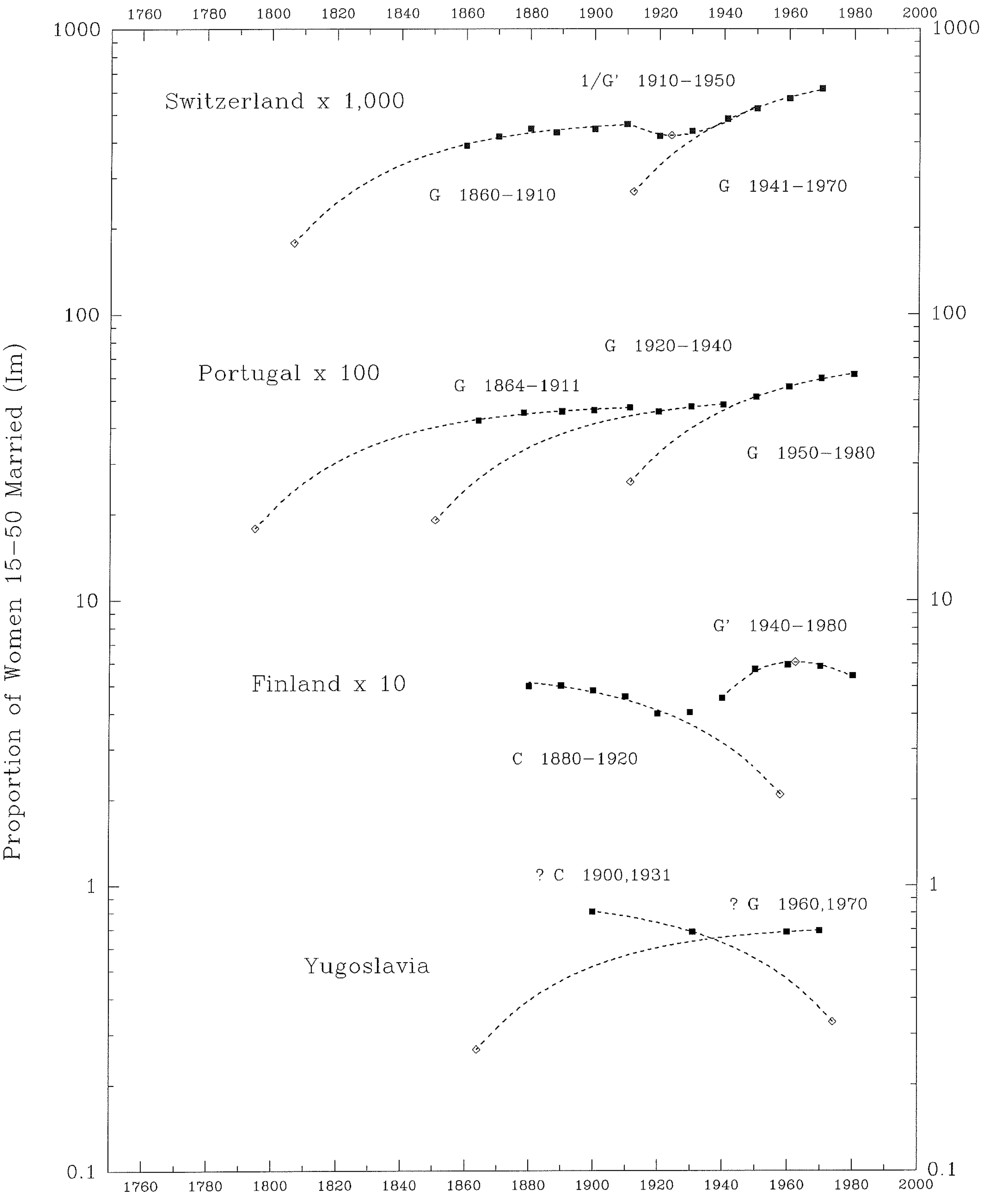
Proportion of European Females 15–50 Married: Sweden, Iceland, Ireland, and Luxemburg



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.2d

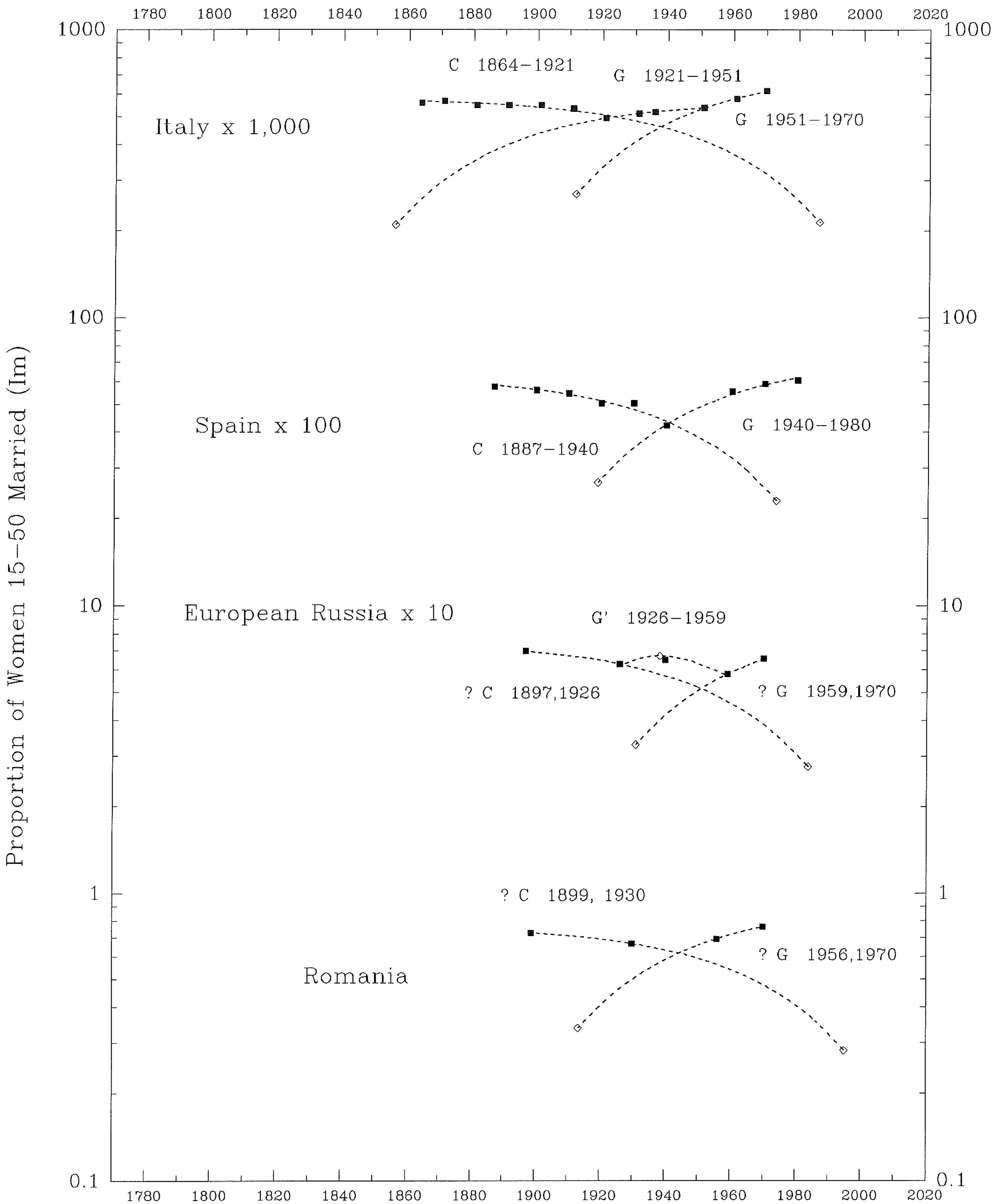
Proportion of European Females 15–50 Married: Switzerland, Portugal, Finland, and Yugoslavia



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.2e

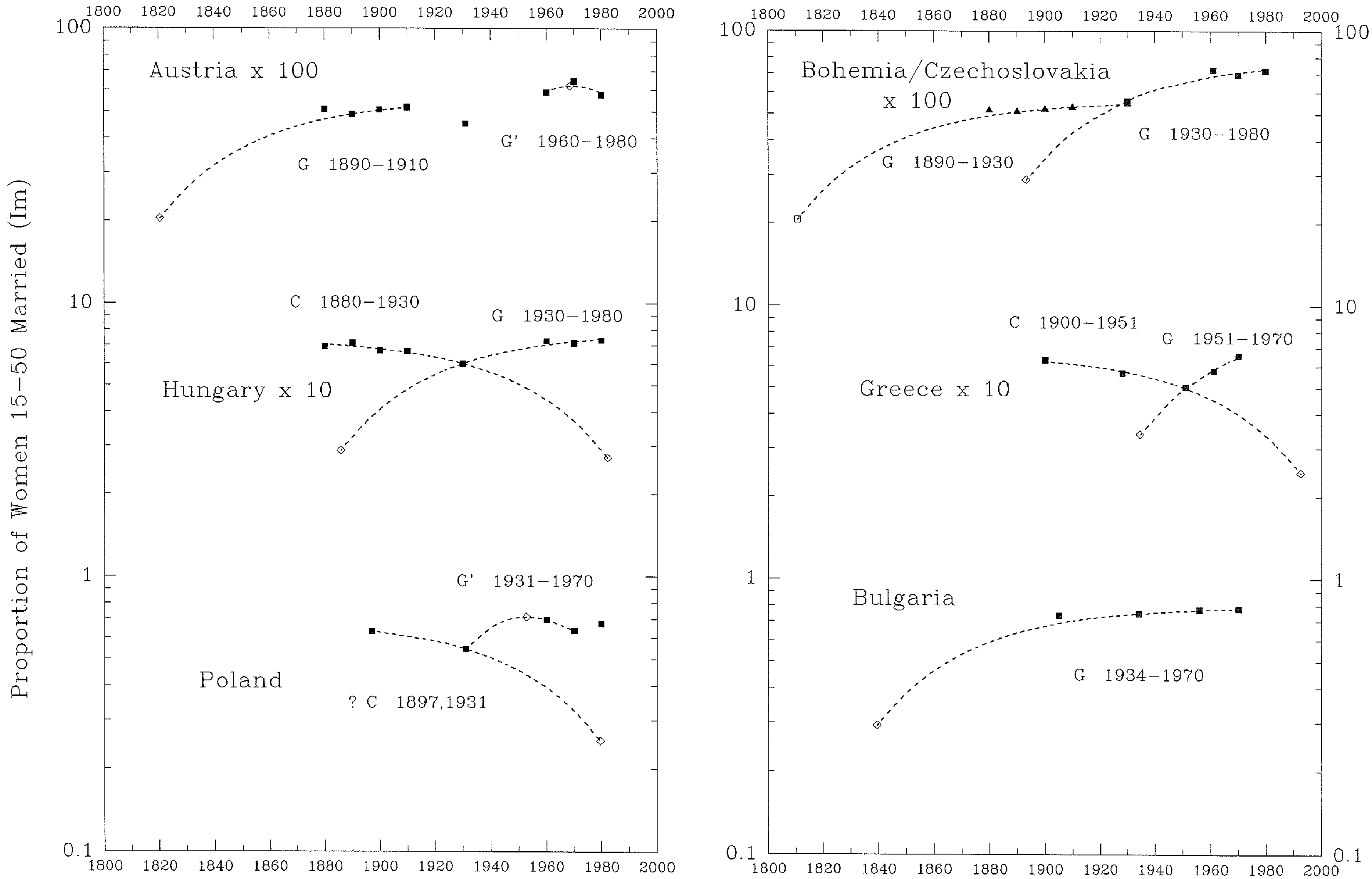
Proportion of European Females 15–50 Married: Italy, Spain, European Russia, and Romania



Source: Coale and Treadway 1986, 78, 80–152.

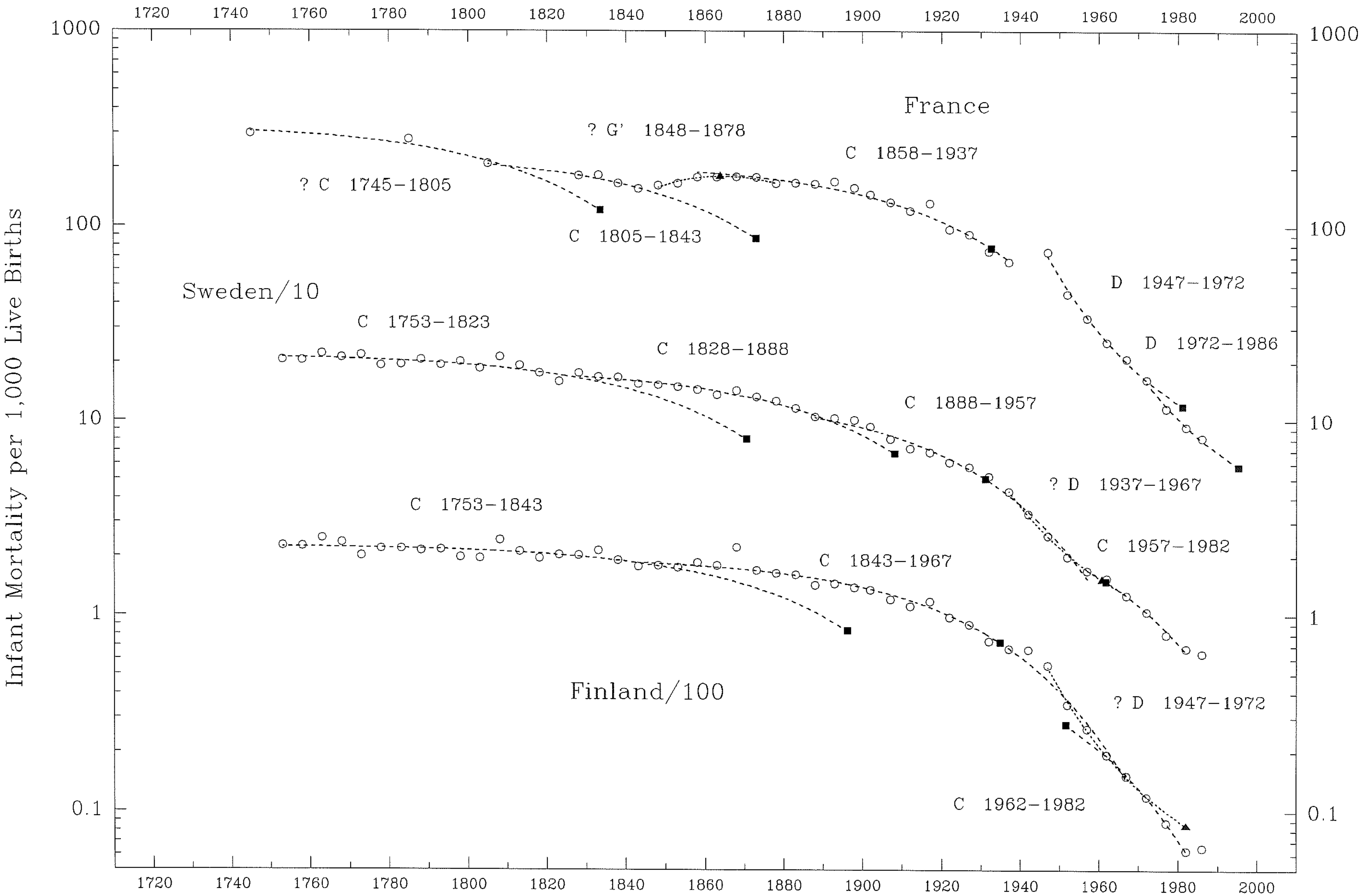
Figure 4.2f

Proportion of European Females 15–50 Married: Austria, Hungary, Poland, Bohemia/Czechoslovakia, Greece, and Bulgaria



Source: Coale and Treadway 1986, 78, 80–152.

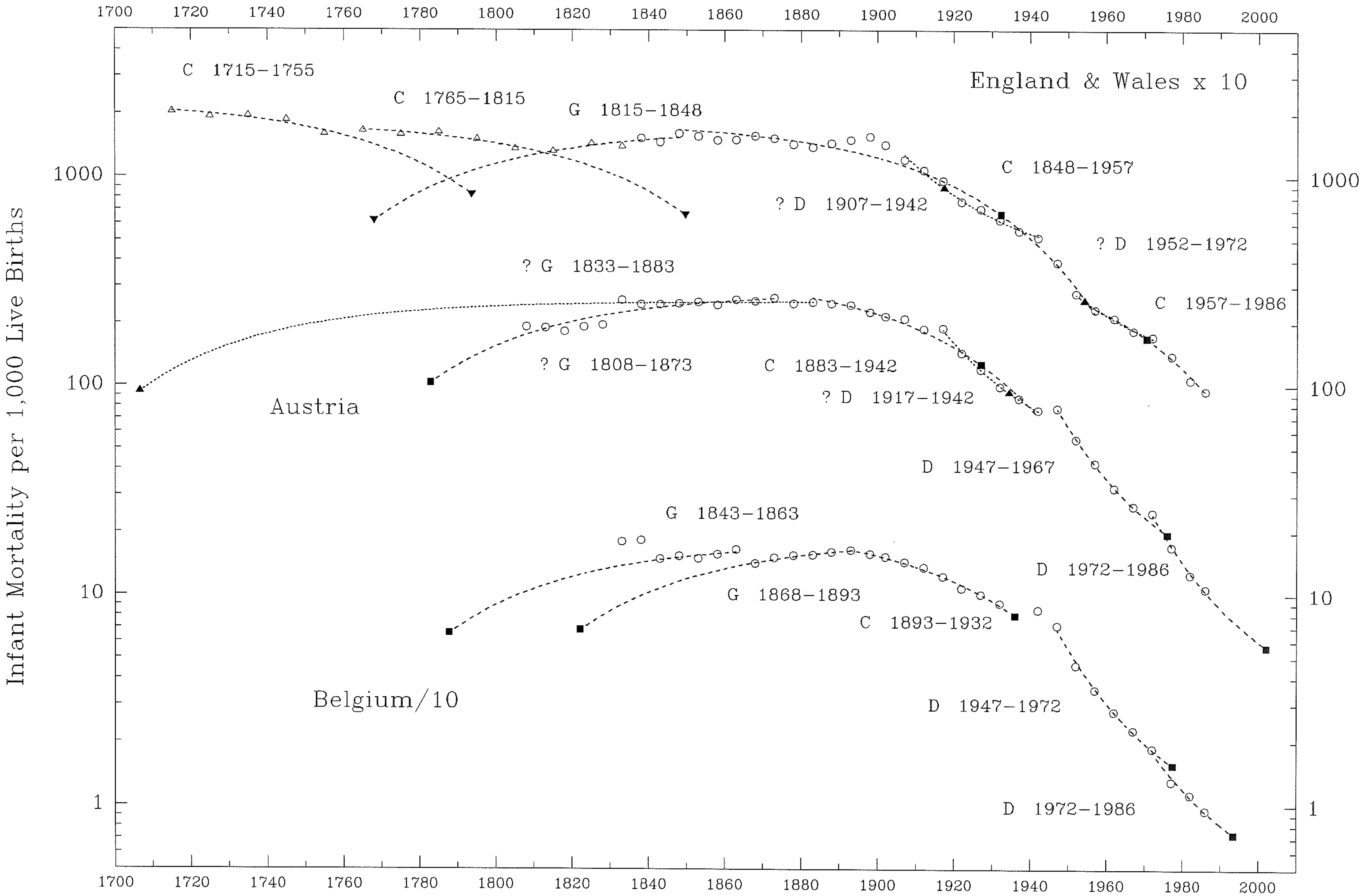
Figure 4.3a
Infant Mortality Rates in European Countries:
France, Sweden, and Finland



Source: Chesnais 1992, 580–97.

Figure 4.3b

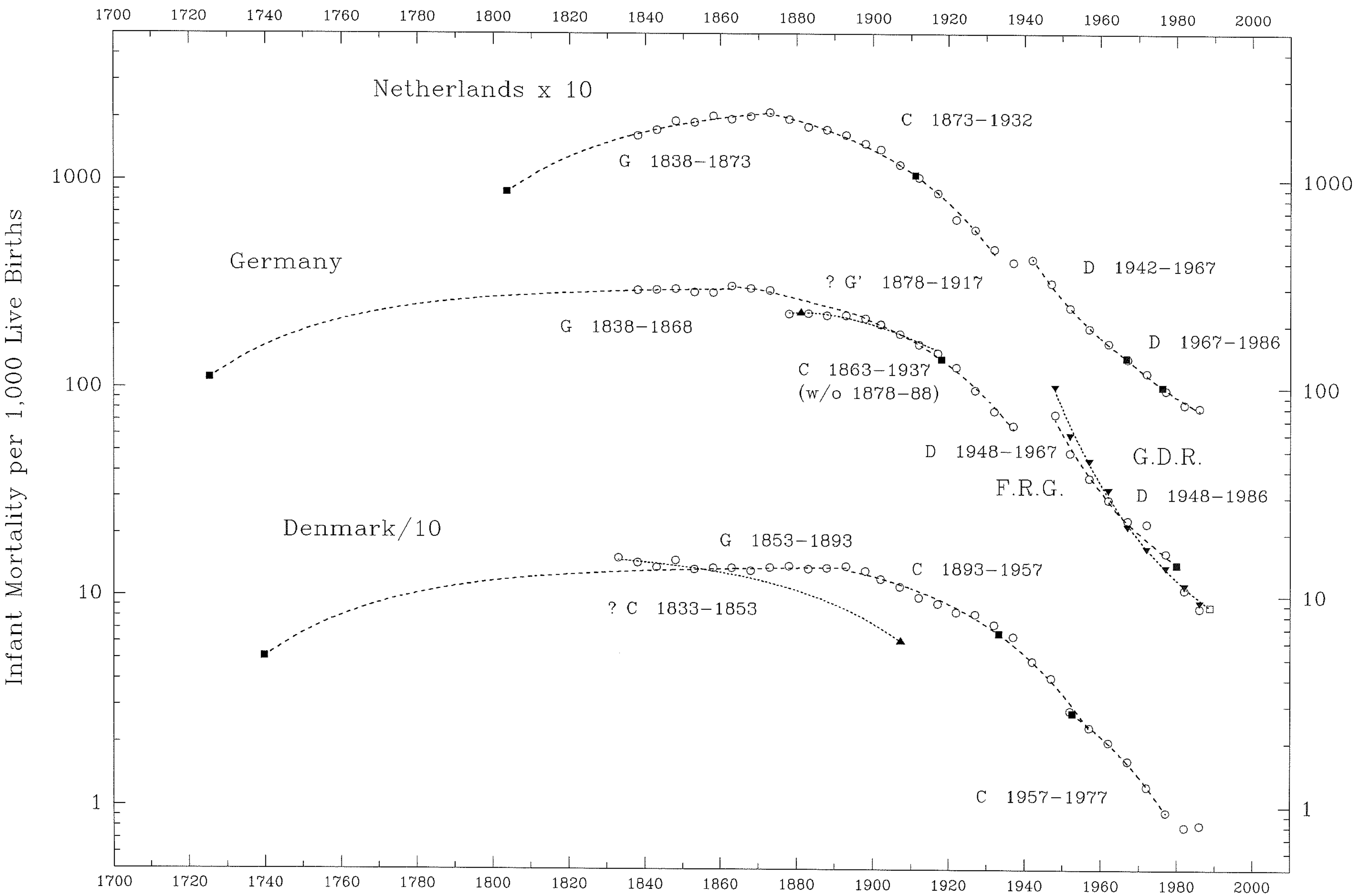
Infant Mortality Rates in European Countries: England and Wales, Austria, and Belgium



Source: Chesnais 1992, 580–97; Schofield 2000, 63.

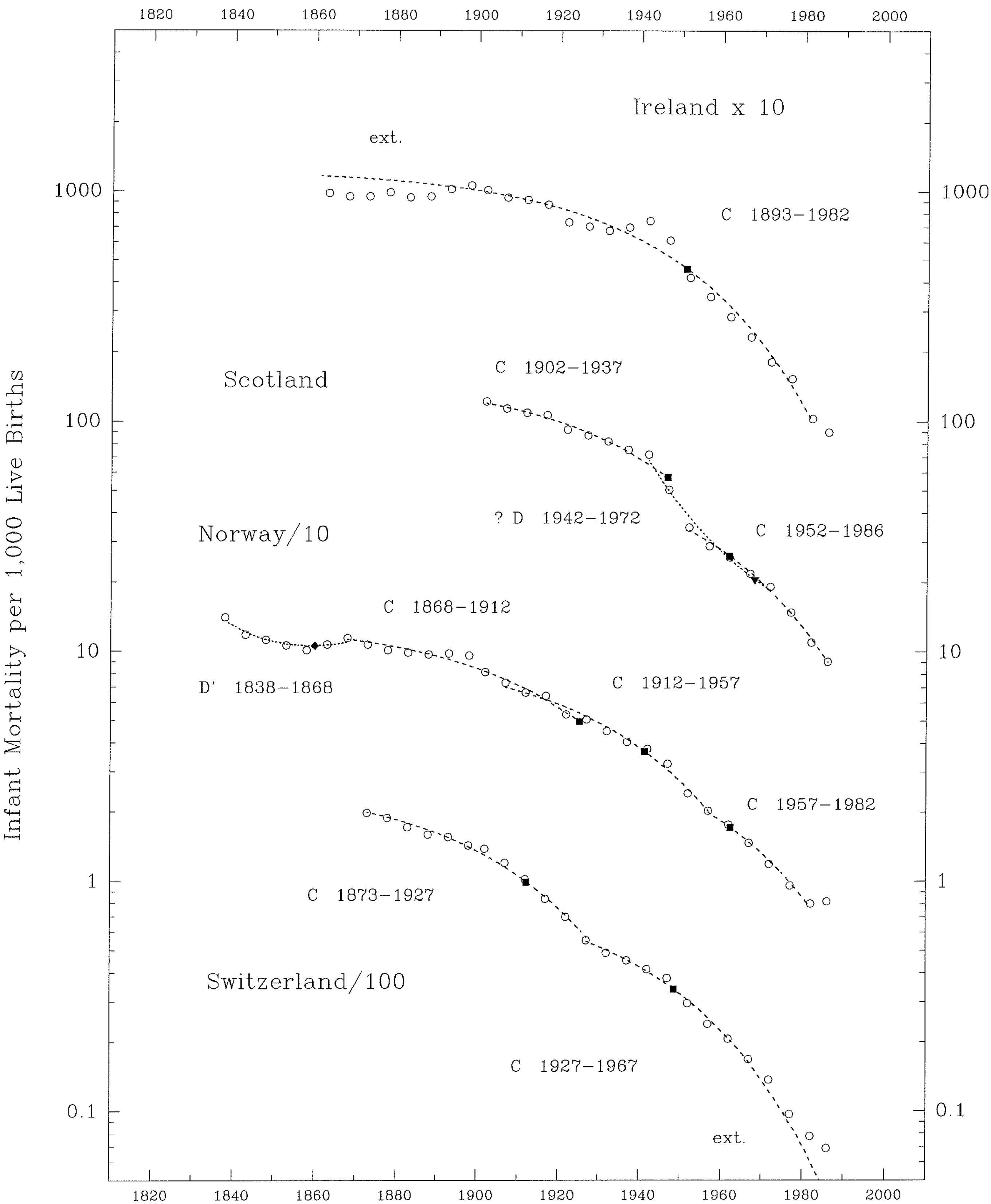
Figure 4.3c

Infant Mortality Rates in European Countries:
The Netherlands, Germany, and Denmark



Source: Chesnais 1992, 580–97.

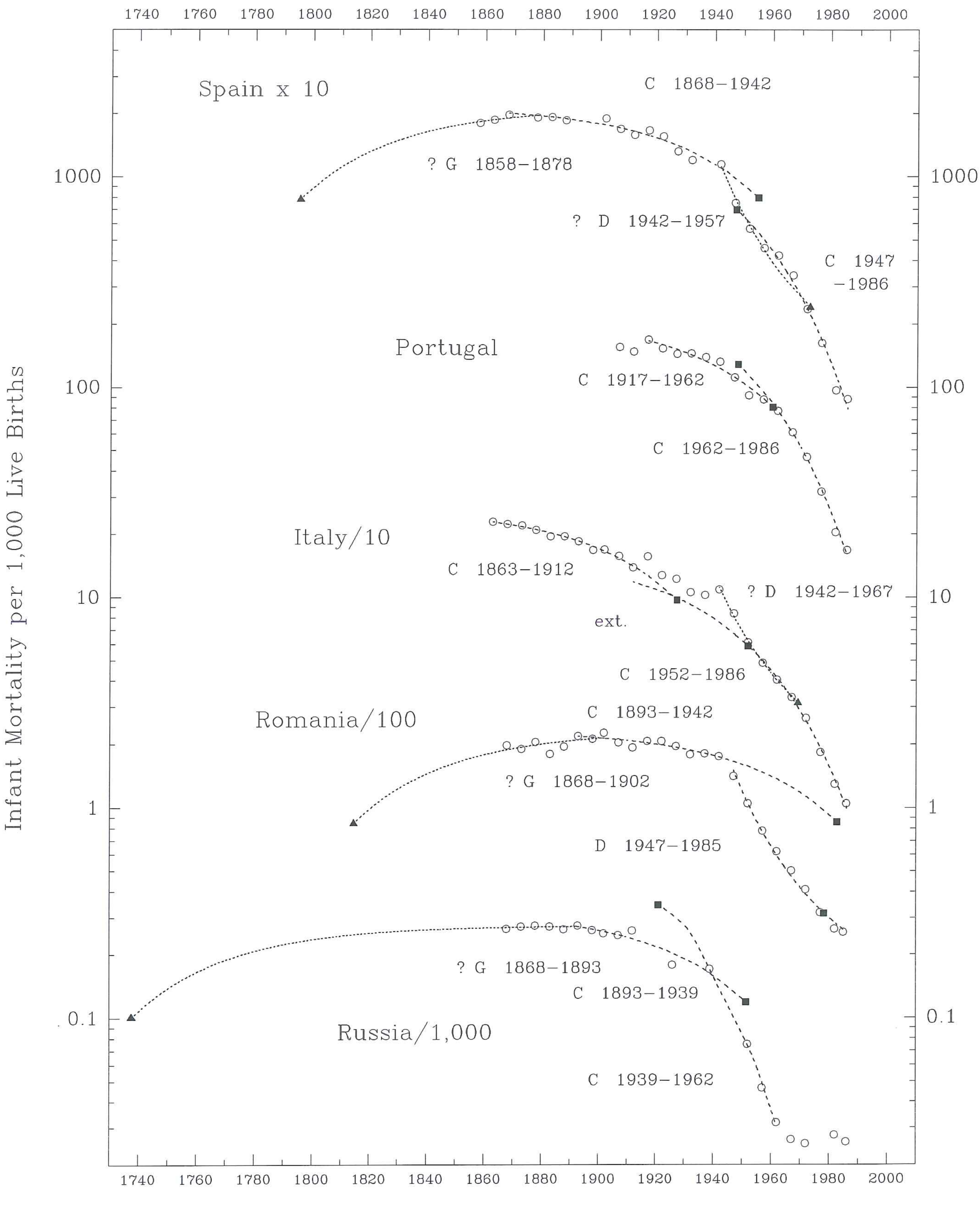
Figure 4.3d
Infant Mortality Rates in European Countries:
Ireland, Scotland, Norway, and Switzerland



Source: Chesnais 1992, 580–97.

Figure 4.3e

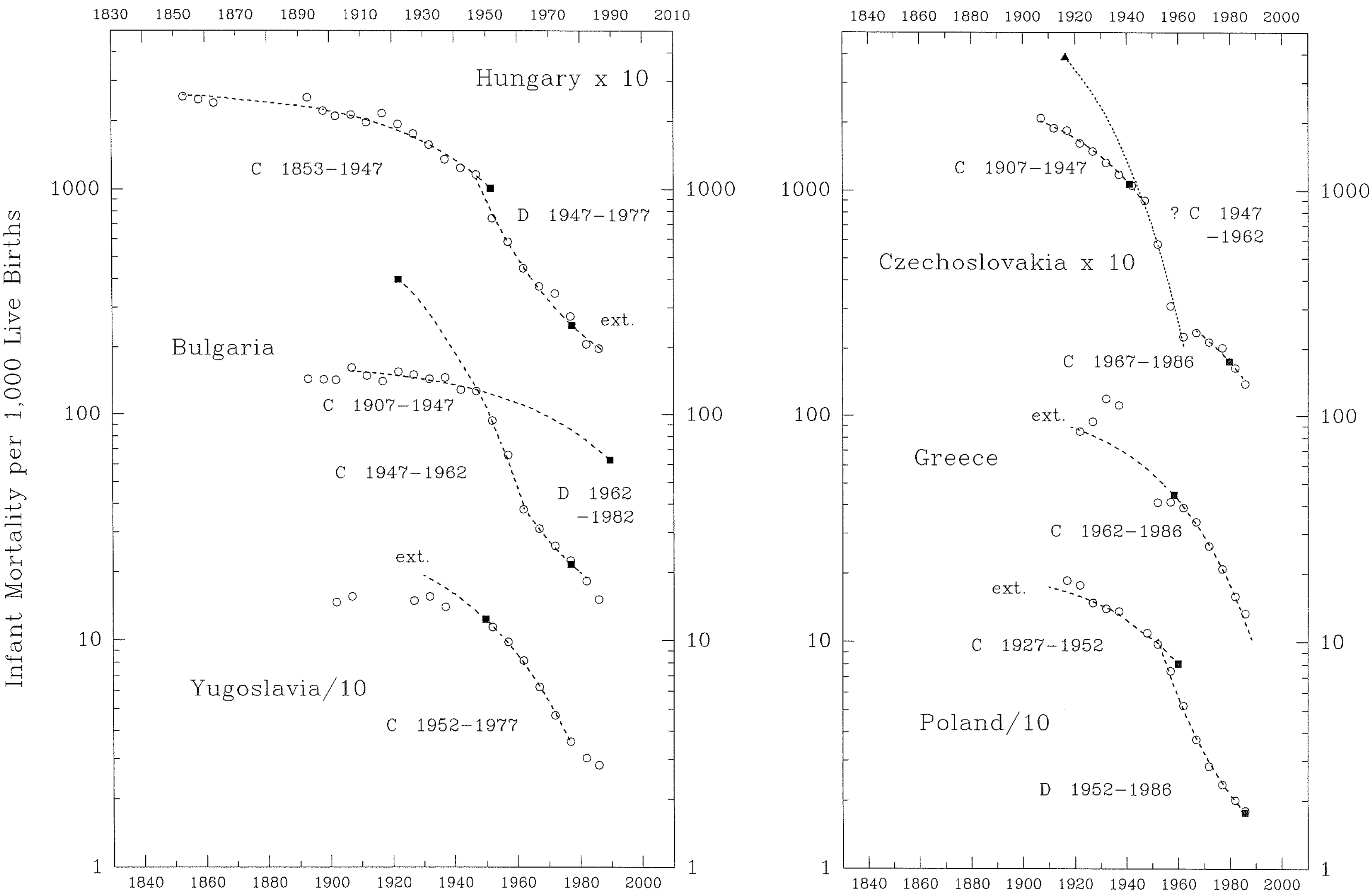
Infant Mortality Rates in European Countries: Spain, Portugal, Italy, Romania, and Russia



Source: Chesnais 1992, 580–97.

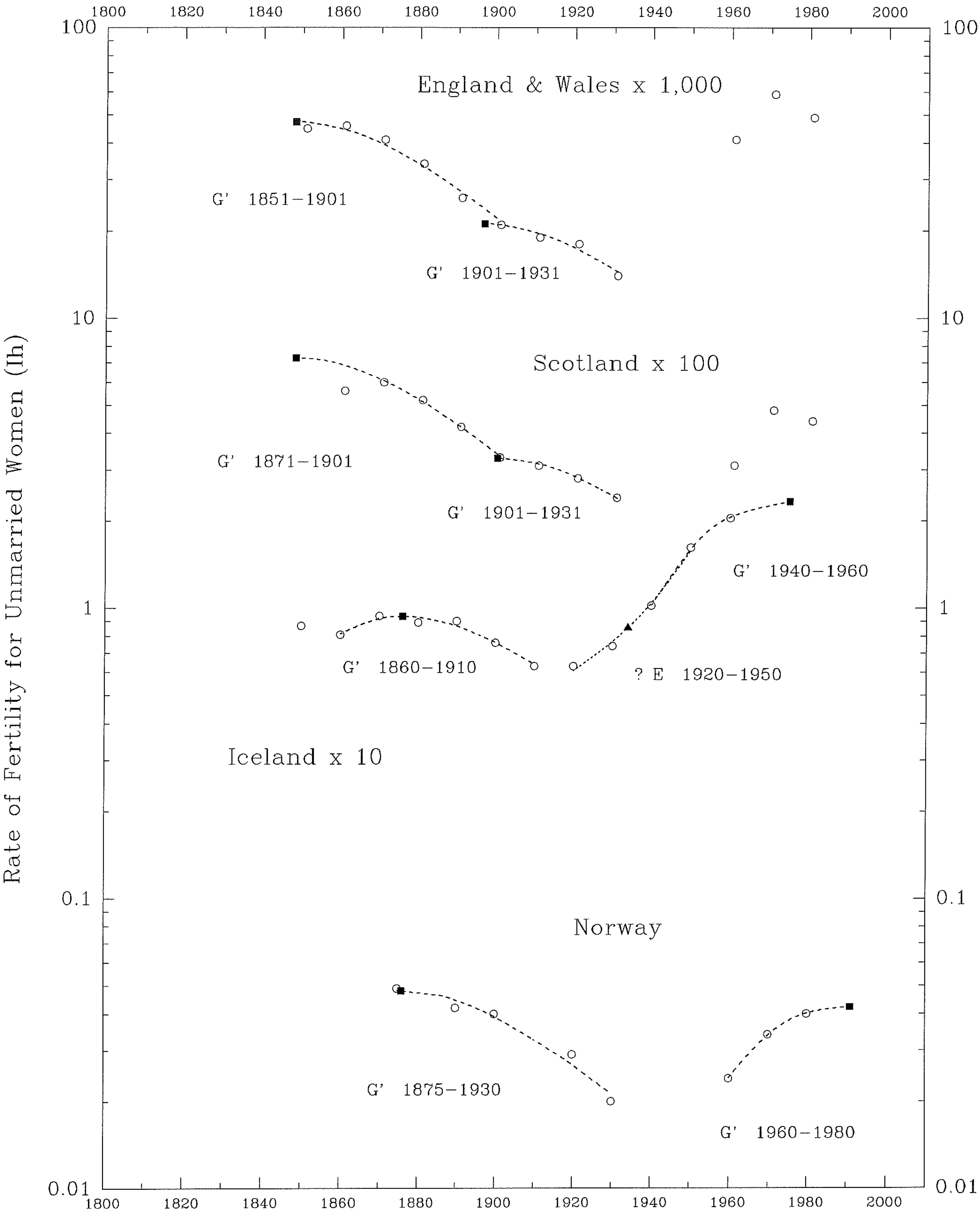
Figure 4.3f

Infant Mortality Rates in European Countries:
Hungary, Bulgaria, Yugoslavia, Czechoslovakia, Greece, and Poland



Source: Chesnais 1992, 580–97.

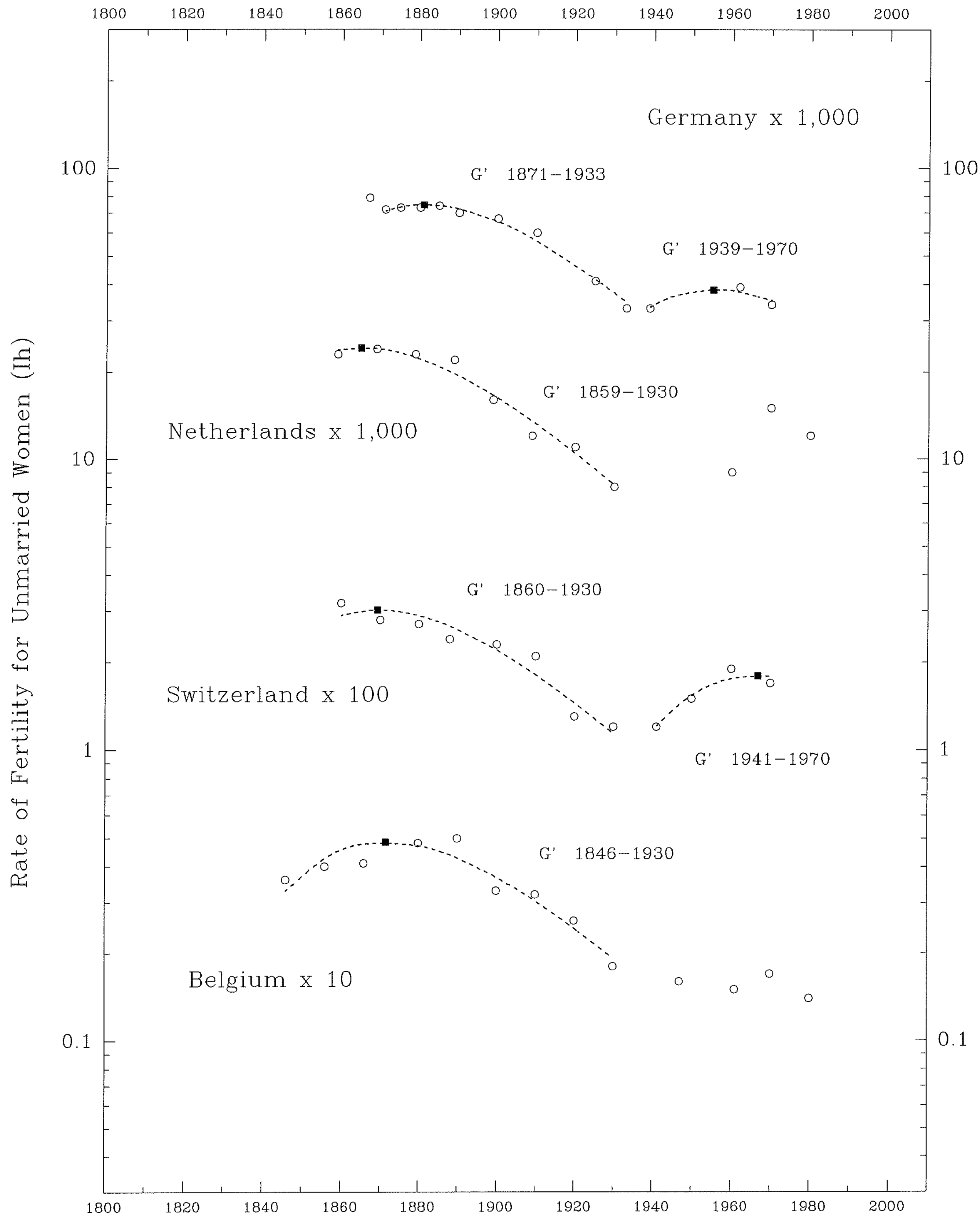
Figure 4.4a
European Trends of Extramarital Fertility:
England and Wales, Scotland, Iceland, and Norway



Source: Coale and Treadway 1986, 78, 80–152.

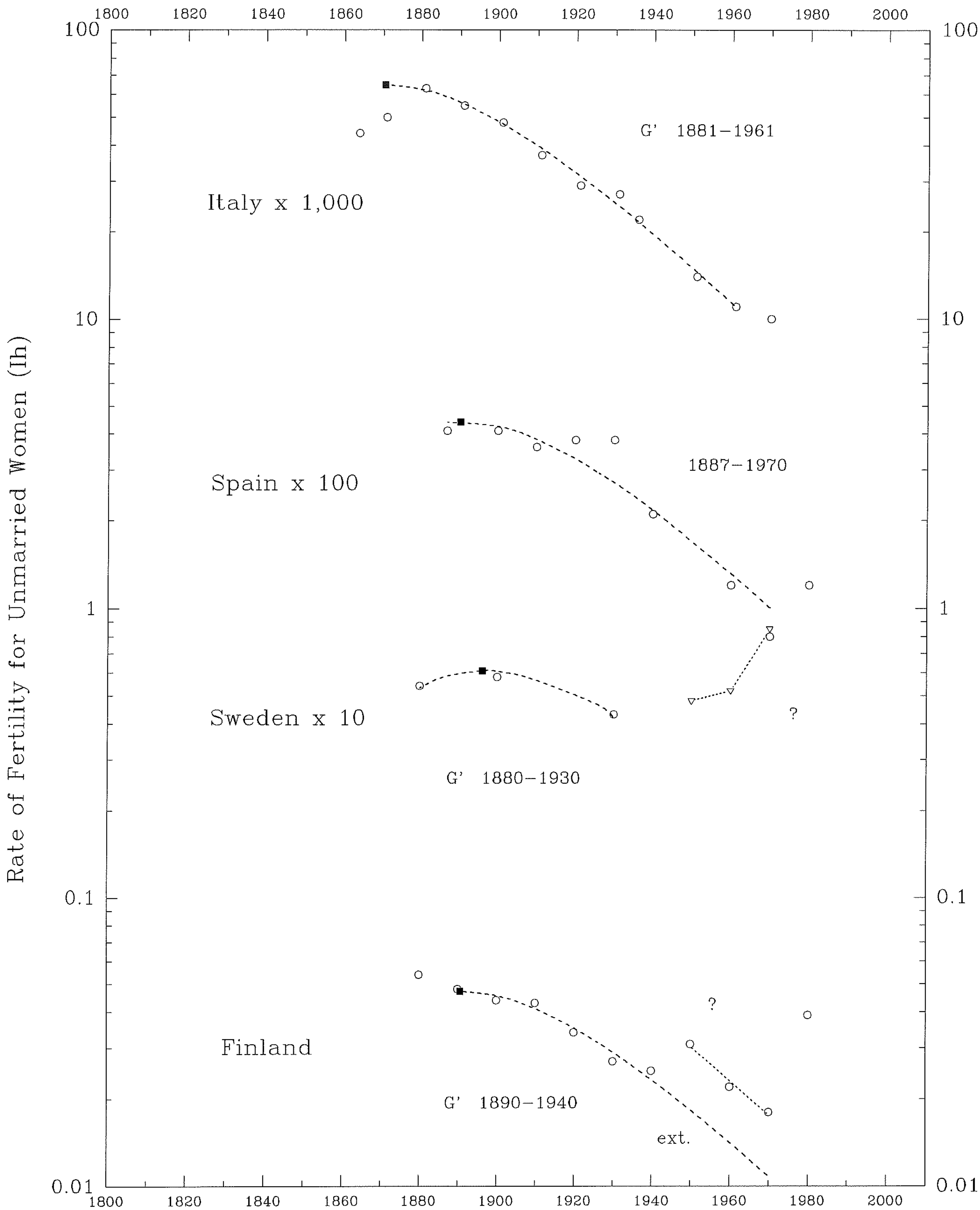
Figure 4.4b

European Trends of Extramarital Fertility:
Germany, the Netherlands, Switzerland, and Belgium



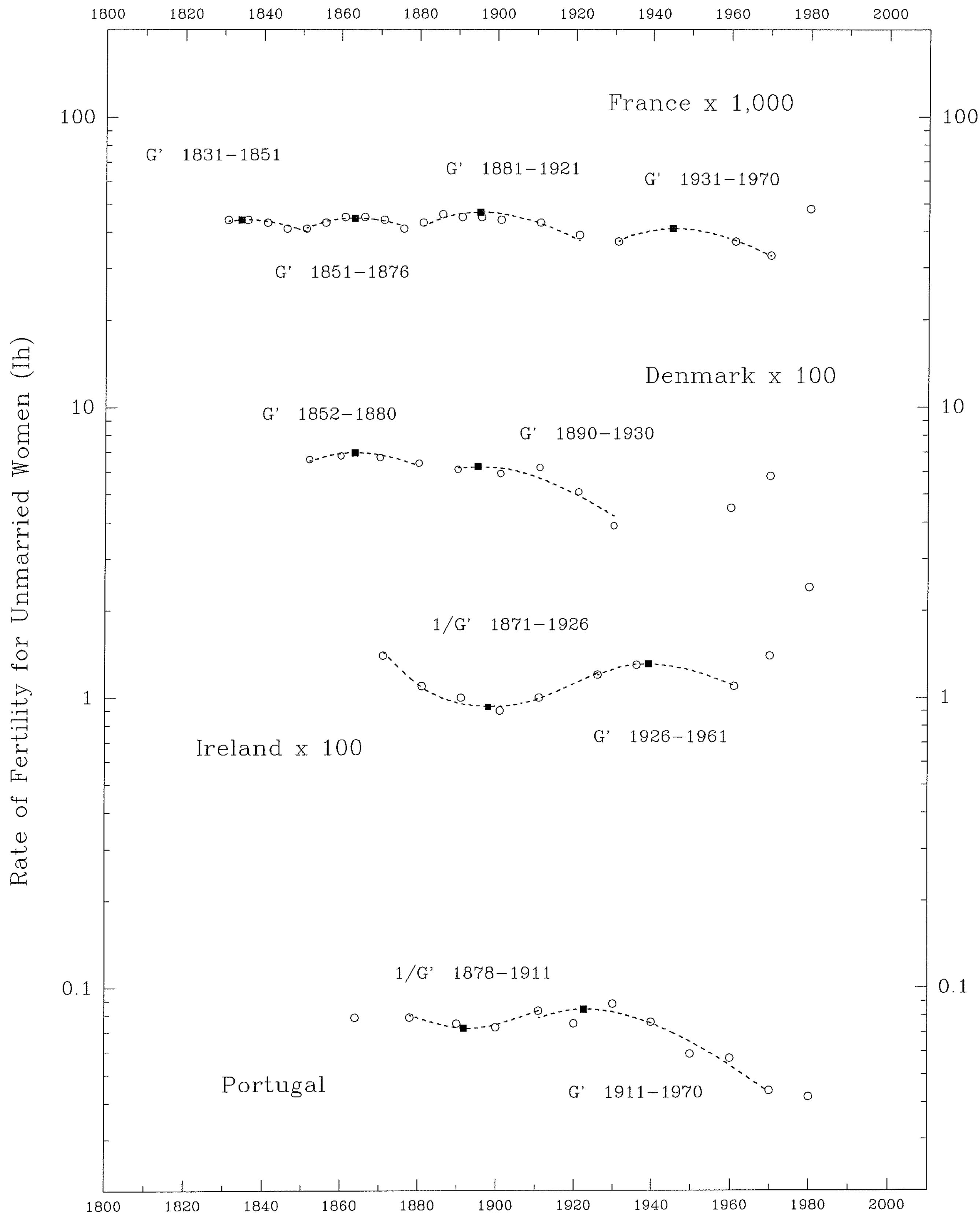
Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.4c
European Trends of Extramarital Fertility:
Italy, Spain, Sweden, and Finland



Source: Coale and Treadway 1986, 78, 80–152.

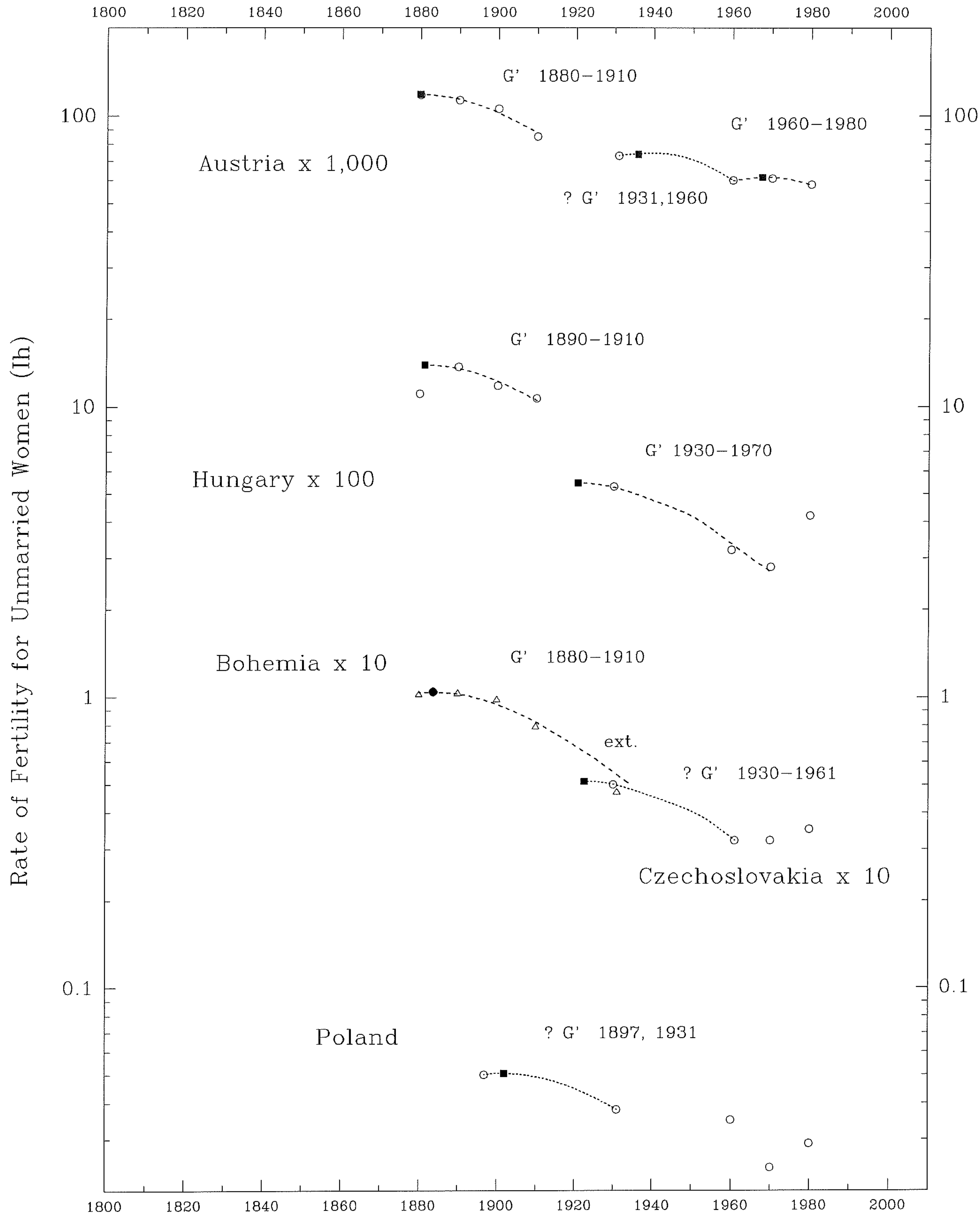
Figure 4.4d
European Trends of Extramarital Fertility:
France, Denmark, Ireland, and Portugal



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.4e

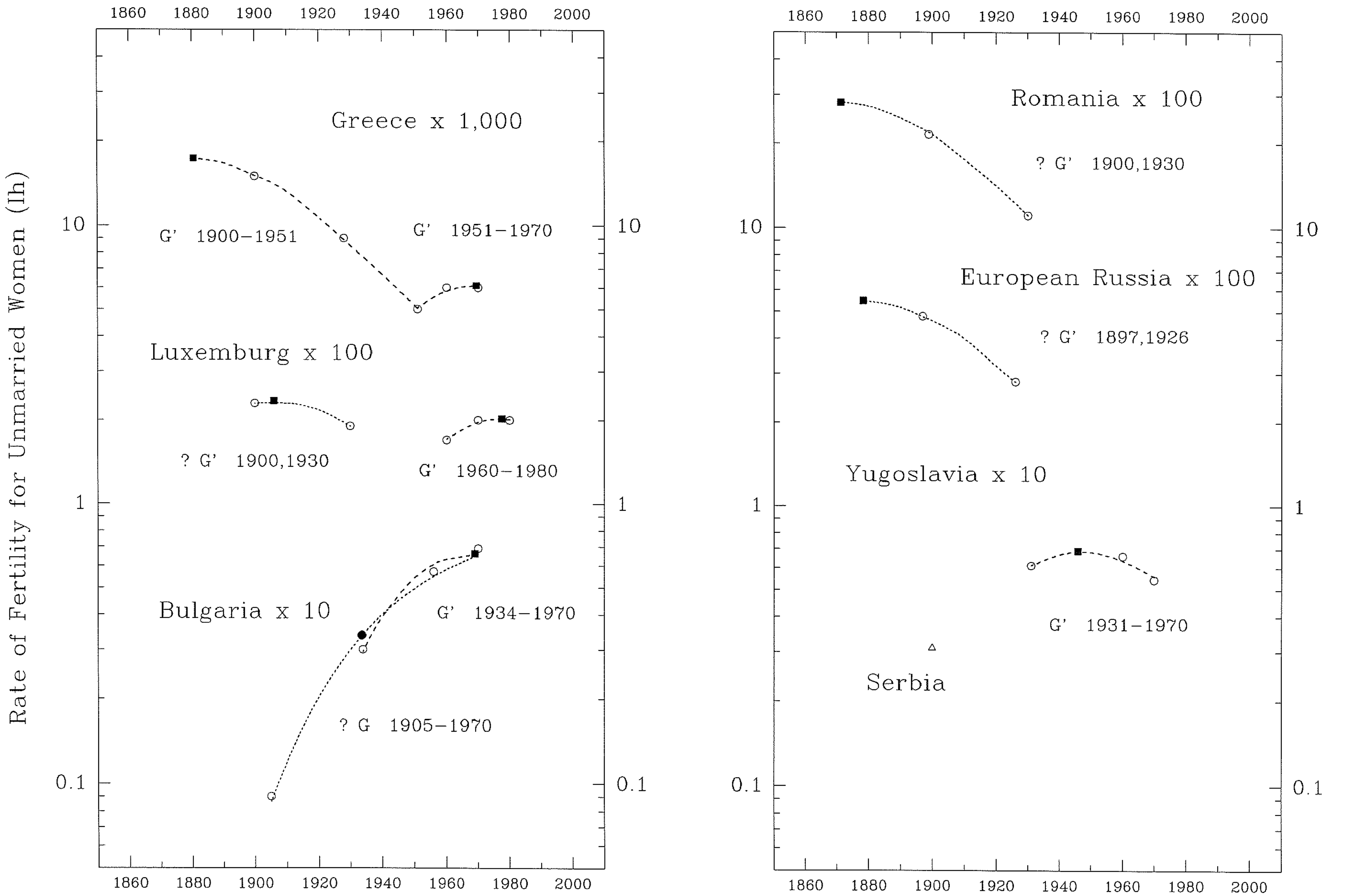
European Trends of Extramarital Fertility:
Austria, Hungary, Bohemia/Czechoslovakia, and Poland



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.4f

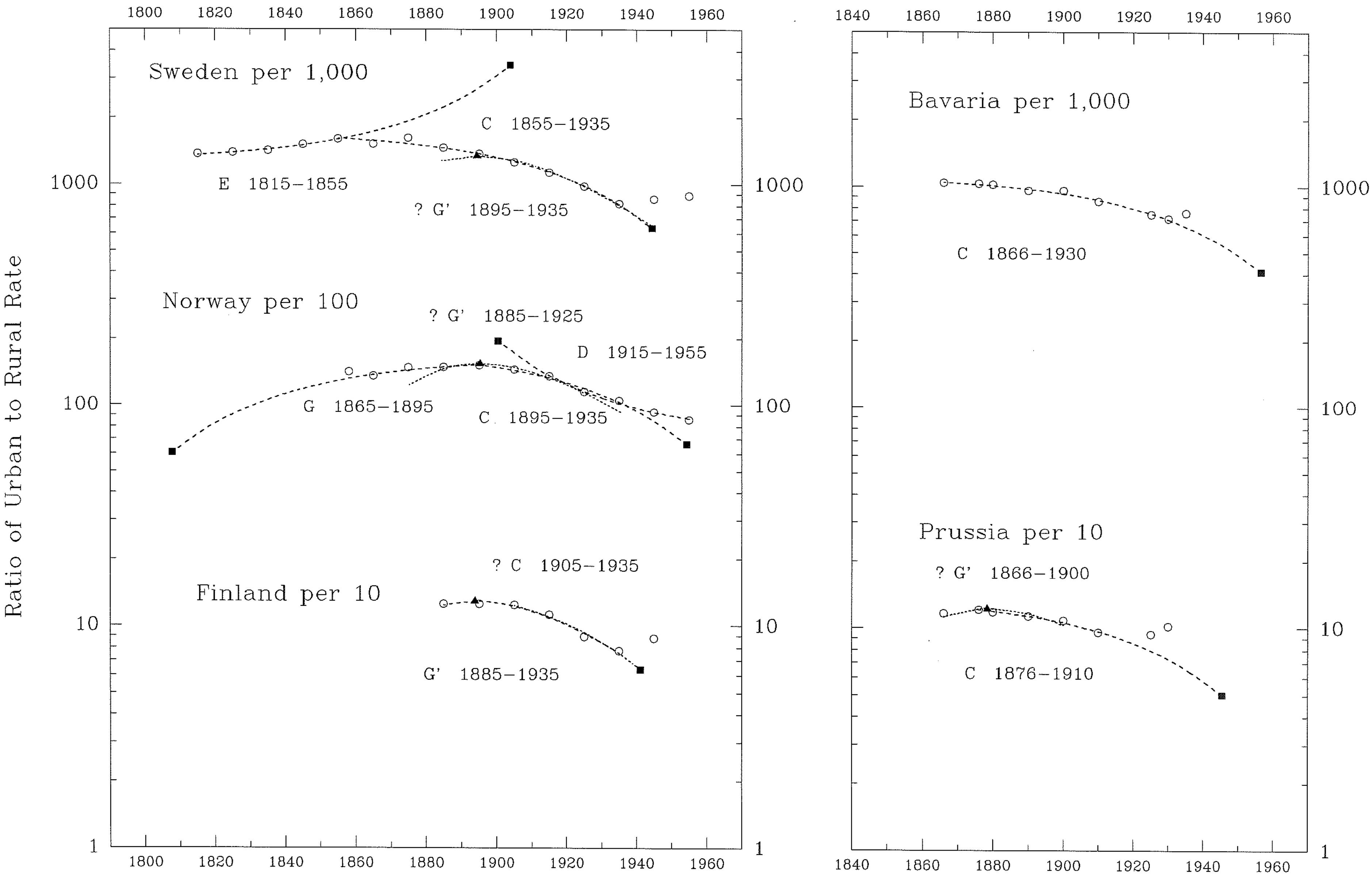
European Trends of Extramarital Fertility:
Greece, Luxemburg, Bulgaria, Romania, European Russia, and Yugoslavia



Source: Coale and Treadway 1986, 78, 80–152.

Figure 4.5

Comparing Urban and Rural Rates of Infant Mortality in Scandinavia and Germany



Source: F. van de Walle 1986, 217.

Table 4.1

Trends of Marital Fertility (Ig) in European Countries

Country	Basic C Trend	Alternate G' Year 0	Later C Trend	Alternate G' Year 0
Belgium	1866-1910: 1914 = .391	1863	1961-1980: 1994 = .166	1944
England & Wales	1881-1931: 1928 = .316	1874	1961-1981: 1992 = .157	1954
Germany	1875-1939: 1928 = .350	1874	1962-1980: 1972 = .220	-
Denmark*	1880-1921: 1934 = .314	1881	1930-1970: 1995 = .140	1937
Bohemia/Czechoslov.?	none	1881	none	-
Switzerland	1860-1930: 1936 = .300	1883	none	-
Netherlands	1879-1930: 1937 = .374	1886	none	-
Scotland	1861-1931: 1941 = .312	-	none	1936
Sweden	1860-1900: 1962 = .273[a]	1881	1930-1970: 1996 = .227	-
"	1910-1930: 1920 = .433[a]			
Finland	1900-1940: 1945 = .327	1894	1950-1970: 1961 = .331	
Norway	1875-1920: 1947 = .320	1884	none	-
Iceland	1870-1940: 1953 = .326	-	none	?
Luxemburg	1900,1930: 1920 = .445	-	1930-1980: 1993 = .139	-
France*	1871-1911: 1927 = .216	-	1961-1980: 1990 = .187	1950
Italy*	1881-1951: 1959 = .274	1904	1951-1970: 2014 = .149	
Portugal*	1900-1940: 1959 = .301	-	1940-1980: 2008 = .191	-
Spain	1887-1950: 1969 = .268	-	1950-1980: 2020 = .174	-
European Russia	1897-1970: 1961 = .317	-	-	-
Romania	1899-1970: 1962 = .276	-	-	-
Austria (big)	none	1889		
" (small)			1960-1980: 1976 = .219	-
Hungary (big)	1880-1910: 1968 = .235	1889		
" (small)	1930,1960: 1963 = .191		none	1968
Yugoslavia	1931-1970: 1969 = .258	-	-	-
Greece	1928-1970: 1972 = .252	-	-	-
Poland	1931-1970: 1975 = .238	-	-	-
Ireland	1871-1936: 1979 = .279	-	none	-
Bulgaria	?	-	-	-

* Has 1/G' trend in 1800s. [a] Estimated from Knodel and van de Walle.

Sources: Figures 4.1a through 4.1f; Knodel and van de Walle 1986, 397.

Table 4.2

Trends in the Proportion of European Women Married (I_m)

A. Populations with G trends for the Later 1800s and Early 1900s

Country	Basic G Trend	In 1900	Intermediate Trend	In 1970	Trend for Later 1900s
France	1831-1876 G 1735 = .20	.54+	1876-1901 G 1759 = .20	.62	1901-1960 G 1847 = .25
Norway*	1875-1920 G 1764 = .16	.42		.65	1930-1960 G' 1959 = .69*
Sweden*	1880-1930 G 1771 = .16	.41		.60	1930-1970 G' 1956 = .64*
Scotland*	1861-1881 G 1778 = .17	.45	1891-1931 *E* 2021 = 1+	.69	1961-1981 G' 1967 = .68*
England & Wales*	1851-1871 G 1780 = .20	.48	1891-1931 *E* 2015 = 1+	.72	1961-1981 G' 1967 = .71*
Portugal	1864-1911 G 1795 = .18	.46	1920-1940 G 1851 = .19	.60	1950-1980 G 1911 = .26
Denmark*	1870-1930 G 1803 = .19	.47		.65	1960-1980 G' 1958 = .67*
Netherlands*	1859-1889 G 1806 = .19	.45	1899-1930 G 1839 = .20	.66	1960-1980 G' 1970 = .66*
Germany	1867-1910 G 1806 = .20	.51+	1925-1939 G 1902 = .30	.70	?
Switzerland	1860-1910 G 1807 = .18	.45	1910-1950 /G' 1924 = .24	.62	1941-1970 G 1912 = .27
Bohemia/Czechoslov.	1890-1930 G 1811 = .21	.52+		.69	1930-1980 G 1893 = .28
Belgium*	1856-1890 G 1814 = .18	.48	1900-1947 G 1866 = .25	.70	1947-1980 G' 1965 = .73*
Austria*	1890-1910 G 1820 = .20	.51+		.64	1960-1980 ?G' 1969 = .62*
Ireland**	1871-1891 G' 1869 = .40*	.32	1901-1936 G 1848 = .15	.49	1936-1970 G' 1960 = .51*
Iceland**	1850-1880 G' 1856 = .37*	.38	1880-1940 G 1851 = .17	.60	1950,1960 ?G' 1965 = .59*
B. Countries with C Trends in Later 1800s and Early 1900s					
Finland*	1880-1920 C 1958 = .21	.48		.59	1940-1980 G' 1962 = .61*
Poland*	1897,1931 ?C 1980 = .25	.63		.64	1931-1970 G' 1953 = .71*
European Russia*	1897,1925 ?C 1984 = .28	.70	1926-1959 G' 1938 = .67*	.66	1959,1970 ?G 1931 = .33
Spain	1887-1940 C 1974 = .23	.56		.59	1940-1980 G 1919 = .27
Luxemburg*		.46	1900,1930 ?G 1863 = .24	.70	1960-1980 ?G' 1966 = .69
" [a]	1839-1900 C 1975 = .21	.50	1900-1922 G 1843 = .20	.67	1922-1981 G 1884 = .25
Italy	1864-1921 C 1986 = .21	.55	1921-1951 G 1856 = .21	.62	1951-1970 G 1912 = .27
Hungary	1880-1930 C 1982 = .27	.67		.71	1930-1980 G 1886 = .29
Yugoslavia	1900,1931 ?C 1975 = .33	.81		.70	1960,1970 ?G 1864 = .27
Greece	1900-1951 C 1993 = .25	.63		.66	1951-1970 G 1935 = .34
Romania	1899,1930 ?C 1995 = .28	.73		.76	1956,1970 ?G 1914 = .34
Bulgaria	?	.74		.78	1934-1970 G 1839 = .29

* = Has G' trend (or, **, two); + = above average for this group of countries; [a] per all females 15 or over.

Sources: Figures 4-2a through 4.2f; Luxembourg 1990, 18.

Table 4.3

Relationships of Transition Era European Trends in Marital Fertility, Infant Mortality, and Proportion Married

Zero Years for Trends

	1	2	3	4	5
<u>Country</u>:	C in I_g	C in M_i	I_g - M_i	G' in I_g	Trends for I_m
Belgium	1914	1938	-24	1863	G,G
Luxemburg	1920	?	?	-	G
Sweden	1920	1931	-5	1881	G
England & Wales	1928	1932	-4	1874	G,E
Germany	1928	1918	10	1874	G
France	1927	1933	-6	-	G,G,G
Denmark	1934	1933	1	1881	G
Switzerland	1936	1912	24	1883	G,1/G'
Netherlands	1937	1911	26	1886	G,G
Scotland	1941	1947	-6	-	G,E
Finland	1945	1935	10	1894	<u>C</u>
Norway	1947	1941	6	1884	G
Iceland	1953	?	?	-	G',G
Austria	-	1927	-	1889	?G
Bohemia/Czecho.	-	1941	-	1881	G
Hungary	1968	1952	16	1889	<u>C</u>
Italy	1959	1927	32	-	<u>C</u>,G
Portugal	1959	1960	-1	-	G,G
European Russia	1961	1952	9	-	?<u>C</u>,G'
Romania	1962	1983	-21	-	?<u>C</u>
Spain	1969	1955	14	-	<u>C</u>
Yugoslavia	1969	1950	19	-	?<u>C</u>
Greece	1972	1958	14	-	<u>C</u>
Poland	1975	1960	15	-	?<u>C</u>
Ireland	1979	1951	28	-	G',G
Bulgaria	?	1990	?	-	?

Sources: Figures 4-1a through 4.1f, 4.2a through 4.2f, and 4.3a through 4.3f; Tables 4.1 and 4.2.

Table 4.4

Trends of Infant Mortality in Europe Following World War II

A. D Trend Clearly Evident

Belgium		1947-1972	D	1977	1972-1986	D	1994
Netherlands		1942-1967	D	1967	1967-1986	D	1976
France		1947-1972	D	1981	1972-1986	D	1995
Germany	FRG	1948-1967	D	1980			
	GDR	1948-1986	D	1988			
Austria		1947-1967	D	1976	1972-1986	D	2002
Hungary		1947-1977	D	1977			
Poland		1952-1986	D	1986			
Romania		1947-1988	D	1978			
Bulgaria			-		1962-1982	D	1977

B. D Shape Possible, but Likely to Be Transition between C Trends

Scotland	1942-1976	?D	1968	1952-1986	C	1962
England & Wales	1917-1942	?D	1917			
	1952-1972	?D	1954	1957-1986	C	1970
Sweden	1937-1967	?D	1961	1947-1982	C	1962
Finland	1947-1972	?D	1982	1967-1982	C	1952
Spain	1942-1957	?D	1973	1947-1986	C	1947
Italy	1942-1967	?D	1969	1952-1986	C	1952

C. Only C Trend Present

Ireland	1893-1982	C	1951
Norway	1957-1982	C	1962
Denmark	1957-1977	C	1953
Switzerland	1927-1967	C	1949
Portugal	1962-1986	C	1948
Czechoslovakia	1967-1986	C	1980
European Russia	1939-1962	C	1921
Yugoslavia	1952-1977	C	1950
Greece	1962-1986	C	1958

Sources: Figures 4.3a through 4.3f.

Table 4.5

G' Waves of Marital (I_g) and Extramarital (I_h) Fertility in Europe since the Middle 1800s

(excluding those begun after World War II)

A. Comparing I_g and I_h Movements

	I_g	I_h
Belgium	1846-1930 G' 1863 = .857	1846-1930 G' 1872 = .048
England and Wales	1861-1931 G' 1874 = .707	1851-1901 G' 1848 = .047
" " "		1901-1931 G' 1897 = .021
Germany	1867-1939 G' 1874 = .777	1871-1933 G' 1881 = .075
Denmark	1870-1930 G' 1881 = .693	1852-1880 G' 1864 = .070
"		1890-1930 G' 1895 = .062
Bohemia	1880-1910 G' 1881 = .675	1880-1910 G' 1884 = .104
Switzerland	1880-1930 G' 1883 = .673	1860-1930 G' 1869 = .030
Netherlands	1879-1930 G' 1886 = .808	1859-1930 G' 1865 = .024
Sweden	1880-1930 G' 1876 = .735	1880-1930 G' 1896 = .061
Norway	1875-1930 G' 1884 = .773	1875-1930 G' 1876 = .048
Finland	1890-1930 G' 1894 = .698	1890-1940 G' 1891 = .047
Austria	1880-1910 G' 1889 = .694	1880-1910 G' 1880 = .119
Hungary	1880-1930 G' 1889 = .602	1890-1910 G' 1881 = .139
Scotland	-	1871-1901 G' 1849 = .073
"	-	1901-1931 G' 1900 = .033
Iceland	-	1860-1910 G' 1876 = .094
Ireland*	-	1871-1926 /G' 1898 = .009*
"	-	1926-1961 G' 1939 = .013
France	-	1831-1851 G' 1835 = .044
"	-	1851-1876 G' 1863 = .045
"	-	1881-1921 G' 1896 = .047
Luxemburg ?	-	1900,1930 ?G' 1906 = .023
Italy	-	1881-1951 G' 1871 = .067
Portugal*	-	1878-1911 /G' 1892 = .072
"	-	1911-1970 G' 1923 = .084
Spain	-	1887-1970 G' 1890 = .044
Greece	-	1900-1951 G' 1880 = .017
Romania ?	-	1900,1930 ?G' 1871 = .028

B. G' and 1/G' of I_h by Timing

	G' or 1/G'
France I	1831-1851 G' 1835 = .044
England and Wales I	1851-1901 G' 1848 = .047
Scotland I	1871-1901 G' 1849 = .073
France II	1851-1876 G' 1863 = .045
Denmark I	1852-1880 G' 1864 = .070
Netherlands	1859-1930 G' 1865 = .024
Switzerland	1860-1930 G' 1869 = .030
Italy	1881-1961 G' 1871 = .067
Romania ?	1900,1930 ?G' 1871 = .028
Belgium	1846-1930 G' 1872 = .048
Norway	1875-1930 G' 1876 = .048
Iceland	1860-1910 G' 1876 = .094
European Russia ?	1897,1926 ?G' 1878 = .055
Austria I	1880-1910 G' 1880 = .119
Greece	1900-1951 G' 1880 = .017
Germany	1867-1939 G' 1881 = .075
Hungary	1880-1930 G' 1881 = .139
Bohemia	1880-1910 G' 1884 = .104
Spain	1887-1970 G' 1890 = .044
Finland	1890-1940 G' 1891 = .047
Portugal I*	1878-1911 /G' 1892 = .072*
Denmark II	1890-1930 G' 1895 = .062
France III	1881-1921 G' 1896 = .047
Sweden	1880-1930 G' 1896 = .061
England and Wales II	1901-1931 G' 1897 = .021
Ireland I*	1871-1926 /G' 1898 = .009
Scotland II	1901-1931 G' 1900 = .033
Poland ?	1897,1931 ?G' 1902 = .051
Luxemburg ?	1900,1930 ?G' 1906 = .023
Hungary II	1930-1970 G' 1921 = .055
Portugal II	1911-1970 G' 1923 = .084
Czechoslovakia ?	1930,1961 ?G' 1923 = .051
Austria II ?	1931,1960 ?G' 1936 = .074
Ireland II	1926-1961 G' 1939 = .013
Yugoslavia	1931-1970 G' 1946 = .069

European Russia ?	-	1897,1926 ?G' 1878 = .055	Germany II	1939-1970	G' 1955 = .038
Poland ?	-	1897,1930 ?G' 1902 = .051	Bulgaria	1934-1970	G' 1969
Yugoslavia	-	1931-1970 G' 1946 = .069			
Bulgaria	-	1934-1970 G' 1969 = .066			

* Inverted G' trend present.

Sources: Table 4.1; Figures 4.3a through 4.3f.

Table 4.6

Comparing G' Surges in Percentage of Females 20-24 Married and Rates of Extramarital Fertility in Certain Countries

Country:	% 20-24 Married	Ih	% 20-24 Married	Ih
England & Wales	1851-1891: 1868	1851-1891: 1848	1911-1931: 1924	1901-1931: 1897
Belgium	1856,1900: 1891?	1846-1930: 1872	1900-1920: 1913	1st continued
Netherlands	1869-1899: 1890	1859-1930: 1865	1909-1930: 1923	1st continued
Germany*	1867-1890: 1882	1867-1939: 1881	1900-1925: 1910	1st continued
Scotland	1881-1921: 1902 1/	1871-1901: 1849	1911-1931: 1923?	1901-1931: 1900
Sweden**	1843-1885: 1865 1/	1880-1930: 1896	1905-1925: 1910	1st continued
Italy	1871-1901: 1891 1/	1881-1961: 1871	1881-1936: 1933 1/	1st continued
Portugal	1864-1890: 1881?	1875-1911: 1892 1/	1911-1940: 1921 1/	1911-1970: 1923
Ireland	none	1871-1926: 1898 1/	1911-1931: 1930	1926-1961: 1939

1/ = 1/G' rather than G'; * = early nuptuality estimated by I_m; ** = by proportion first married under 25.

Sources: Figures C.3a and C.3b; Table 4.5.

Table 4.7

Trends of Relative Infant Mortality for Cities Compared with Other Demographic Movements

Country:	G' in Rel. M_i	G' in I_h	C in Rel. M_i	C in CDR
Sweden	1895-1935: 1894	1880-1930: 1896	1855-1935: 1944	1843-1923: 1941
Norway	1885-1925: 1895	1875-1930: 1876	1895-1935: 1954	1823-1933: 1948
Finland	1885-1935: 1894	1890-1940: 1891	1905-1935: 1941	1873-1953: 1959
Bavaria	1866-1890: 1871?			
"	1890-1925: 1894?		1866-1930: 1956	
Prussia	1866-1900: 1879		1876-1910: 1946	
All Germany		1871-1933: 1881		1867-1932: 1929

Sources: Figure 4.6; Tables 4.5 and 2.1a.

Table 4.8
G' Surges in Fertility by Date of Zero Year and Accompanying Trends in Nuptuality, Population Growth, Emigration, and Urbanization in Europe from the 19th Century into the 20th Century

	(1)	(2)	(3)	(4)
Country:	G' in I_h	G' in I_g	G in I_m	Emigration
England & Wales	1848* 1897	1874	1780	1822-1897 G' 1876 1892-1912 G' 1947
Belgium	1872*	1863	1814	1847-1867 G' 1883 1872-1902 G' 1909 1902-1912 G' 1937
Netherlands	1886*	1872	1806	1847-1902 G' 1908
Denmark	1864* 1895	1881	1803	1867-1927 G' 1897
Germany "	1881*	1874	1806	1822-1892 G' 1886 1897-1912 G' 1886
Switzerland	1869*	1883	1807	1868-1927 G' 1889
Bohemia/Czechoslov.	1884	1881	1811	(in Austria)
Hungary	1881	1889	C	1872-1912 G' 1947
Austria	1880	1889	1820	1842-1877 G' 1891 1877-1912 G' 1936
Norway	1876*	1884	1764	1847-1927 G' 1893
Sweden	1896*	1876	1764	1852-1892 G' 1915
Finland	1891*	1894	C	(in Russia)
Scotland	1849 1900	-	1778	(in Britain)
Ireland	*1898* 1/G' 1939	-	G'	1812-1852 G' 1865 1832-1912 G' 1841
Iceland	1876	-	G'	(in Denmark)

(5) E in % Urban	(6) E in Pop. Growth	(7) H in % Urban	(8) H in Pop. Growth
1700-1850 E 1854	1726-1806 E 1822	1800-1950 H 1750	1816-1861 H 1758 1861-1931 H 1794
1800-1890 E 1862	1700-1850 E 1830	1850-1950 H 1748	1815-1866 H 1717 1876-1910 H 1790
1750-1815 E 1869	1750-1839 E 1866	1910-1970 H 1820	1815-1869 H 1728 1869-1889 H 1799 1899-1947 H 1849
1700-1800 E 1834[sb] 1750-1890 E 1885[sv]	1735-1801 E 1857	1850,1910 ?H 1840[sb]	1801-1845 H 1706 1850-1890 H 1775 1890-1945 H 1833
1750-1850 E 1870	1700-1800 E 1821[v] 1864-1910 E 1923 1910-1950 E 1977	1850-1910 H 1846	1816-1864 H 1743
1700-1850 E 1868	1700-1800 E 1833[v] 1880-1910 E 1934 1910-1970 E 1985	1850-1913 H 1813	1837-1888 H 1712
1750-1850 E 1886[a]	1880-1910 E 1945 1910-1930 E 2004	?	1828-1900 H 1729[b] 1857-1890 H 1737[c]
1750-1850 E 1886[a]	1910-1941 E 1977	?	1880-1910 H 1811
1750-1850 E 1886[a]	1850-1880 E 1906 1880-1910 E 1936	?	none
1750-1890 E 1885[sv]	none	1850,1910 ?H 1840[sb]	1818-1893 H 1758 1893-1948 H 1797
1810-1890 E 1899[3]	none	1870-1940 H 1842[3]	1848-1943 H 1757
1750-1890 E 1885[sv]	none	1850,1910 ?H 1840[sb]	none
1750,1800 ?E 1812[v]	1755-1821 E 1839	?	1811-1871 H 1741 1871-1911 H 1779
1750,1800 ?E 1828[v]	1725-1791 E 1812	1841-1901 H 1792[3]	1777-1841 H 1729 D decline
1750-1890 E 1885[sv]	1769-1860 E 1890	1850,1910 ?H 1840[sb]	1901-1940 H 1833

France	1835* 1863 1896	-	1735 1754 1847	1855-1915	G' 1888
Portugal	*1892* 1/G' 1923	-	1795	1867-1927	G' 1916
Luxemburg	1906*	-	C	?	
Italy	1871	-	C	1877-1897 1897-1912	G' 1920 G' 1940
Spain	1890	-	C	1865-1922	G' 1938
European Russia	1878	-	C	1877-1912	G' 1938
Yugoslavia	1946	-	C	?	
Greece	1880	-	C	?	
Romania	1871	-	C	?	
Poland	1902	-	C	(mostly in Russia)	
Bulgaria	1969	-	?	?	

* = Countries with the earliest C in I_g; + = all females of fertile age; [v] = from de Vries; [sv] = Scandinavia from de Vries; [sb] = Scandinavia from Bairoch; [a] = pre-1919 Austria and Hungary; [3] = from Figure 3.7 in Harris 2003; [b] = Bohemia; [c] = Czechoslovakia; [x] = Serbia.

Sources: Tables A.1, 4.1, 4.2, 4.3; Harris 2001, 148-49; Harris 2003, 24, 209, 277, 286; de Vries 1984, 36, 39, 45-46; Figures 4.5a through 4.5f.

1700-1850 E 1865	1792-1827 E 1876	1850-1950 H 1786	none
1750-1910 E 1973V	1841-1890 E 1920	1910-1970 H 1846	none
?	none	?	none
1700-1850 E 1880V	none	1880-1980 H 1805	1861-1936 H 1755
1700-1850 E 1887V	1857-1920 E 1952	1850-1950 H 1808	1797-1877 H 1680 1920-1960 H 1929
1700-1850 E 1896	none	1850-1910 H 1796	1815-1857 H 1707 1858-1897 H 1821 1897-1939 H 1830
?	none	?	1884-1910 H 1839X
?	none	?	none
?	1844-1912 E 1918	1800-1910 H 1721	none
?	1700-1800 E? 1877	1800-1980 H 1807	none
?	?	?	none

Table 4.9

Some Contemporary European Combinations of Trends: Death Rates-Birth Rates-Population Growth

D-B-G Trends:	C-E-E	C-C-E	C-D*/C-H
England	1726-1806	-	1816-1861*
			1861-1939
Ireland	1725-1791[d,b]	-	1777-1841[d,b]
Scotland	1755-1821[d,b]	-	1811-1871[d]
			1871-1911
Denmark	1735-1801	-	1801-1845*
			1890-1845
Netherlands	1750-1839	-	1815-1869*
			1869-1889
			1899-1947
Belgium	1700-1815[d,b:x]	-	1815-1866
			1876-1910
Germany	1700-1800[d,b]	1864-1910	1816-1864*
		1910-1950	
Switzerland	1700-1850[d,b]	1880-1910	1837-1888[d,b]
		1910-1970	
Austria	1850-1880	1880-1910	-
Romania	1844-1887[d]	1887-1914	-
Portugal	1841-1890[d]	-	-
France	-	1792-1827	-
Spain	-	1857-1920	1920-1960
Czech Lands	-	1880-1910	1851-1890
		1910-1930	
Hungary	-	1910-1941	1880-1910
Serbia/Yugosl.	-	-	1884-1910
Russia	-	-	1762-1815
			1815-1857
			1858-1897
			1897-1939
Sweden	-	-	1848-1943
Norway	-	-	1748-1818
			1818-1893
			1893-1948
Iceland	-	-	1901-1940
Italy	-	-	1861-1936
Luxemburg	-	-	-
Finland	-	-	-
Poland	-	-	-
Bulgaria	-	-	-
Greece	-	-	-

* = D in CBR rather than C; [d] = death rate unknown; [b] = birth rate unknown; [x] = inferred from provinces of Antwerp, Brabant, and East Flanders (E.F. wages known to fall like English).

Sources: Tab. C.3; Figs. 2.1a through 2.1e; Figs. 2.2a through 2.2f; Harris 2001, 148-49; Klep 1991, 505, 498.

Chapter 5

Demographic Trends in Europe before and during Modern 'Transition'

Data for a few whole societies--most extensively England, France, and Sweden--reveal something about the nature of demographic trends that appeared in Europe preceding the population changes that began to become widespread during the middle of the 19th century. Still further insight into these earlier movements and their relationships to more recent demographic phenomena is provided by the experiences of certain social groups and local populations that have been studied in detail.

Collectively, this evidence demonstrates how G-related types of trends that are evident in the 'modern' period of the last 150 years or so also appeared in European populations during the 16th, 17th, 18th, and early 19th centuries. To what extent were they generated by comparable dynamics? Or did they result from different forces--or different combinations of forces--that were at work during the 'early modern' era? The findings enhance our understanding of what has been exceptional in a fairly recent history of human demographic development and what kinds of movements are more general for populations.

NATIONAL AND BROAD REGIONAL SIMILARITIES AND DIFFERENCES IN TRENDS OF FERTILITY, NUPTUALITY, AND ASSOCIATED MORTALITY

Simple assessments of rates of growth and the shapes of path along which such expansion unfolded (Harris 2001, 148-53; 2003, 248; de Vries 1984, 36) place the particularly well documented populations of England, France, and Sweden within a European international framework for contrast and comparison. This structure helpfully guides interpretation of what is known about how fertility and related demographic changes have unfolded on that continent since records begin.

From the middle of the 16th century through the first quarter of the 18th, the peoples of Sweden and England extended the strong, sustained regional growth exemplified by the expansion of other participants in the development of North Sea-Baltic Europe: the Low Countries provinces of Antwerp, Brabant, and Flanders between about 1500 and 1565, the Dutch maritime province of Holland to about 1680, and Germany until the disaster of the Thirty Years War--with respective average annual gains of 0.43, 0.37, 0.62, 0.70, and 0.55 percent over long periods of H-shape increase.[1] Receiving comparatively little help from greater agricultural efficiency, rural occupational diversification, or urbanization during this era, the population of France, meanwhile, expanded at a rate near the low end of the international range between about 1550 and 1720: only 0.11 percent in annual average compared with 0.10 in Italy, 0.13 in Belgium, 0.16 in Austria and Bohemia, and 0.18 in Poland. Only Spain fared appreciably worse,[2] with virtually no net growth between 1550 and 1700 thanks to the 17th-century price her people paid for the effort to be a superpower (Elliott 1963), though the population of Atlantic-facing Portugal, becoming again independent from Spain in 1640, increased at almost the English rate (0.34 percent on average).

Across the 18th century, broadly speaking, the populations of England and Sweden once again were at the head of European expansion with average annual growth rates of 0.57 and 0.48 percent--the one along an accelerating E path like Germany (0.49), the other via successive G-shape advances like Austria and Bohemia (0.54) (de Vries 1984, 36; Harris 2001, 212-13). In France, demographic expansion between 1700 and 1826 took the form of two G's followed by a short post-revolutionary E-type acceleration. There was little gain in the number fed per person in agriculture and in the proportion of the rural population taking up activities outside farming--and virtually no advance in degree of urbanization (Harris 2003, 238). Nonetheless, fertility increase during the first half of the 18th century and slower reduction in birth rate than in death rate during the first quarter of the 19th (in spite of spreading family limitation) yielded demographic growth for the whole era that averaged 0.35 percent per year, comparable to rates for Spain (0.34), Portugal (0.37), Italy (0.29), Belgium (0.37), and Poland.[3] The way that observed movements of fertility in New Castile and northern Italy during this era at least in part resemble those in regions of France (along with similarity of change in the death rate for New Castile during much of the 1700s) raises questions about which of the demographic dynamics of this epoch were shared among the more slowly expanding populations of Europe and which were not.

From the early 1800s to World War II, average annual increase in England and the Netherlands came to as much as 1.17 and 1.04 percent as both peoples multiplied along successive H paths and also urbanized in trends of that shape. Some, if not universal, H-type expansion during the 19th century and the early 20th helped elevate numbers in Belgium, Germany, Italy, Spain, and Portugal at rates of 0.64 to 0.80 per year. While Poland and Austria with Bohemia enlarged comparably, in spite of having no H-type phase nationally,[4] France--with just one relatively flat G enlargement from 1826 through 1921--saw her people increase at an average rate of only 0.22 percent per year. With, for example, proportional advances in urbanization and agricultural yields per hectare that paralleled those for England, and labor productivity in agriculture that progressed even faster (Harris 2003, 277, 291), this meant that the French, by curbing demographic expansion through earlier and stronger 19th-century limitation of fertility within marriage, on the whole did more than other, much faster-growing European populations to improve average living conditions between the first quarter of the 1800s and World War II. But this "most important phenomenon in French nineteenth-century history" turned France into a smaller economy and weaker nation relative to her competitors (Crouzet 2007, 237).

{Please note that the Figures and Tables referenced in Chapter 5 are not interleafed in the text but appear at the end of the text (notes). MSW 31 July 2015}

The international behavior of fertility and its concomitants can be insightfully linked to this framework of comparative growth for populations. To begin, Figures 5.1a, 5.1b, and 5.2 present some additional patternings for aspects of reproduction and marriage in France and

Sweden--the countries whose evidence accompanies that of England (Ch. 1) as most ample before the transitional era for Europe in the 19th century.

For these three populations, Table 5.1 summarizes patterns of infant mortality (M_i), overall fertility (I_f) marital fertility (I_g), and nuptuality (I_m) from Chapters 1 and 4 along with total fertility (TFR) and crude marriage rate (CMR) from various sources, and crude birth and death rates (CBR and CDR) from Chapters 1 and 2 for comparison and contrast, both within each country over time and cross-culturally. Present emphasis is on the years preceding the dashed lines for each country. Later trends are included in Table 5.1, however, in order to highlight similarities and differences relative to earlier movements.

Throughout, overall fertility (I_f) moved very much like TFR everywhere. Change in CBR likewise accompanied that in TFR except that in Sweden it fell along just the one C path from the 1690s into the 1930s, not three successive trends of that shape since the 1750s. The patterns for CDR mostly resembled those for M_i in all three countries after the middle of the 18th century. Before then, however, in England at least, they moved quite independently, even at times opposite to each other. Trends of the crude marriage rate (CMR) in England, on the other hand, were similar to the tracks for I_m up to the 1750s, but unfolded inversely thereafter. In Sweden, from the middle of the 19th century forward, CMR declined via C while nuptuality increased in G fashion. A burst of emigration, which took many young people abroad to form their families, contributed to this divergence. For Sweden before 1880, and for France throughout, this particular comparison must be made elsewhere.

All eight variables, in so far as their movements are covered in Table 5.1, changed via G-related trends. That was true just as much before the era of modern ‘demographic transition’--during the 16th, 17th, 18th, and early 19th centuries--as it was from the middle 1800s forwards. These recurring G-connected patterns, furthermore, reveal much about the dynamics at work in the three populations. Some of this insight is familiar; some is not yet perceived as effectively as might be.

It is useful to begin detailed examination of the changes and their consequences that were involved across the three countries with some overall comparison and contrast:

Among these best-documented populations, it was in England that economic development--in agriculture, in other occupations that flourished across the countryside, and in the growth of towns and cities--sufficed to permit the national population to expand in the persistent, only slowly slowing H form for most of the time between the ascension of Elizabeth I and the outbreak of World War II. Starting in the 1550s, periodic declines in the overall death rate combined with some fertility increase between the 1660s and the 1720s to provide the people for persistently sustained H-type growth. The two exceptional periods between the 1550s and the 1930s occurred for just 30 years in the later 17th century, between the Commonwealth and the Glorious Revolution, during which rising death rates--for infants and for the population as a whole--along with curtailed emigration opened the door for more marriage and more reproduction (both in G trends), and from the second quarter of the 18th century into the first years of the 19th, when industrialization and the urbanization that accompanied it could absorb, exploit and yet support (if not generously), the upwardly accelerating number of people produced by simultaneous C-shape decline in mortality and E-form increase in fertility. In spite of these two interruptions to its H-type growth, between the 1560s, when it started to expand this way, and 1939 the population of England multiplied by 13.1 compared with just 2.2 times for the population of France between about 1550 and World War II (0.68 percent per year on average vs. 0.20), during which era of almost four centuries French demographic expansion never took H form (Harris 2001, 148-52; 2003, 232).[5]

Whereas England could be said to offer the ‘ideal type’ of a population that from a very early point in modern history harnessed economic change to expand persistently and robustly, France represents a society in which development in resources for no time on the existing record supported sustained H-form demographic expansion. The ‘ideal type’ found imbedded in the history of this population was almost always one of circumscribed and quickly depleted opportunity for demographic growth. Exceptionally early, however--even among European nations--that curbing operated, in the terms of Malthus, by means of ‘preventative’ rather than ‘positive’ checks. The general historical context suggests that most gains from resources in the 17th and 18th centuries, and perhaps also the 19th, were limited, and instead of supporting more people accrued largely toward furthering the lifestyle of elites and to making France temporarily the preeminent land power in Europe--a posture that, because of the demographic choices that had been made, could no longer be supported in 1871 and 1914 (Crouzet 2003, 234-36).[6]

Much the same C-shape improvements in infant mortality and general death rates occurred there as in England. In France, however, after perhaps sharing similar gain in fertility during the first few decades of the 18th century (following comparable loss to disease in the later 17th century), the population by 1750 or so began to display significant decrease in reproduction. This was powered principally by reduced fertility within marriage, not the opportunity to marry--which had regulated total fertility generally parallel with change in infant mortality in England between the 1550s and about 1730, where reproductive control by couples was comparatively scarce before the 1880s.

While the path of urbanization in France, advancing approximately in E shape between 1700 and 1850 and perhaps via H from 1850 to 1950, broadly resembled movements of similar form in England, the pattern of population increase failed to reflect such change, except for a brief period after the Revolution, whereas in England total numbers and the proportion living in towns or cities quite continually rose in parallel E then H fashion between the 1720s and the 1930s.[7] The processes fueling urbanization did not do much to affect the bulk of the population in France. For example, the total number of people supported per person in French agriculture increased hardly at all between 1600 and 1800; and the proportion of the rural population not engaged in agriculture advanced only from 29 to 34 percent cross the 18th century with development in crafts (many producing luxuries for the well-to-do), some home industry, and the scattered, often small manufacturing enterprises for which the French economy is historically noted (Robb 2008, 100, 154, 265; Crouzet 2003, 236) in contrast to gain from 34 to 50 percent in England (Harris 2003, 238). France, in short, represents a society in which the experience of the bulk of the population from the 1740s to the 1930s--and probably likewise from 1500 or earlier to the 1740s--entailed relatively tight demonomic control in which successive improvements in resources or phases of socioeconomic change brought about only limited, quickly flattening G-type demographic expansions. Beginning at a very early stage in the 18th century, however, the curtailment of reproduction *within* marriage spread as the mechanism for adjusting fertility to 'carrying capacity' in place of limits upon marriage, the regulator in England until the later 1800s (where the spacing of children, for example, actually *decreased* somewhat between about 1580 and the 1820, Fig. 1.8 has shown).

The Swedish population, on the other hand, displays a mixture of these contrasting English and French experiences. It expanded very much like the people of England between about 1570 and 1720[8] with political consolidation under the Vasas and economic development as Baltic-North-Sea-Atlantic Europe flourished at the expense of once-dominant Mediterranean regions. Urbanization in Scandinavia, though beginning at a very low level, quintupled between 1550 and 1700 as--from more comparable starting points--this proportion of the population in England multiplied by 3.8 but that in France by only 2.1 (de Vries 1984, 39). Among scant demographic particulars available this early, furthermore, across the later 17th century and first years of the 18th at least the crude marriage rate in the southern region of Scania gained in parallel G fashion with the CMR in England.

During the 17th century and into the first years of the 18th, however, Sweden committed her developing resources--including her human ones--to an ultimately failing effort to rival France, the Hapsburg Empire, and Russia in replacing Spain as the dominant power in Europe. This involved supporting armies as far afield as southern Germany and the Ukraine. With ultimate defeat in the early 1700s, the Swedes, between the second quarter of the 18th century and the middle of the 19th, like the French then held population increase to a few successive G-shaped patterns within the limits provided by what were apparently rapidly decelerating, quickly used up, opportunities for demographic growth.[9] Like trends in France, and unlike those of England, Swedish fertility came down in C shape along with infant mortality and the overall death rate from about 1753 forward into the early 1800s. This happened more slowly in Sweden than in France, however, with appreciably later target dates for the C curves involved. There, for Sweden, the decline in fertility stalled. By 1800, TFR--as in France--began to follow marital fertility; but until 1900 or so these declines moved along a much flatter C path than that for infant mortality, unlike the much closer matching in France--both up to and then following about 1850.

As of the middle of the 19th century, the Swedish population again began to expand in H form--as in England, but more like the trajectory of English growth between 1816 and 1861 than the rather steeper pattern adopted in England after that point.[10] Urbanization in Sweden, however, from what was still a comparatively low starting level, proportionally advanced more robustly than in England (or France), but likewise in H fashion after about 1870. The continued pairing of extremely slowly accelerating decline in fertility with faster contemporary improvement of that shape in infant mortality--and after 1843 somewhat steeper decrease in overall death rate as well--served to enlarge the size of the Swedish population steadily in only slowly decelerating H form at the same time that it generated significant net emigration during the later 1800s (Fig. 3.1a). Only after about 1900 did change in fertility for Sweden come to parallel C-shape declines in infant mortality and CDR, an alignment that appeared in France by about 1840 and in England by about 1870.

Details of these sometime similar, sometimes contrasting, demographic movements and demonomic relationships among the populations of England, France, and Sweden can be delineated somewhat more specifically, to include changes in components such as celibacy, age at marriage, fertility by age, and signs of strain in the form of illegitimacy, premarital pregnancy, child abuse, or abandonment of religious norms as these broader adjustments of population unfolded:

In ***England***, shows Table 5.1, from the second half of the 1500s into the early 1700s, the total fertility rate--controlled by nuptuality (especially much elevated celibacy for women), as fertility within marriage remained level--paralleled the decline then rise in infant mortality. On the surface, this may look very much like a classic picture of 'Malthusian' demographic regulation, facing little contribution of additional resources under population pressure. That is, first decreasing fertility to about 1650, due to contracting nuptuality (a 'preventative check'), lowered the rate of infant deaths in response to population pressure; then rising nuptuality into the 18th century generated more babies but more deaths among them (a 'positive check') as the 'carrying capacity' of England was strained.

The difficulty with this tempting interpretation, however, is that the crude death rate--which shapes population increase more directly than infant mortality alone--was in fact *rising* as fertility and the birth rate declined from the 1560s into the 1650s. The population of England, meanwhile, could expand for a century along an only slowly slowing H path (and simultaneously supply significant, if decelerating, net emigration) because the gap between births and deaths that opened up in the middle of the 16th century sufficed to provide a wide enough margin to withstand erosion over such a long period, buffered, one sees here, by greater survival among the fewer births that occurred as nuptuality (much affected by emigration and high female celibacy) contracted to the 1660s.[11] Thereafter, D-shape population atrophy between 1656 and 1686, because the death rate as a whole continued to push up faster and faster as far as 1681, appears--by weakening demand upon resources--to have encouraged nuptuality and thereby raised TFR in tandem.[12] The rate for infant mortality, as Table 5.1 indicates, followed these G-type increases; but the more proximate population-regulating CDR did not. And while the G trends for nuptuality, total fertility, and infant mortality continued to parallel each other into the early 18th century, from the 1680s to the 1720s the population of England resumed very much the same kind of H trend of increase as it had followed from the 1560s to the 1650s, assisted by a collapse in the significant rate of net emigration that had pertained before about 1660 (Fig. 1.3), which led to a sharp decline in celibacy (Fig. 1.5), and by a substantial improvement in real wages that had been induced by the demographic losses of 1656 through 1686 (Wrigley and Schofield 1981, 642-44; 414; Ch. X below).

The steady H-shaped five-fold increase in extramarital fertility from the 1650s forward (Fig. 1.4) also contributed. This movement had its zero year only at 1641, much steeper than the underlying H tendency for population growth in England, which was based in the late 1400s. The shape and timing of trend for I_h, nonetheless, resemble characteristics of what seems to have been a pattern of change within English rural employment. From perhaps as early as 1600 into the early 1700s, that is, an H trend with t_0 in the 1630s captures increase in the proportion of all workers in English agriculture who were wage laborers rather than servants, family members, and others who had more durable and complex relationships to the farmers in charge (Harris 2003, 241). Did this monetarization of work in agriculture, where more than half the English population were employed before about the second quarter of the 18th century, foster increased fertility outside marriage? One can suspect that besides encouraging workers to seek employment elsewhere, swelling the uprooted population to be found in cities, by making rural subsistence if not less secure at least more fluid this pattern of change also fostered more illegitimacy in the countryside. The diffusion of wage labor, even more steeply than the somewhat flatter H-type increase simply of scale in agricultural operations (base year in the 1550s, shows Harris 2003, 241), seems in England from the 1600s into the 1700s persistently to have encouraged births outside marriage at the same time that it made familiar the owner-worker relationships that would characterize industrial employment.

During the long era from the middle of the 1500s to about 1730, in short, a simple, direct effect of ‘carrying capacity’ upon I_m, TFR and I_f, or M_i is evident only for the 30 years between 1656 and 1686; and that apparently worked in the *opposite* direction of what one would expect from increasingly oppressive ‘density.’ Here, reproduction was *encouraged* to make up for a temporary sag in population rather than punished for oversupply. Otherwise, any such demographic response in nuptuality, fertility, or infant mortality to resources that for some reason expanded in H form, were only indirect, with infant mortality even moving opposite to the ultimately more determinative CDR between the 1550s or earlier and the Civil War and not sharing the 1/G' dip of the crude death rate between 1681 and 1731.

The relationships for England, however, altered significantly around 1750. Now nuptuality increased in accelerating E fashion into the 1810s, still taking the total fertility rate with it as marital fertility rates remained constant. In this era, however, infant mortality declined in *opposite* C form. That combination made the population 'explode' in accelerating E shape, as the CDR (especially after 1761) for the first time moved like M_i--easing comparably via C. In the economy, real wages deteriorated in C manner (Ch. X) without stopping either nuptuality or fertility from pushing upward. Their starting level was high enough to be able to yield ground without inducing either 'preventative' or 'positive' checks in the English demonomic system.

Beginning in the 1750s, meanwhile, the arrival of industrialization saw a return to G' surges of I_h in England like the one of the late 1500s and early 1600s (though not as great, shows Fig. 1.4). The first and then the second thrust (which took off just as the trend for 1758-1783 approached its crest) carried the rate of illegitimate fertility upward until at 1810 it reach 0.056, almost three times the level of the 1750s--where, after long but gradual ascent, extramarital reproduction had finally returned to the maximum attained around 1600 by the long G' surge of 1568 to 1648. Strongly elevated illegitimacy was one of the prices that the English population paid for the upheavals of the Industrial Revolution. It apparently had also accompanied the expansion of Elizabethan towns two centuries before.[13] This demographic consequence, like the renewed rise of celibacy for women across the later 1700s and early 1800s, is not given much consideration in discussions of well-being under the new industrial economy, which focus overmuch on male wages. Then, somehow, the index shifted downward around 1830; but a new G' surge followed. Calculated for 1833 through 1873 in Figure 1.4, the peak at 1858 reaches

0.047. This resembles the beginning of the ‘transition’-era G’ trend for I_h in England with Wales from 1851 through 1901 (Tab. 4.5 and Fig. 4.4a).[14]

From about 1815 or so into the middle of the 19th century, the TFR continued to move opposite to the rate of infant mortality. Now, however, total fertility sagged in D form while M_i rose via G. Since marital fertility continued to hold level, it was still nuptuality that guided TFR downward. Though I_m underwent a 1/G’ sag between the 1820s and the 1860s, this path, where there was overlap as far as 1851, was not very different from the current D course for TFR (and the CBR), a conclusion that the 1/G’ pattern of I_f for 1823 through 1858 supports (Tab. 5.1). Falling fertility and rising infant mortality, nonetheless, did not prevent the population of England from returning to H-shape growth between 1816 and 1861 (with abundant net emigration) because the crude death rate declined in C form.

Finally, control of fertility within marriage spread significantly in England during the middle of the 19th century. Now couples could more readily limit their offspring as more and more babies survived with improving living conditions and health care. The C-shape decline of I_g into the 1930s steered TFR down in parallel fashion, and the path of nuptuality became largely irrelevant for fertility rates, if anything rising somewhat--and after 1890 taking E form opposite to the downward curving of fertility. Diffusing ability to limit births (whether spacing or stopping pregnancies), along with improving life expectancy, contributed to more frequent and more lasting marriage. The national population, meanwhile, continued its tendency to expand in H fashion, its size doing little to shape movements in fertility or mortality directly through interaction between demographic growth and economic circumstances.

In all, fertility and infant mortality, even the classic ‘preventative check’ of curtailed nuptuality, in England between approximately 1560 and 1730 (except perhaps from 1656 to 1686) were as weakly or indirectly influenced by limits of ‘carrying capacity’ as in the era from Waterloo to World War II. Though population increase took very different shape between about 1730 and 1815, much the same can be said about those years also. Economic growth, in terms of real per capita income, may indeed have become substantial only in the early 1800s (Clark 2004x, xxx). By the middle of the *1500*s, however, the overall level of living conditions in England apparently relieved the population collectively (in spite of horrid Hogarthian exceptions and long deterioration of real wages into the early 1600s and again across most of the 1700s) from any harsh Malthusian calculus of ‘checks’ that might have existed in the middle ages.

There may have been short-term adjustments to “fit” the persisting H-form expansion of population with the path of sustained socioeconomic development; and real income per capita may have advanced only modestly for the time being. But, except for the brief “labor shortage” period between the Civil War and the Glorious Revolution that resulted from surging overall death rates and consequences of net emigration upon domestic reproduction, neither fertility nor mortality display direct imprints of limits determined by carrying capacity. Any demonomic response to changing resources operated instead through one or another aspect of the *quality* of life during development, not through chances for life itself. Malthus failed to grasp how much, even two and a half centuries before his own time, resources--notably though not exclusively in his own country--could expand to accommodate, even feed off, gains in population, exploiting processes that did not wait upon the growth of per capita GDP with 19th-century industrialization (which economists tend to sanctify) but began to appear in some modernizing parts of Europe, including England, as early as the 16th century.

That there is always *some* ultimate adjustment between population and resources--true even in the most modern, “liberated” circumstances it must be recognized--is a not very informative conclusion. The productive insight lies in grasping the nature of the mechanisms involved. In England, since the middle of the 16th century the relationships of the demographic trends observed suggest that, for all the misery that some indeed experienced, sheer Malthusian impoverishment was not a collectively determining force for population size or for the movements in fertility, nuptuality, and mortality that shaped those numbers. An ‘escape’ had occurred to conditions under which the regulating mechanisms operated instead through the distribution of an expanding abundance of resources and changing ways of life *above the minimum threshold* for various groups in the population. To consider these new demonomic relationships as continuing ‘homeostasis’ at a “prosperous” level up until the economic advances and widespread flexible marital fertility of the 19th century (R. D. Lee 1987, 459) seems to pay insufficient attention to how differently, already by the 1500s, the adjustments between population and resources in England worked compared with prior circumstances there--or the continuing experience of many contemporary countries, even within Europe. And it underestimates what the ‘agricultural revolution’ of early modern England in fact shared with the much later ‘industrial revolution’ in matters of demonomic interaction between resources, on the one hand, and, on the other, population growth and its contributing processes of fertility, nuptuality, mortality, and migration (both internal and external).[15]

Enduring expandability of collective resources in partnership with population growth, demonomic advance sufficient to have warded off for long periods of time the deadly hand of ‘positive checks,’ was the innovation of the 1500s in England (and apparently even a little earlier in the Low Countries). The 19th-century ‘transition’ then featured the replacement of nuptuality by marital fertility as the regulator of population size in any response to changing mortality, but still within a framework of resources that could be significantly and adequately enlarged.

Presaged by the return of demographic expansion in England and other ‘developed’ countries from H to more curtailed G form since World War II (Harris 2001, 148-49, 385), limits for this kind of flexible demonomic regime loom ahead with the progressive exhaustion of many of Earth’s resources, perhaps bringing about still another ‘transition,’ and possibly not a pleasant one. ‘Crashes,’ for example, are a familiar feature in the biological populations to which some analysis (as by R. D. Lee 1987) compares human experience. ‘Positive checks,’ which have disappeared for many (though by no means all) of the world’s peoples, could well again become a force in the future--even for those societies with the most felicitous histories of demonomic development, the ones which have at some point or other since the 1500s most successfully participated in the great ‘escape’ from subsistence-level demonomic dynamics.

As long noted, historical trends for ***France*** contrast markedly with those for England. Across the first half of the 18th century, data for infant mortality and nuptuality are not readily available. Marital fertility, however, apparently rose in G fashion and imprinted that pattern upon TFR--based upon aggregated local studies in Normandy and southwestern France (Fig. 5.1a). Trends of both I_g and TFR in the Paris basin, in contrast, during this period were mostly flat--if anything, already beginning to decline slowly in C form. The G-type movements for TFR outside the Paris basin on average resemble patterns of that shape for England in the decades before and after 1700, though the French trend is rather steeper, with zero year around 1652 rather than 1615 (Tab. 5.1).

Unlike the case in England and Sweden with their sustained, only slowly decelerating H trends, the population of France had grown very little between 1500 and the middle of the 1600s.[16] Then, what may have been D-type contraction occurred across the later 17th century (Dupâquier 1997, 448, 451; compare Harris 2001, 148, 152). This closely resembles the decline found in contemporary England, suggesting similar forces at work--probably principally diseases and not just plague (Goubert 1965, 467). Dupâquier (1997, 246) calls attention to a depressing effect also upon baptisms, as in Auvergne, though the English response was opposite G-type improvement in fertility from about 1660 forward (Tab. 5.1). Associated with this much flatter population growth in France across the 16th and 17th centuries was little advance in urbanization: over the 17th century just from 8.7 to 10.9 percent living in places of 5,000 or more inhabitants (following perhaps some actual contraction during the 1500s) in contrast to the rise from 8.0 to 17.0 percent in England (Harris 2003, 238, from Wrigley 1985a).[17] Meanwhile, the numbers of mouths fed per person in agriculture in France increased just from 1.45 to 1.58 between 1600 and 1700 compared with gain from 1.43 to 1.82 in England; and the proportion of the rural population engaged in activities outside agriculture grew from a shared level around 1600 of 24 percent to 29 rather than 34 percent (ibid.). Some economic change did occur in

France across the 16th and 17th centuries,[18] but only enough to foster a little overall demographic expansion, not the more persistent and more substantial H-type growths found in Antwerp, Brabant, and Flanders up until the revolt against Spain, in the Dutch maritime province of Holland as far as the 1680s (as it usurped much of the economic lead of these Hapsburg Low-Country holdings), in Germany until the Thirty Years War, and in England and Sweden on into the early 1700s--all beneficiaries of the early modern development of the Atlantic-North Sea-Baltic axis of Europe at the expense of formerly preeminent Mediterranean zones.

At last, however, increase in TFR during the first half of the 18th century, largely though not totally due to rising I_g, pushed up the size of the French population to new levels after about 1700 also in G fashion--with t_0 around 1650 compared with base points for TFR and I_g in the vicinity of 1652 and 1630 respectively (Tab. 5.1). This happened, though, as urbanization in France actually atrophied somewhat between 1700 and 1750, the amount of population fed per person in agriculture rose only from 1.58 to 1.63, and the fraction of the rural population occupied outside farming swelled just from 29 to 31 percent (Harris 2003, 238). There is, in other words, little evidence of broad economic development to support even the modest French demographic expansion of the first half of the 18th century. Underlying strain is indicated, even without considering the role of particular crises or public policies.

As the population enlarged in G fashion after 1700 under these relatively unsupportive circumstances, French women and children paid a price. Between 1695 and 1735 the percentage of females who never married rose in G form parallel to growth, with base year about 1667 (Fig. 5.1b). Premarital pregnancy, potentially another reflection of demographic pressure against relatively inelastic socioeconomic opportunity, also began to increase--in this case along an E path that would continue through the third quarter of the 18th century (ibid.).[19] In some communities, meanwhile, the proportion of all babies who were illegitimate or abandoned rose--typically in G' manner--to new heights in the middle to later 1700s, as did the number of Paris children 'farmed out' for wet-nursing in Beauvais (Figs. C.4, C.7 in App. C). Nationally, illegitimacy probably increased in G fashion from 1755 through 1785, though Blayo's calculations suggest an E trend for the second half of the 18th century that resembles the path for increasing premarital pregnancy (Fig. 5.1b).

One aspect of response to such demographic strain seems to have been the beginning of growing tendencies toward secularization already by the first years of the 1700s, judging from the omission of religious stipulations from testaments in Provence, on the one hand, and, on the other, marriage during the prohibited seasons of Advent and Lent in the Belgian fringe of French language and culture represented by rural Wallonia (Figs. C.5 and C.6).

In England, meanwhile, during the first half of the 1700s as fertility rose with nuptuality in G mode with t_0 only somewhat earlier than in France (Fig. 1.4, Tab. 5.1), illegitimacy and especially premarital pregnancy expanded comparably along H paths like the size of that population--but much more steeply (zero years around 1590 and 1630, not 1492, shows Fig. 1.7). The proportion of celibacy among women, in contrast, between the late 1600s and about 1750 fell dramatically, from about three times the percentage in France (Fig. 5.1b) to only approximately the same level. Even as disruption and relocation from rural occupational diversification and urbanization fostered illegitimacy and premarital pregnancy in England, economic changes improved the overall chance to marry. Urban residence, rural employment outside agriculture, and mouths fed per person in agriculture all rose in H form, with base years around 1570, 1550, and 1515 respectively.

Starting in the vicinity of 1750, total fertility rates for France began to fall off very generally in C mode. Once again the path largely paralleled that for marital fertility (Wrigley 1985b, 42, and Weir 1993, 151, reconstitution, for I_g), but now *down* rather than up. As the righthand panel of Figure 5.1a indicates, the earliest--and, before 1800, the most--reduction in marital fertility occurred in Normandy (approximately from 0.80 to 0.42). Change in the southeast Paris basin became significant only following the Revolution, and took D rather than C shape, though this different path reduced I_g to approximately the level for Normandy by about

1880. Further decline, perhaps again in D form, lowered this regional index by 1900 to about 0.32, like that for southwestern France and only some three-quarters of the rate for Normandy. In southwestern France I_g was still rising up to the eve of the Revolution; but it reached a maximum there of only about 0.63, roughly the level to which by that time the indices for Normandy and the southeast Paris basin had fallen from their maxima in the early 1700s.

It is useful to note, furthermore, that estimated total fertility in southwestern France, running from about 4.7 to 5.3 between 1700 and 1740 (the lefthand panel of Fig. 5.1a), was on the whole just a little higher than the 4.6 average for the English population in the first half of the 18th century (estimated as 2.05 times the GRR in Wrigley and Schofield 1981, 528-29), while national TFR for France in the 1740s stood slightly over 5.0 (the righthand panel of Fig. 5.1a). Like the similarity of early English and Swedish crude birth rates (around 30 and 34 at 1700 vs. 43 for France), these finding indicate that the level of reproduction of the English population as calculated by Wrigley and Schofield was not, as some have argued, markedly low or out of line with the demography of other parts of northwestern Europe.

The gross reproduction rate for France declined comparably to TFR and I_g (Fig. 5.1b; Wrigley 1985b, 37). Infant mortality, meanwhile, shrank into the early 1800s along a rather earlier C curve (Tab. 5.1). This lag of fertility behind mortality, as has been seen for crude death and birth rates in Chapter 3, helped drive the size of the French population higher in E fashion between 1792 and 1827. Such dynamics of growth were quite different from those that generated contemporaneous E-shape increase in England, where *rising* fertility (thanks in large part to E-type gain in nuptuality) accompanied C-form decrease in infant mortality to feed upwardly accelerating expansion. M_i dropped away via C in both countries, if rather more steeply in France between the 1740s and the first years of the 1800s (Tab. 5.1). As this happened, marital fertility in France responded to restrain population increase across the second half of the 18th century into quickly decelerating G shape. In England, in contrast, though real wages suffered inversely with demographic pressure, overall growth in national resources allowed nuptuality to expand (as female celibacy contracted even further) and take fertility and the size of the population up with it, free of a penalty to be paid in infant or total mortality.

Patterns of urbanization, the proportion of rural population not engaged in agriculture, and the number of people supported per person in agriculture (Harris 2003, 225, 236-38; from Wrigley 1985a) again sketch out the way that economic development supported population growth in England as opposed to France during the 18th century. The agricultural population in England fed 1.65 times as many people as itself in 1670, but 2.76 times by 1801. In France, between 1700 and 1800 the ratio changed only from 1.58 to 1.70, taking what may have been an H path between 1600 and 1800 with base year way back around 1345 as opposed to the 1670-1750 H trend for England from a zero year about 1514, probably followed by further E-type increase to 1800. Between the third quarter of the 17th century and the end of the 18th, the proportion of the rural population in England engaged in activities other than agriculture rose from 30 to 50 percent, while between 1700 and 1800 in France the gain was only from 29 to 34 percent. As Wrigley pointed out two decades ago (1985a), two rural populations (and most lived in the countryside in both nations) that were similar in these respects as of the late 1600s had diverged markedly by 1800. Meanwhile, the proportion of the English people who lived in towns and cities doubled between 1670 and 1801 (from 13.5 to 27.5 percent) while in France 10.9 percent had urban residence around 1700 and just 11.1 percent at 1800 (barely 10.3 percent at mid-century).

Not only did the French rural population do little to add to the numbers of people who engaged in crafts, trade, protoindustrialization, or city life. Confronting what were apparently continually limited resources, it had to contend constantly with just keeping itself viable. In consequence, between 1720 and 1826 it grew at an average annual rate of about 0.34 percent compared with 0.57 percent between 1726 and 1806 for the slow-starting but accelerating population of England and 0.48 percent for the people of Sweden from the 1720s through the 1840s, even though they--like the French except between 1792 and 1827--multiplied via successive G-shape surges without an H path (Harris 2001, 148).

Under what seem for most people to have been little-changing socioeconomic conditions, even with more limited demographic growth than in England, the proportion of first pregnancies that were premarital climbed in France between 1755 and 1805 along a G path with zero year at 1744 (Fig. 5.1b), appreciably steeper than the increase of that shape in the population between 1752 and 1792 (t_0 at 1702). From 1775 through 1815 celibacy expanded in comparable G form (base year at 1754), while between the 1740s and the 1790s the fraction of births that were illegitimate accelerated upward via E. This path (“Blayo” in Fig. 5.1b), with zero year at 1795, extends forward in time the kind of E trend identified for all premarital pregnancy between about 1705 and 1780 (t_0 at 1796). In certain communities that have been studied, meanwhile, is evident another G’ surge in illegitimacy or abandonment of babies, beginning in the 1760s and peaking around 1800 (Figs. C.4 and C.7). As of the 1830s, however, the trends for I_h (though not for illegitimacy) in France took G’ shape that resemble what was happening to extramarital fertility in England after 1833 and in several other countries of Europe across the later 19th century (Tab. 4.5).

At least for Provence, G-shaped advances in secularization encouraged such looser conformity with religious expectations for marriage, procreation, and parenthood. These paralleled movements during the later 18th century in celibacy and premarital pregnancy (Fig. 5.1b; also illegitimacy according to Fine). The proportion of testaments that omitted religious stipulations rose in G fashion between 1740 and 1780 with zero years for masses and invocation of the Virgin in the 1740s, for any type of religious reference in the 1720s (Fig. C.5). Meanwhile, the percentage of marriages taking place during proscribed periods of the church calendar surged in G’ manner between the 1760s and the 1810s in several parts of France[20]--and also of Belgium, though in this era (after earlier surges in the 18th century) lagging there about 20 years and starting to become more significant only with the French Revolution and occupation (Fig. C.6).[21]

French population growth was driven by lessening mortality. The latter was a pattern of demographic change shared with England across the later 18th century, but--in contrast--was accompanied in France by little gain in agricultural productivity, occupational change, and urbanization to support the demographic increase it generated, or by emigration to relieve the pressure. The absence of such avenues of relief encouraged French couples to manage their reproduction much earlier than the English. From the 1760s into the 1780s, seemingly in G manner with t_0 around 1779, family limitation as measured by the *m* index began to become a factor for the French population as a whole, not just a few elites (Fig. 5.1b). Then, spurred by the cultural atmosphere of the Revolution, its prevalence surged upward in accelerating E fashion to significant levels above 0.2 before taking up a more gradual but steady path of further increase across the 19th century and into the 20th, reaching 0.9 by the 1930s, in G or perhaps H fashion.

From about 1800 to 1840, total and marital fertility in France came down together with infant mortality once more, approximately in C form though M_i might be trended to take D shape virtually opposite to the contemporary G in England. Meanwhile, around 1830 nuptuality and fertility uncoupled--as they did, via somewhat different trends, in England after about 1850 (Tab. 5.1). The growth of the French population during the second quarter of the 19th century, however, again took G shape rather than the H path found in England. In general, across the first half or two-thirds of the 19th century the regions of France--though starting with diverse conditions--experienced comparable demographic change (except in the industrial North), developments that tended to distinguish them from other parts of Europe (Wrigley 1985b, 173).

The C-type decline in marital fertility in France across the first half of the 1800s (Fig. 5.1b from Weir 1993, 151, reconstruction), for example, with target year about 1881 ran closely *opposite* to the E pattern for urbanization in France during these decades, which had its t_0 around 1869 or 1885 (Harris 2003, 277; Lepetit and Poussou 1988, 203). The more people lived in towns and cities, the more I_g fell. Though, as elsewhere, the social uprooting involved in urbanization can be expected to have furthered practices of family limitation, in France peasant couples deeply engaged in such practices (Crouzet 2003, 237). Meanwhile, the proportion of females who never married could finally shrink in D manner from 1815 through 1875, and did so approximately opposite to the G-shape growth of the population from the 1820s forward (with zero years about 1756 and 1774, respectively).

As had been the case in England between the middle of the 17th century and the middle of the 18th, and--judging by nuptuality--probably again from there into the early years of the 19th (Figs. 1.7 and 1.4), processes associated with urbanization and economic development allowed demographic expansion and reduced celibacy at the same time even while depressing living standards during the later 1700s. The rate of illegitimacy in France, however, gained (in a G trend with base around 1798) alongside population growth instead after about 1825--the two guided simultaneously by the pace of socioeconomic change, as had also previously been the case in England. The 18th-century metamorphosis in England had been powered by chances to marry more often and be married longer. In 19th-century France, the change was instead regulated by decline the reduction of fertility within marriage, which did not substantially diffuse across the English population until the 1880s.

Considering the whole era from the later 17th century to the later 19th, female celibacy evolved in France very differently from that in England (Figs. 5.1b, 1.5). To make this comparison, some 20 years must be subtracted from the trend boundaries in Fig. 5.1b for females as of their 40s to approximate when French women would typically have been married.

First, at no time did the level reach as high as the English “plateau” of the 17th century. Save for the years from about 1760 through the Napoleonic wars it stayed close to 10 percent, not 20. Second, from about 1675 through 1855 most of the time the French rate moved in an opposite direction from the English one, rising as the other fell, declining as the other increased:

England:	**France**:	
Celibacy	Celibacy	Population
1599-1694 H 1460		
1684-1739 D 1690	1675-1715 G 1647	1675-1700 D 1566
1704-1754 C 1756	1715-1755 G 1687	1700-1752 G 1650
1759-1844 H 1711	1755-1795 G 1731	1752-1792 G 1702
	1795-1855 D 1755	1792-1827 E 1876
		1826-1921 G 1774

Through the end of the 1600s and the beginning of the 1700s, the French rate rose in G fashion while the English rate plummeted via D. In England, the curtailed emigration of males generated the change. In France, meanwhile, the campaigns of Louis XIV aggravated impediments to the marriage of young women as the population contracted for reasons of disease as well as chronic warfare (Harris 2001, 152). From 1715 through 1755, frustrations for females the wishing to marry magnified still further in G form as the population increased in this shape (while female celibacy in England declined significantly further via C). A similar paring of French trends occurred again from 1755 to 1795. Twice between 1715 and the Revolution, that is, moderate G-shape expansion in the French population contributed to stronger increase in this pattern for female celibacy (with t_0's about 30 years later). Pressure from insufficiently expanding resources seems indicted. Changes from the Revolution that affected the opportunities for ordinary French people, the values of society, and the institutional framework within which the French lived, finally, reduced celibacy for women in D form into the middle of the 19th century or later as the national population expanded oppositely in somewhat stronger G fashion. Meanwhile, from 1759 through 1844 never marrying among women expanded in H form along with the return of strong emigration.

During the later, modern period discussed in Chapter 4, after about 1840, urbanization in France that took H form between 1850 and 1950 with base year around 1786 (Harris 2003, 277) seems to have set the course for family limitation as measured by *m* (Weir 1993, 157), even though French peasants are particularly known for limiting their reproduction (Crouzet 2003, 237).[22] What economic change, for example, might have steered urbanization and family limitation simultaneously? One possibility is greater productivity of labor in agriculture. This, too, increased in H form for France across the 19th century--rather less steeply than *m* (zero year around 1738 rather than 1770, but considerably more strongly than in the United Kingdom (in contrast to very comparable advances in yields per hectare; Harris 2003, 291).

With early nationwide advances in managing fertility within marriage, in country and in city, opportunity for young females to wed did not rise, fall, or fluctuate with 19th- and early 20th-century changes in the economy of France as it did in several other European countries (Tab. 4.6; Figs. C.3a, C.3b). Overall, demographic behavior across France now converged toward the experience of the rest of Europe (Wrigley 1985b, 173). While Wrigley (ibid. 174-75) emphasized widespread regional upward reversals in the level of marital fertility during the 1860s and 1870s, the *national* trend suggests more of a slight 1/G' dip into the 1850s across a C trend from 1831 through 1911 (Fig. 4.1a).

In many different ways identifying the G-related trends involved helps in understanding better the position of French demographic adjustments among international patterns since the later 17th century. Sometimes these movements were distinctive. Sometimes they were not so unlike what is found in the English and other populations as European societies 'modernized.'

[SPACE]

In ***Sweden***, there are signs (at least according to evidence from the southern province of Scania) that the crude rate of marriage may have risen in G form from about 1650 through 1710, parallel with the CMR and nuptuality in England from around 1660 into the first half of the next century--with all three zero years in the vicinity of 1607 (Fig. C.2; Lundh 1999, 220; Tab. 5.1).

The sudden drop of level in Scania between 1710 and 1715 is likely reflect what the costly Great Northern War, which ended Sweden's 17th-century bid to be a leading continental power, did to the chance for women to wed. Their average age at first marriage, for example, crested in the first years of the 1700s (Lundh 1999, 222).

The populations of both countries, meanwhile, expanded in comparable H form between the third quarter of the 1500s and the 1720s (except for the interrupting English sag between 1656 and 1686).[23] In England, by 1600 the percentage of people who lived in towns and cities was increasing in H form parallel with the long-term growth of the population--even more strongly than it did from 1670 through 1750 (Harris 2003, 225). In Sweden, though, estimating from Scandinavia more generally, from about 1650 into the 1700s urbanization advanced only in G fashion from a base year in the 1630s (ibid., 275; de Vries 1984, 39). That path resembles the movement of the crude marriage rate more than the pattern of population growth. In Sweden, unlike England, urbanization did not increase more, and more persistently, than the crude marriage rate, which for each of the two countries expanded during this early era only in more rapidly decelerating G form in contrast to the H path taken by the populations as a whole.

By the 1750s, however, nuptuality,[24] total fertility, and infant mortality in Sweden (Tab. 5.1) began to move instead like these trends in France--decreasing over the long term in C fashion that targeted zero years a generation or two later than in France as French infant mortality improved sooner, but with the three trends comparably paralleling each other closely as far as about 1800. The Swedish population, meanwhile, expanded via a series of G-shape gains without showing the E form evident in contemporary England or, more briefly, in France following the Revolution.[25] The G-shape increase between 1748 and 1783 had its base year at 1706 much like the 1702 observed for the 1752-to-1792 gain in France. C-shape decline in the rate of marriage likewise appeared as population expanded, with t_0's at 1896 for France between 1742 and 1827 and at 1898 for Sweden from 1753 to 1838 (Fig. C.2; and marriages per female 20 to 50 in Fig. C.3a).

In Sweden, furthermore, it seems to have been the reproduction of young women that suffered particularly, since fertility for females 20 through 24 declined in appreciably steeper C fashion than the path of that shape for total fertility through the 1750s, 1760s, and early 1770s (Fig. 5.2). The ratio of fertility for women in their early twenties to total fertility generally contracted in C fashion between the middle of the 18th century and the middle of the 19th toward a zero year around 1900 even as fertility for females 20 through 24 itself rose in E form between the 1770s and the 1820s (t_0 about 1904, shows Fig. 5.2). Between the 1780s and the 1840s, meanwhile, the age-specific fertility of Swedish women in their early twenties fell relative to that for females in their later twenties along a C path with target year in the 1890s (Figs. 5.3, C.8).

The average age at first marriage for females in Sweden rose from the low it had reached in the vicinity of 1750, following the crisis of the early 1700s, to a new high around 1800 as real wages for agricultural workers (still the bulk of the labor force) dropped to a low about 1805 in the wake of a G' surge of improvement from 1750--or earlier--to about 1770 (Lundh 1999, 222, 226-27, 230). Another G' "boom" in farm wages from about 1810 through 1850 (peaking near 1833) probably produced decline in the mean age of first marriage for women to about 1830. Then, across the remainder of the 19th century, this average for Sweden as a whole fell back as real wages for agricultural labor improved in E fashion.

These Swedish trends in age of marriage differ from English long-term C, G, and E patterns for the percentage of women who wed under 20 or under 25, mean female age at first marriage, and length of reproductive span (Figs. 1.5; Wrigley et al 1997, 134) except for the E-type upward acceleration during the second half of the 19th century, movement that appeared in England from about 1780 to 1831 (or later). Is this an effect of later industrialization? While the best patterns for real wages in England across most of the 19th century are likely to be successive G trends, between 1850 and 1900 these approximate E movement not unlike that in Sweden (Fig. X.x). Before then, in contrast, no G' surge appears in England, as it does twice in

Sweden. In the province of East Flanders in Belgium, however, two G' "booms" in farm wages were followed by E increase, much as in Sweden:

England	East Flanders	Sweden
1730-1810 C or D	1706-1796 G' 1740	1750-1800 G' 1769
1800-1864 G	1796-1846 G' 1808	1810-1850 G' 1833
1864-1913 G	1847-1892 E 1893	1850-1900 E 1907

These patterns indicate, on the one hand, somewhat different social and demographic accompaniments to industrialization in the country where it originated than where such economic development was copied; on the other, some national lagging as such modernization diffused internationally. What comparisons or contrasts to these movements are to be found elsewhere, both within Europe and beyond it?

As in England, urbanization (again judging from Scandinavia as a whole) increased between 1700 and 1800 in E mode, like fertility for females 20 to 24 but more steeply--with target year much like that for the contemporary E urban trend in England (1834 vs. 1836). For the time being, until about 1880, in Sweden young fertility declined (Fig. C.8) roughly opposite to advancing urbanization, whereas in England it gained parallel with the proportion of people who lived in towns and cities.

The first major Swedish departure from the French experience, meanwhile, was the way the C trend in total fertility there stopped in the early 1800s, to be replaced by later and flatter C movement. In France, TFR and I_g followed M_i in C trends over the first half of the 19th century that targeted the 1870s. In Sweden, as the path for infant mortality remained on the same track that it had followed since the 1750s, total and marital fertility leveled out for the time being, assuming new C paths that aimed at zero years that would arrive only in the 1960s (Tab. 5.1). While C-type decline in marital fertility, in other words, seems to have begun to guide TFR in

Sweden only about half a century later than in France, around 1800 rather than 1750, it spread much more slowly, particularly before French marital and total fertility took up new, flatter C trajectories in the middle of the 19th century (in this period, somewhat before infant mortality set a new downward C course). The new French paths, with target years in the 1930s, were the kinds of track to which Swedish infant mortality and fertility finally shifted in the years around 1900, whereas the English population had assumed such patterns more in the middle 1800s--at the same time as the French, though starting at an appreciably higher level.

From the 1840s to World War II the population of Sweden expanded in H form, like the contemporary movement in England but somewhat more flatly,[26] as both countries could sustain robust only slowly slowing demographic growth in spite of falling fertility because both infant and later mortality declined sufficiently. The ratio of marriages to the number of women 20 through 44 in Sweden declined from the 1820s to the 1920s, clearly in D form from a base year around 1796 (Fig. 5.2), as the crude marriage rate also contracted along a rather different path into the 1890s or later (Fig. C.2). That D trend was very much the inverse of the G pattern for population growth in Sweden between 1823 and 1848 (Tab. 5.1), but kept on going for decades more as demographic increase shifted into an H trajectory.

One consequence of the failure of marriages to expand with the number of women was that during the 19th and early 20th centuries illegitimacy in Sweden rose substantially. Most precisely, the pattern was one of a series of G’ surges (the righthand panel of Fig. 5.3). Together, however, from the 1820s through the 1920s these movements tended to follow an underlying H path with base year in the 1750s, or parallel with the course of population growth for Sweden from the 1840s to the 1940s.

Fewer new marriages could produce more population in part because the proportion of women who wed under age 25 gained in G mode from the 1870s into the 1920s with zero year around 1818 (Fig. 2.3a). Nuptuality was apparently expanded by longer-lasting unions. By the 1840s, furthermore, fertility for Swedish females from 20 through 24 began to increase gradually in E shape on into the 1900s, even while total fertility fell via C as in England and France (Fig. 5.2; Tab. 5.1). This made the proportion of the TFR that was composed of the reproduction of women in their early twenties (Fig. 5.2) rise in H manner between 1883 and 1943 more steeply than the H-shape demographic expansion occurring between 1848 and 1943, though not quite as much as urbanization in Sweden between 1870 and 1940 (zero years at 1825, 1757, and 1842 respectively). Now in Sweden, young fertility rose with urbanization, whereas during the first half of the 19th century the trends had run opposite, with early reproduction falling in C fashion as urbanization increased via E. The frequency of divorce in Sweden, on the other hand, exploded upward between the 1850s and the 1920s along an E-shape course that, with target year around 1894, paralleled advance in urbanization as far as 1890.

Other European Societies: Figure 5.3 and Table 5.2 illustrate how some comparable trends for fertility occurred in other countries besides England, France, and Sweden before the later-19th-century era of quite general European transition. The evidence is only fragmentary. It serves, however, to illustrate the ways that in other populations movements tended to resemble in shape, if not always in timing or in combination, what is familiar from the three best-documented nations.

In Spain, marital fertility between 1768 and 1860 then between 1860 and 1910 contracted in C fashion much like the paths found in southwestern France across the Pyrenees between 1830 and 1870, then from 1870 to 1900, though in each phase several years later for Spain and at an appreciably higher level (Fig. 5.3 and Tab. 5.2; Fig. 5.1a). For Italy as a whole, on the other hand--and for Portugal as well (Fig. 4.1e)--there is some indication of a 1/G’ dip in I_g from the 1860s into the 1880s preceding C-shape declines targeting the 1950s which resembled, though at significantly higher levels, patterns in southwestern France after 1870 and in Normandy between 1820 and 1900. Both France then Denmark display a similar 1/G’ sag for a while in the middle of the 19th century.

In contrast, first Belgium then later the Netherlands experienced relatively short G' *bulges* in marital fertility in the 1800s preceding longer trends of this shape that lasted to the 1930s (Fig. 4.1a).[27] The latter, longer, transition-era G' movement was shared by Denmark (as well as England and Wales, Germany, Bohemia, Switzerland, Sweden, Norway, Finland, Austria, and Hungary) but not by France, Luxemburg, Spain, Portugal, probably Italy, or the countries of the Balkans and eastern Europe, summarizes Table 4.5.

Meanwhile, what is known of gross marital fertility ("GMF"--legitimate births per married woman) in northern Italy indicates C-shape decreases during the second half of the 19th century in Tuscany and Liguria (the left panel of Fig. 5.3; from Livi-Bacci 1977, 30) that closely resemble current movement for marital fertility in Spain and in southwestern France. The C trend between 1836 and 1881 in Piedmont, however, was noticeably flatter. It came down, instead, parallel with the declines of marital fertility in Spain, southwestern France, and Normandy after 1860, 1870, and 1820 respectively (Tab. 5.2).

The average number of children produced per lasting marriage ("CPM") in Tuscany, furthermore, shrank between 1822 and 1857 in C fashion just somewhat later than a comparable measure for southwestern France and Normandy leading up to about 1810 (Tab. 5.2, Figs. 5.3 and 5.1a). Then it declined, at least through the remainder of the 19th century, very much like marital fertility in Italy as a whole and in Portugal--or Spain, southwestern France, and Normandy.

Though blurred by 25-year moving averages, the decrease in number of children per marriage in the Spanish heartland of New Castile in C fashion between 1790 and 1810 (Tab. C.4, estimated from Livi Bacci and Reher 1993, 76) meanwhile very much resembled the decline in Normandy and southwestern France during that period (though it subsequently bulged in G' shape between 1820 and 1850 like the contemporary swelling of marital fertility in Belgium). Previously, family size in New Castile between 1700 and 1750 contracted in C shape parallel with such decrease in the southeast Paris basin between 1700 and 1810, then rose back in G form from 1750 through 1790 rather more flatly than gains of that shape for the number of children born to women who married in their early twenties in southwestern France and Normandy during the first half of the 1700s (Tab. 5.2).

Celibacy in New Castile between 1670 and 1790 similarly increased much like contemporary movement in France (Tab. C.4; Livi Bacci and Reher 1993, 71). Though rising not as much, and proceeding via one G trend rather than two, long-term increase and the shape of change through which it was achieved resembled the French experience, not the plummeting D then C declines of female celibacy in England during this era. Subsequent modest D-type reduction in failure to marry in New Castile between 1770 and 1820, however, ran counter to the direction of trends in France and in England--in spite of several years of occupation and nasty warfare. How might this decline have come about? Finally, from 1820 through 1860 celibacy in the heartland of Spain surged in G' fashion to crest around 1840. This movement resembles a possible G' lift in England from 1814 through 1844 during the long-term H-shape advance of the era of industrialization that began about 1760 (Fig. 1.5), but contrasts sharply with the post-Napoleonic decrease of celibacy for women of age to marry from 1815 through 1875 in France (Tab. C.4)

Still earlier, from the middle of the *17th* century to its end, children born per family in New Castile, the crude birth rate for that region, and the crude marriage rate all rose in G fashion not unlike gains in the marriage rate, nuptuality, the birth rate, and fertility in England with t_0's in the vicinity of 1600 (Livi-Bacci and Reher 1993, 76, 75; Tabs. 5.1 and C.4). Contributing to the gain in these rates for New Castile was the way that--assisted by decline in infant and childhood mortality (unlike the *rise* in infant mortality for England after 1640 and for all under 15 there between 1610 and 1680, shown in Tab. 1.4)--the proportion of babies living long enough to marry also swelled in G fashion, though by 1670 this change tended to push up the index of celibacy for women turning 25 (Tab. C.4). Each population was recovering from blows suffered earlier in that century from plague, other disease, and the consequences of war (Harris 2001, 157-58).

Prior to about 1640, in both New Castile and England fertility and infant mortality had fallen in parallel C fashion with target dates in the vicinity of 1700. The marriage rate declined and celibacy increased in each population, though in trends of different shapes, while survival to marriage age contracted in New Castile in D form along with CMR and opposite to the G path of the celibacy index. In both populations, reduced opportunities to marry depressed collective reproduction, thereby apparently making it easier for the fewer children who were born to survive (Tab. C.4).

Whereas, as noted, the number of children per family in New Castile tended to follow patterns of reproduction in regions of France from about 1700 into the 1800s, the crude birth rate did not mimic such movements. Instead, it leveled out in later stages of a protracted 1640-1880 G trend unlike either the successive C declines found in France and the long C tendency in Sweden or the E-shape increase followed by D-type contraction in England. The crude death rate, meanwhile, after resembling to about 1770 the C decline of 1752 to 1827 in France, took paths to 1880 that departed from patterns in all of the three best-documented European nations. In part this was because of a G' bulge culminating around 1804 that appeared in the era of French occupation and the bitter resistance that it engendered. Infant and childhood mortality in New Castile, meanwhile, returned to following the track of children per family between about 1750 and 1800 after a very weakened connection between about 1640 and 1750, though it then switched to move inversely after 1820. Its paths bear no resemblance to the patterns of the more general crude death rate--nor to contemporary trends for either infant mortality or CDR in England, France, or Sweden.

From the middle 1600s into the early 1800s change in celibacy approximately followed both the degree to which young residents of New Castile survived to marriage age, just the opposite of the inverse relationship to these two series from about 1580 to 1650. Then, during the first half of the 19th century movement in celibacy switched back again to countering, not following, survival (Tab. C.4).

In a later period, celibacy in England and Wales, Ireland, and probably Scotland seems from the later 1800s into the early 1900s to have increased in G form along with real wages for English workers (Anderson 1999, 75; Kennedy 1999, 92-93; Fig. X.x). In the Netherlands, from 1880 through 1920 celibacy perhaps comparably expanded with wages (if wage trends there were similar to the neighboring Belgian ones). In Flanders from the 1840s through the remainder of the 19th century, in contrast, the crude marriage rate accompanied wages--as had been the case since the 1720s (note 27), but via E trends (Devos 1999, 116; Fig. "D.2"). That the frequency of marriages tended to accompany both wages and rates of celibacy, or failure to marry, may seem counterintuitive. The type and amount of work open to women, the fact that wage series are typically for men, and the effects of enlarged proportions of the young in populations offer clues for explaining the apparent anomaly. Complicating, though perhaps in the end illuminating, the analysis, in Herstall in the faster-industrializing Ardennes at the eastern fringe of Belgium, for the hundred years after 1811 celibacy tended to rise and fall opposite to the pattern for Flanders (Gutmann 1991, 283; local wages not specified).

As noted, another significant regulator of reproduction in historical populations has been the typical age of females at first marriage. Alone, this measure changes so little proportionally that G-related patterns are often difficult to identify. The reproductive span for women, determined in combination with the age of mothers at birth of the last child, however, is trended insightfully in such terms.

In the Spanish town of Aranjuez, for example, from the early 1870s through 1923 the mean number of births ever born to women declined in C fashion toward a zero year in the vicinity of 1940 compared with C-type contraction having t_0 around 1944 in the average duration of reproduction for wives from 1873 through 1940 (Reher and Sanz-Gimeno 2007, 709, 711). Marital fertility, total fertility, infant mortality, and the crude birth rate for Spain all decreased along comparable C paths across the later 1800s and early 1900s (Tab. C.1). Earlier in New

Castile, in contrast, from 1820 to the 1850s children per marriage bulged in G' form along with the proportion of women who did not marry (peak years around 1843 and 1840: Tab. C.4). A rough estimate of reproductive span (based upon age of first marriage without allowance for stopping before the end of possible fertility) has indicated some curtailment, too, in England between the 1620s and the 1670s; but only about 7 percent compared with as much as 45 percent in more modern Aranjuez.

In Belgium during the second half of the 19th century, the average age at first marriage for females maximized about 1860, like total, marital, and extramarital fertility (Deprez 1979, 271, from É. van de Walle; Figs. 4.1a, 4.4b).[28] Meanwhile, the proportion who had never married by age 50 swelled in G' fashion to a peak near 1864, implying poorest opportunity for females of age to marry about 1836, or roughly contemporary to what was a low for fertility. Across the later 1800s and early 1900s, in contrast, age at first marriage contracted in C-type manner. If flatter because of the scale of this change, the trend accelerated downward along with the proportion never married, total fertility, marital fertility, and the crude birth rate--all of which accompanied C decline in infant mortality (ibid., 271, 269; Tab. C.1). In England and Wales and in Scotland, meanwhile, the average female age at first marriage rose progressively faster via E into the early 1900s--*opposite* to C-shape declines in fertility and infant mortality but along with E-form expansion in nuptuality (Anderson 1999, 76; Tab. C. 1). What allowed nuptuality to increase in these countries in the face of delay in marriage during decline in fertility, whereas in Spain female age at marriage and the proportion of women never married shrank along with fertility and the lessening infant mortality that drove it--and in Belgium nuptuality rose (in successive G paths) as the age of marriage and the measures of fertility fell?

Drawing upon evidence from the Belgian city of Leuven during the second half of 19th century, van Bavel (2004, 104-05) has argued that spacing between births (to handle current family pressures, not meet some ideal final total of surviving children) was present before modern fertility 'transition.' Then, during this phase, ending reproduction while still fertile replaced spacing as the mechanism of control. The English population does display some evidence of changing spacing in the 1600s and 1700s (Fig A.2). The much more recent Aranjuez data, however, show trends toward *both* later first birth and earlier last birth--in approximate E and C shapes respectively (Reher and Sanz-Gimeno 2007, 711).

In Flanders and Brabant from the 1630s to about 1800, late or early marriage for women tended to follow the ups and downs of wages for East Flanders (Fig. D.2). During this protoindustrial era, good conditions for work tended to delay marriage. Across the 19th century, in contrast, later marriage accompanied lows for wages. In the Ardennes, however, the highs and lows were approximately opposite to those in western Belgium (Devos 1999, 118-19). Similarly contrasting movement also appeared in Ulster, another European region better known for protoindustrial than for agricultural activity from the 1770s through the 1840s (Macafee 1997, 53). It would seem that the kind of work available, whether it was for the man or for the woman, and how the family calculated the costs or benefits of another child altered. Data from Germany across the later 1800s and early 1900s indicate that the proportion of females over 14 who were gainfully employed rose in H fashion approximately parallel with the pace of urbanization in the country (base years about 1860 and 1845: Knodel 1974, 226; Harris 2003, 271), trends which bear no obvious relationship to patterns of fertility between about 1870 and the 1930s (Tab. C.1).

Yet another factor regulating reproduction was the death with childbirth of still fertile mothers. In England, during most of the 17th century maternal mortality rose in E form *along with* urban, and to a lesser extent, rural wages--probably because of urbanization, particularly to deadly London. Then, into the 1700s wages rose again while between about 1662 and 1712 maternal mortality declined in C fashion. Further C-shape reduction in maternal mortality accompanied C decline in real wages from the 1730s to the 1810s--first to the 1760s along a path shared by France, then by another C trend while the French rate failed to improve further in the late 1700s and early 1800s (Wrigley et al. 1997, 236; Harris 2003, 187; Harris 1997, Tab. 12.1; Fig. X.x; Vandenbroeke 1991, 200). In contrast, for Flanders, Germany, and Sweden available evidence shows maternal mortality rising and falling in G' fashion--with highs accompanying low wages in all three countries in the middle of the 19th century, about 1780 or 1790 in Flanders and Sweden, and in the vicinity of 1710 in the earliest-reaching record for Flanders (Vandenbroeke 1991, 200; Lundh 1999, 230; Fig. D.x). What differences in employment and living conditions may have generated these distinctions?

In all, identifying the G-related trends involved in fertility, nuptuality, and mortality helps in understanding both the relationships of such movements to each other for particular populations during certain eras and similarities and differences in historical experience from one population to another. These national and regional insights can be expanded for earlier periods and for other societies within Europe by what has been learned from studies of elites and of some local populations.

INSIGHT FROM CERTAIN SOCIAL GROUPS IN EUROPE 1525-1875

Aggregate reduction of fertility and family limitation by couples within marriage both have an extended history in Europe before their broad dissemination across populations in the 19th century. Understanding how reproduction changed during the long but mostly thinly and unsystematically documented pre-transition period is advanced by work that historical investigators have done over the past half century with two kinds of sub-groups within populations, elites and local communities.

To begin, there is evidence that as soon as the 16th century fertility generally started to fall in certain European elites, and that by the 17th century among these special groups family limitation of some consequence began to appear as a mechanism for reducing reproduction. To what extent did these 'forerunner' movements in fertility, and in the way in which it was controlled, resemble the forms observed for such demographic phenomena during the modern era of more widespread fertility transition? And what does that comparison of early and later eras do to confirm or to revise our evolving understanding of how G-related patterns permeate change in populations?

Table 5.3 presents what appear to be likely or possible ("?") G-related trends in the size of families among several different European elites (as collated by Livi Bacci 1986, 185-86). The curves are fitted to average numbers of children born to women who married by age 20 (technically, the total of age-specific fertility rates from age 20 through 50, or $TLFR_{20}$). Mostly, movements for women age 25 to 50 ($TLFR_{25}$) follow these trends.[29] For many periods only what *might* have been a G-related trend between two points in time can be suggested. Support for these tentative propositions, however, is frequently provided by other demographic information that is available for the society in question. In the table, these congruent trendings are presented in italics.

Some of the earliest elite evidence indicates fertility increase in quite flat G form for the ruling families of Europe between 1525 and 1625 (also perhaps rather more steeply and at a higher level for the bourgeoisie of Geneva between 1575 and 1625). Comparable G-type rise before C-form decline has also been encountered in TFR and I_g across the first half of the 1700s for the *general* populations of Normandy and southwestern France (Fig. 5.1a) and for children per family in New Castile from 1640 through 1700 (Tab. C.4), while overall fertility for the English population climbed in similar G fashion between 1663 and 1723 (Fig. 1.4) only to be followed by further, now accelerating, increase across the remainder of the 18th century.

For most documented elites, however, family size came down, and down again, in C-shaped fashion from the 16th to the 19th centuries. In the timing of these C trends, among the first observed patterns for reducing fertility, the leading families of Genoa, the British peerage, and Geneva's bourgeoisie led the way, having zero years for their fitted curves targeted between 1687 and 1700.[30] The level of the curve of declining reproduction in the British peerage was just barely higher than the Genoese one while that in Geneva was almost half again as high.

At first one might ask what coincidence made the leading families of Britain during the second half of the 16th century and the first half of the 17th behave the same way demographically as those of more neighboring Geneva and Genoa. The quinquennially calculated gross reproduction rate for England from 1556 through 1661, however, declined in C shape with base year at 1701 (Fig. 1.1 in Ch. 1, from Wrigley and Schofield 1981, 528-29). Meanwhile, children per family in New Castile decreased during the first half of the 1600s along a C path that targeted about 1688 (Tab. C.4). Scattered pieces of international evidence support each other. Fertility decline in this form and timing, in other words, may well have been quite common within western Europe during this era, and not just for elites. What could have brought that about? Simply local interpretation for this pattern of early modern demographic change does not seem adequate.

Among five recorded elites, then, from the second or third quarter of the 1600s forward family size, according to Table 5.3, may have fallen off in C form with t_0 between 1735 and 1766. The aristocracy of Milan began such decline from a level that between 1625 and 1675 closely resembles the starting point for Geneva's bourgeoisie at the start of downward movement there in the first decades of the 1600s--9.47 total births vs. 9.42 (Livi Bacci 1986, 185). Even with a second possible C decline in Milan following between 1675 and 1725, nonetheless, the Geneva trend ran lower; and the elite of Genoa produced fewer children still. By the end of this phase of reduction, though, it was the families of French dukes and peers that contained the least offspring of all.

Once again, much of the thinly supported trending that is hypothesized for these movements is reinforced by other regional information whose data are available more frequently than the every-half-century or so averaging that is typical for small elites. From 1662 through 1714 completed family size in Geneva as a whole (Perrenoud 1990, 247; Harris 2003, 204, 207) came down in a C trend with t_0 at 1762 with about the same height as at the corresponding zero year of 1756 for the 1675 through 1725 evidence for the bourgeoisie alone. In Rouen (ibid.), meanwhile, the citywide C trend for the period from 1655 through 1715 with its t_0 at 1755, though considerably higher, declined almost exactly parallel with the family size of French dukes and peers from 1675 to 1750. The national elite both started and ended with fewer children, which suggests that prior to 1675 reduction in the French peerage took place for which there is no record, a decrease that perhaps resembled observed decline for the British elite from the second half of the 1500s into the first half of the 1600s. The families of men in Rouen who had non-manual occupations, furthermore, shrank earlier in C fashion (Bardet 1990, 274). From 1680 through 1720 their eventual number of offspring atrophied along a curve that targeted 1743.[31] This makes their decline resemble those for elites in Milan and Genoa across the 17th century (technically, 1600-49 to 1650-99) somewhat more than the trend for French dukes and peers from 1650-99 to 1700-99.

From 1575 through 1675, reproduction in the families of British peers in which the women had married only after reaching age 25 atrophied this way, too. But for the wives of peers who had been wed by 20, the second C pattern of reduction in the number of children instead ran from 1625 through 1725 with t_0 at 1791 (even as marital fertility for the English population at large stayed flat and TFR enlarged in G shape, shows Tab. 5.1). While a little later and flatter than the trend for Europe's ruling families over the same 100 years, this movement for the British peerage paralleled contemporaneous decline in fertility for the elite of Florence between 1650 and 1725. Though based upon the evidence of just two dates, that suggested trend would almost exactly parallel the more amply documented decline from 1681 through 1763 in the *birth rate* for the Jewish community within this city that has been identified (Fig. 2.2g and Tab. 2.3a (Livi Bacci 1977, 42; 1986, 191).

Possibly taking a somewhat later C pattern of reduction, into the 18th century family size for the elites in Genoa and Milan declined further, apparently headed toward t_0's in the early 1800s. The birth rate for the Jewish community in the nearby city of Leghorn, however, from 1713 through 1788 atrophied via a C path with zero year at 1828 (ibid.), while in Geneva, whose fertility decline had paralleled that for Milan between 1675 and 1725, from 1747 through 1805 (the right side of Tab. 5.3) family size now shrank in C fashion with t_0 at 1820--as did the number of children per woman married by 20 in Rouen between 1715 and 1774 (Perrenoud 1990, 247; Harris 2003, 204, 207). The thin, only suggestive data from the elites of Genoa and Milan, in other words, nest in a congruent environment of fertility change from Leghorn to Geneva, and resemble developments in distant Rouen--contemporary cases which all offer more ample documentation of an international patterning and timing of change. Then, in a still later cluster of C-shaped declines, from the early into the later 1700s the typical family size of the Florentine elite, the rulers of Europe, and the Belgian aristocracy all shrank toward a zero year that would have arrived around the middle of the 19th century (the bottom of the left-hand section of Tab. 5.3). These movements resemble the contracting C paths of children per family in New Castile between 1700 and 1750 and again from 1790 to 1810 (Tab. C.4), and also the fall of TFR in France from 1742 through 1807 (Tab. 5.1). All contrast cleanly with a contemporaneous oppositely rising E pattern for fertility in England between 1726 and 1806. The historical reasons for all patterns can best be explored within this broader international context for changes in European fertility, which includes both elites and ordinary people.

Totally different during this period was movement in the number of children for the British peerage between 1725 and 1775. This *rose*. To posit that it did so in E form based upon just two dates that have evidence (as at the top of the right-hand section of Tab. 5.3) may at first seem unjustified. Starting from 1675, however, family size for such elite women who had been married only after reaching 25 similarly increased over a 100-year period (across three rather than two points of estimation) via that accelerating "relative" of the G curve toward a zero year also around 1833. For the English population at large, furthermore, the gross reproduction rate clearly did climb in E form between 1726 and 1816 toward a t_0 at 1851--as from 1718 through 1808 I_f rose in the same shape of trend toward 1855 (Tab. 5.1). Unlike the English case, the suggestion that increase in family size for the elite of Milan, though appreciably later in timing, rose between 1775 and 1825 in E rather than some other manner is at present only speculative.[32]

Among the families of Geneva's bourgeoisie, for some reason--perhaps just because of the only very broad time segments recorded--family size between 1775 and 1825 declined via an appreciably later, flatter C path than Perrenoud's calculations (1990, 247) for the general population of that Swiss city from 1747 through 1805 (t_0 possibly at 1863 rather than 1820). Across the century from 1775 through 1875, meanwhile, the British peerage returned to reducing reproduction via a still later C pattern. While the suggested 19th-century trend for Milan's aristocracy is based upon just two points in time, 1825 and 1875, its possible zero year at 1902 conforms with those for the C declines of birth rate for the Jewish populations of several northern Italian cities in this era (Livi Bacci 1986, 191): the average for Modena and Verona from 1788 through 1886 (1905); Padua from 1839 to 1905 (1904); Florence from 1788 through 1843; and Leghorn first between 1788 and 1818 (1905) then, rather more steeply, from 1823 to 1848 (1886).[33]

Flatter and later still was the 19th-century C-shape decline in the size of the ruling families of Europe. In their particular institutional context, of course, it was especially important to ensure a male heir who attained maturity. In Geneva's bourgeoisie, finally, average family size increased somewhat between the first half of the 19th century and the second. For women married by the age of 20 an E curve with zero year at 1966 would fit the two data points; for those married only by 25 the steeper E curve would have a t_0 more like 1939. During the late 1800s and first years of the 1900s demographic growth in the Canton of Solothurn, in western Switzerland at the other end of the Jura Mountains from Geneva, expanded in E fashion toward a zero year in the 1930s (Harris 2001, 335) as did the population of all Switzerland between 1880 and 1910 (ibid., 148, 163), perhaps signaling that reproduction was increasing in this manner broadly within Swiss society as well as for the infrequently documented Geneva elite.

In all, Table 5.3 offers a rather more organized and insightful framework for making comparisons and contrasts than has been previously available concerning how, beginning in the 1500s, family size came down among certain special subgroups in the population of Europe before the fertility transition became a widespread phenomenon. Successive G-based trends, particularly C, dominated the shape of this type of demographic change for these ‘social-group forerunners’ as much as they did among nationwide fertility developments in Europe in more modern times beginning in the middle 1800s.

For some of these distinctive groups of families the Coale-Trussell index of fertility control, *m*, is available. For the elites of Milan and Florence two versions have been calculated, one by Livi Bacci (1986, 185-86) and the other by Guliano Pinto and Eugenio Sonnino (1997, 504). Both are graphed in Figure 5.4 and summarized in Table 5.4 without trying to determine just how the differences appear.

For Milan, the calculations of Livi Bacci for 1625 through 1725 closely fit a G pattern with a t_0 value of .340 at 1636. This curve, Figure 5.5 indicates, perhaps applied across the next 100 years as well. Equally tight, however, is the way the alternative computations of Pinto and Sonnino from 1625 through 1725 (the solid triangles) hug an appreciably later G trend with its zero year at 1663 and a higher level of .456, though a projection of this curve (fitted to bears little relationship to the subsequent calculations of Livi Bacci for 1775 through 1875. In the end, while both the timing and the level of the analyses differ, the expansion of fertility control in either case took G shape. At issue are just when and how far this behavior developed, not the form that the change took through time.

For the elite of Florence, the alternative computations of *m* by Livi Bacci and Pinto and Sonnino hold closer to each other. While each calculation relies upon just two data points, the timing of G-shape change that they would fit is nearly the same (t_0 at 1629 vs. 1622). The level via Livi Bacci is just a little lower. These two calculations, furthermore, approach the 1636 zero year for Milan according to Livi Bacci, suggesting that across northern Italy fertility control in urban elites spread quite simultaneously. This impression is furthered by the way that for Genoa’s leading families *m* from 1625 through 1737 rose at least approximately in G form with zero year around 1630. While calculation at 1675 is rather high for such a fit, the interpretation seems to be strengthened that urban elites in northern Italy began to control their fertility in a fairly common timing as well as in a shared G shape of trend.

In somewhat later movements, the families of Geneva's bourgeoisie, on the one hand, and French dukes and peers, on the other, also seem to have taken up managing their fertility in G form. In the Swiss city, the fit is quite clear and may have continued into the 1800s, depending upon how stable the widely spaced computations are. For the elite of France, evidence exists only at 1675 and 1750 (for the periods 1650-1699 and 1700-1799); but the G curve that would fit this information has its t_0 around 1663 compared with the 1653 of Geneva. It would seem that in these two neighboring francophone societies fertility control in the elite progressed in generally the same way as, about a generation earlier, it had evolved among the cities of northern Italy. Did the Medici connection of the French royal family introduce more than just forks to enliven French culture?

The Belgian aristocracy, finally, moved tentatively toward fertility control between 1715 and 1790--perhaps in G fashion with zero year around 1727. While this movement roughly parallels a second upward trend in Florence between 1725 and 1775 (with t_0 at 1718 according to Livi Bacci and 1701 via Pinto and Sonnino), the *level* was less than one quarter of what was current in the Tuscan capitol. By the first half of the 19th century, however, at least the industrial families of Ghent were appreciably further along in their management of fertility (m = .656 compared with .422 for the Belgian aristocracy at 1790). By then, however, the index reached as much as 1.794 for the elite of Florence during the second half of the 1700s, 1.537 for the families of French dukes and peers, 1.003 in Milan's aristocracy, and from .976 to 1.380 among the bourgeoisie of Geneva). Unfortunately m appears to be unknown for the British peerage. The offered trendings, nonetheless, besides suggesting a universality for how fertility control disseminated in G form, illuminate further the way that the conscious reduction of reproduction spread across Europe.

As noted, generally speaking women who married earlier in the end had more children than those who married later. Before fertility control became widespread, delayed nuptials did most to bring or to keep fertility in marriage down. For the special groups whose particulars have been collated by Livi Bacci, detailed age-specific information is not available. It is possible from what is known, however, to pattern the ratio of the sum of fertility rates from 25 to 50 relative to the sum for females 20 to 50. While $TLFR_{25}$ and $TLFR_{20}$, as these are labeled, each repeatedly bend downwards in relatively similar C form, some difference due to the not quite simultaneous timing of these paired curves generates a characteristic pattern. The trend for the ratio of $TLFR_{25}$ to $TLFR_{20}$ offers some evidence of the relative significance of younger as opposed to older mothers in the reproduction of the ‘forerunner’ groups studied.

As fertility control (*m*) spread via G during the 1600s and 1700s in the elites of Milan, Florence, Genoa, Geneva, France, and Belgium, the ratio of fertility for females after 25 to those after 20 contracted in roughly opposite D trends. Reproduction among women over 25 became relatively less important as elite fertility as a whole declined in C fashion. Among British aristocrats, in contrast, the $TLFR_{25}/TFLR_{20}$ ratio increased in approximate G form opposite--for example--to the path for French dukes and peers. The reason may be that the British practiced primogeniture, and established ways of productively placing younger sons without dividing land. E-type increase for the ratio in the British aristocracy between about 1725 and 1825 then roughly paralleled fertility gains for the population as a whole, a shape of path followed by the ratio in the business-based bourgeoisie of Geneva[34] though not in other later elite populations. The *level* of the British ratio--like the national birth rate to 1750 or later (Tab. B.2a)--was until the 18th century *lower* in England than in France (and in Italy and Switzerland).

Through several perspectives, from the 1600s forward change in fertility and its control passed through early modern elites of Europe in G-related forms. Often these movements appear to be not so different from trends for fertility in general populations. What might have continually, and apparently ubiquitously, filtered or guided the historical development of reproduction--from total children produced to fertility control within marriage to the ages of mothers at which children were borne--into such repeated patterns?

FURTHER EVIDENCE FROM LOCAL DEMOGRAPHIC EXPERIENCE: SOCIAL CLASS, COMMUNITY TYPE, AND CULTURAL SETTING

Selected local evidence helps fill out the picture of how G-related trends characterized many aspects of fertility and its concomitants in European history. It also expands an understanding of the ways that these movements unfolded internationally across social, cultural, and economic contexts that contained both similarities and differences.

The issue has already been raised as to what the demographic experience of elites did or did not share with the lives of more ordinary people. Certain patterns for such unusual families have been compared with those for total populations. In assessing similarities and differences among social groups this way, it is important to keep in mind that basic methods for controlling fertility were simple and long-known. These actions, though imperfect, even accounted for much of the reduction in births that occured on a large scale during the modern fertility transition of the 19th and early 20th centuries in Europe (Coale 1986,). The differences between earlier and later eras lay principally in how many people used them, in an expansion of motivations for applying them.

To begin, reducing reproduction was clearly not just a prerogative of elites. Figure 5.5 demonstrates how the wives of manual workers in Rouen who were married from 1680 through 1780 lowered family size in C form with t_0 at 1817. First, though, it was the non-manual couples of the city who began to curb their initially larger families between 1680 and 1720. Subsequently, as far as the Revolution further reductions during the 18th century for manual and non-manual households tended to be parallel.

A limitation upon any case for diffusion outward from Rouen (and, by implication, still larger central places) to less urbanized locations is that data so far are not offered that allow comparison of other communities studied with Rouen's *first* recorded C-shape decline in completed fertility, embracing marriages from 1655 through 1715 with zero year at 1755. For Normandy in general, however, from 1750 through 1790 completed family size for women married age 20 through 24 declined via a C trend with t_0 near 1819 (Fig. 5.1a). That matches later contemporaneous movement in Rouen (Perrenoud 1990, 247, and Harris 2003, 204, 207, for 1715-1774; Perrenoud 1990, 249, and Fig. 5.5 for 1720-1780). By this point in time, the capitol cannot be said to be significantly leading the region. Earlier, in contrast, while from 1655 through 1715 completed family size in Rouen came down in C fashion with zero year at 1755, the available evidence for Normandy as a whole displays first some substantial G-shape *increase* in the number of children from 1700 though 1730, then C-form decline from 1730 through 1750 that targets the 1790s rather than the 1750s. Thus, the central place first experienced C-type decline in family size even as the region as a whole saw enlargement in G shape. Then the C trend for the region came down more slowly than that of its capital city. Finally, during the second half of the 18th century, further decreases in Rouen and for Normandy in general tended to unfold in parallel form (though at a lower level in the capital city because of earlier reduction). The evidence, in other words, suggests that any 'forerunner' role for the city had been played out by the middle of the 1700s.

Family sizes in Vexin and in Meulan (nearest to Paris) at the end of the 17th century are noticeably lower than what is evident in Rouen, though Rouen subsequently exceeded or matched these communities in reducing fertility (Bardet 1990, 267-68; Table 5.5). Had lower levels been endemic in the socioeconomic and demographic life of these communities for generations? Or do these numbers reflect previous trends of change across the later 1600s of the sort observed for Rouen? Meanwhile, that on the other side of the Paris basin (southeast, as opposed to northwest down the Seine toward Normandy) completed family size for women married 20 through 24 ran appreciably higher than in Normandy in general or in the towns of Vexin and Meulan. The *trend*, however, from 1750 (perhaps as early as 1700) to 1810 took C form with t_0 around 1849, or generally parallel with such movements for Barentin from 1760 through 1800 (1854) and for three villages near Rouen from 1720 through 1800 (1842). So far the evidence from the higher region in the Seine watershed, whose family size in general started, and for most of the 18th century stayed, above that in Normandy, resembles closely the shape and timing of change that was taking place in the lagging communities as yet documented within Normandy (Tab. 5.5). For what kinds of populations do records exist from the southeast portion of the Paris basin, and how were their movements and levels perhaps related to what was happening in the national capitol?

Table 5.5 adds estimated trendings for some of the regional and local series for overall fertility that French historical demographers have provided (Bardet 1988, 355-58).[35] In all, successive C-shape waves of fertility decline seem to have spread across many kinds of local and regional populations in France both before and during the general European period of fertility transition. Earliest, Rouen pairs up in change of completed family size across the second half of the 17th century and the first years of the 18th with the culturally French Swiss city of Geneva. The findings for the middle era (roughly the 18th century), which appear in the central column, involve C trends whose t_0's successively cluster around 1816 (including second contractions in Rouen and Geneva), 1838, and 1851. Some groupings of likely patterns after 1800 appear in the rightmost section of the table. In all, from about 1650 through 1850 repeated C-shape contractions in family size appeared across regions and communities all over France and in Francophone Switzerland, producing the early fertility reduction for which French culture is historically noted.

Local information also reveals more about when during the course of their lives women bore children. In Geneva, from the later 1600s into the 1720s the number of children eventually produced by women who had married at all fertile age levels declined in closely parallel fashion. The t_0's for all the C curves of this era cluster in the 1760s and 1770s.[36] While the levels for the various nuptial cohorts verify the familiar fact that, historically, the later a woman married the fewer children she bore in the end,[37] females who married at all ages experienced proportional reduction in fertility together. Subsequently, in contrast, across the remainder of the 18th century the *younger* the age of marriage the stronger the drop (the earlier the zero year) for the C trends of decline; and Genevan women married past their 35th birthday display no further reduction at all between the 1740s and the 1800s.

Looking at the impact of duration of marriage another way (Perenoud 1990, 253), the number of children born to women in Geneva from the 10th through the 20th anniversary of their unions[38] over the era from the 1600s into the 1700s tended, it is estimated, to decline in C fashion toward a zero year around 1740. The flatter C trend of shrinking reproduction during years 5 through 9, had its t_0 rather later, in the 1770s. The number of children borne in the first 5 years of marriage, meanwhile, actually *rose* slightly in G form between 1635 and 1726. Only from 1726 through 1805 did births during these first years of unions come down via C (with zero year around 1832). Over the latter part of the 18th century, then, the progeny of women in the 6th through 10th year of marriage atrophied along a second C path with t_0 around 1812, and the still later years of wedlock also produced fewer children in new fertility decline (though shifts around 1750 and 1770 keep the movements for 11 through 15 and 16 through 20 from taking C shape).

Adding to the insight from Geneva is the way that the average age at which women who had married between 15 and 30 gave birth to their *last* child became progressively younger--in two successive C trends, from 1635 through 1702, then from 1726 through 1805 (ibid., 254). The first decline carried the mean age down from 40 to 36, the second from 36 to 32, with estimated t_0's in the vicinity of 1770 and 1867 (as for time married, graphed but not shown). Having fewer children late in marriage typically characterizes conscious family limitation. Contrary to the speculation of Van Bavel (2004, 105) about ‘fertility transition,’ based upon Belgian Leuven for the 19th century, the women of Geneva were apparently ‘stopping’ reproduction already in the 17th and 18th centuries.

Across the 17th century, meanwhile, marriage before 20 and before 25 became less frequent among the women of Geneva (ibid. 249). The percentages fell in C form from 1635 through 1702 with zero years in the vicinity of 1713 and 1723 respectively, it is estimated. Marriage at age 30 or over, furthermore, became *more* common. Before the 1700s, in Geneva at least part of the observed reduction in fertility still came from more delayed marriage, the main mechanism of family control considered to have been predominant before the modern transition. Then, in the 18th century, the proportion of women marrying young increased: among weddings from 1702 through 1771 for those under 20 via a G path with t_0 near 1670; for marriages of 1747 through 1805 for all under 25 in the same shape of curve based around 1695. Spreading practices of family limitation now allowed women to wed young without the consequences of having more children.

At each of four successive stages of reproductive life, age-specific fertility for the women of Geneva declined in C form from the middle of the 1600s into the early 1700s shows Figure 5.7 for mothers age 25 and older.[39] The younger are the women who are being considered, the later-timed and flatter become the curves. For women 20 through 24, meanwhile, little change is evident: a very gradual C pattern from 1635 through 1805 that targets only 1845--alternatively, perhaps even slight G-shape increase occurred from 1662 through 1726; and for those 15 through 19, E-shape gain in fertility probably occurred between 1662 and 1702 (graphed but not presented). Then, from the first part of the 1700s across the 18th century as far as 1805, age-specific fertility for all four groups age 25 or more once again declined in C form. Now, as Figure 5.7 shows, the trends from the oldest to the youngest women covered became more parallel than they had been in the 1600s. The zero years for the curves, that is, line up more perpendicularly between about 1790 and 1815 rather than spreading out all the way from about

1700 to 1790 as they had done during the previous phase of fertility reduction. For women 20 through 24 the C pattern (not shown) was rather later, with t_0 only at 1845.What cause of reproductive decline was in Geneva more connected with the current age of women in the 17th century than it was in the 18th? Or does the shift in comparative patterning among age groups signal that the mechanism(s) controlling family size had fundamentally changed?

From the 1600s into the early 1700s C-shape decline in age-specific fertility for Geneva compares broadly with the general nature and timing of trends for the elites of Florence and Milan across the Alps (Pinto and Sonino 1997, 504). All four age groups from 25 through 44 could have followed quite parallel C patterns, though the *levels* for just the leading families within the cities of northern Italy (especially Florence) were low from start to finish compared with those for the more diverse general population of Geneva. In Milan for women 40 through 44 and for Milan and Florence together for those 35 through 39, the fertility rate came down via possible C trends to around 1720 compared with an average near 1715 for these two age groups in Geneva.[40] For those aged 25 through 34, potential C patterns would have t_0's clustered around 1770 both for the two Italian elites and for the general population of Geneva. The analysis can only be rough because of the paucity of evidence; but declines of age-specific fertility across these three cities from the 1600s into the early 1700s seem to be mostly parallel.

Table 5.6 presents some less urban local French comparisons with the age-specific fertility declines of Geneva during the next phase of reducing reproduction, across the later 1700s and early 1800s (Lachiver 1973, 390).[41] Some of the estimated fittings are quite rough; the notes identify data-points that lie off the proposed curve or that have been averaged to obtain a sense of where the underlying trend seems to lie. On the whole, however, the patterns very much resemble those of Geneva: C-shape decline is likely or possible for all age groups; with few exceptions (most in Donnemarie), older women experienced earlier and therefore contemporaneously steeper C-type reductions in fertility; and the timings of these trends are closely comparable age group by age group. In short, from rural parishes to significant towns and right across the Paris Basin age-specific fertility declined as it did in Geneva--hundreds of miles away. What might have made fertility reductions across the life cycle take such similar C shapes in so many and such different places?

Using the evidence from Geneva to represent this whole cluster of francophone communities, Table 5.7 displays comparisons and contrasts in age-specific fertility during successive eras between the 1600s and the 1900s for several European societies or groups of communities within them.

In the 17th century, first of all, women from 20 through 44 in England as well as Geneva experienced fertility decline in C form. Only English females in their weakly reproductive later 40s, a group not documented for Geneva, had more children with time. In fact, for women 20 through 34 the C contractions into the 1660s or later were steeper (had earlier t_0's) in *England*; and all followed lower paths (targeting 0.05 to 0.15 at their zero years rather than 0.08 to 0.19 even at later dates). Young females 15 through 19 in England, meanwhile, also experienced less fertility this way while in Geneva they gave birth *more* frequently (via E across the later years of the century). In short, from 1600 through 1675 or so (across blocks of 25 years centered from 1612 to 1662) age-specific marital fertility declined even more markedly in England than it did in Geneva between the 1620s and the early 1700s, whose women have long been regarded as a historical leaders in fertility control. In England, too, the reduction was noticeably steeper for wives 25 and over than for younger women, though consistent progression from older to younger groups, step by step, was more evident in Geneva.

The demographic crisis that trimmed the population of England between 1656 and 1686 thanks to an upwardly accelerating death rate, and to consequences in fertility from Civil War disruptions and from having exported so many young persons overseas, terminated this international parallelism of the earlier decades of the 17th century. While the observed C-shape declines in marital fertility for the women of Geneva continued into the early 1700s, as of the 1660s or so, *gains* in marital fertility appeared for each category of English women--in G fashion for most groups, via E for those 25 through 29 and 15 through 19. Women in their 40s experienced stronger G advances than younger wives. All ages responded with increasing fertility to the temporary easing of demographic pressure.

From the early or middle 1700s into the early 1800s, age-specific fertility can be followed in several European populations. Table 5.7 adds to the continuing evidence of England and Geneva information from Sweden, several German villages, and both Protestant and Catholic communities of the Transdanubian region of Hungary (Knodel 1986, 358; Andorka 1979, 17, 21). Figure 5.8 graphs the German trends.

In Geneva, another wave of C-shape declines, still from age 25 upward somewhat steeper with each successive older group of women, reduced fertility even further. Close parallels with this patterning and its timing appear in many French locations (Tab. 5.6). In the Catholic communities of Hungary (Bakonya and Töttös), slightly later, but comparably age-related decreases occurred. Whereas for their four Calvinist Protestant counterparts (Vajszló and Besence, Alsónyék, and Sárpilis) data are mostly available at only two dates, similar C trends would be appropriate for the information that is known (Andorka 1979, 17, 21).[42] The *levels* to which fertility was being reduced in Transdanubia, furthermore, matched the age-specific rates targeted some two decades before by the Geneva patterns. Since the Hungarian trends started out at about the same levels achieved in Geneva by the later 1700s, however, had the kind of *prior* reduction observed in that city from the 1600s into the 1700s also occurred in southern Transdanubia? In the German villages, meanwhile, C patterns progressively delayed at younger ages also appear. This whole set of curves, however, is timed appreciably later than in Hungary and Geneva; and the levels even then run appreciably higher. Rural German wives 15 through 24, furthermore, meanwhile tended over time to have *more* children along G-shaped paths.

Subsequently, from the early 1800s to the end of the century, total fertility in the Protestant communities of the Transdanubia region[43] declined once more in C fashion. Now, however, while the cohorts from 25 through 39 followed such pattern, fertility among women 40 to 44 for some reason rose modestly; and among those 15 though 24, the decline took D rather than C form. For 200 farm families on Funen, the fertile southernmost major island of Denmark, meanwhile, data available for several years around 1790 and then in the vicinity of 1840 (Johansen 1991, 184) suggest that marital fertility for women in the three age-groups above 35 all declined in C form with t_0's in the vicinity of 1880. That makes them come down roughly in timing with the 25 through 39 cohorts in the Protestant communities of Transdanubia in Table 5.7. The levels are higher, however--signaling perhaps that, unlike the Hungarian experience, no previous phase of fertility reduction had occurred. Among younger age groups from 20 through 34, furthermore, the Danish rates on average appear to be flat, with the index for females 15 through 19 even rising significantly. Below age 35, in other words, the changes in age-specific fertility in Funen may be more like those of Knodel's villages in Germany.

These very local movements, because of their thin base of evidence, need further exploration. They would seem, however, to offer some insights that are worth following through into how during the early modern era fertility reduction diffused down the age ladder and across various areas of Europe.

Swedish women in all age categories, meanwhile, display C-type decreases in marital fertility from the 1750s, where the records begin, into the 1770s or 1780s (Fig. C.8 in App. C). Overall, the timing of these resembles those for Geneva and the communities of France. Age by age, however, above 19 it was *younger* Swedish women for whom the trends were steepest, just the reverse of what has been found in Geneva, France, Germany, Hungary--and in England before the 1660s. How did that inverted tendency appear; and what were the consequences of the difference? Then, in the vicinity of 1770 or 1780 fertility *increased* into the 19th century for Swedish wives from 20 through 44. For those 20 through 34, the advances took E shape; for women 35 through 44, the pattern was G.

In England, where such a switch from contraction to expansion in age-specific marital fertility had occurred a century before, women in their 30s display from the 1730s to the 1780s

C-shape declines that sit about halfway in timing between the trends in Hungary and the ones for German villages. Females in their later 40s also had C-type movement--but comparatively late and flat for this age bracket. Elsewhere in the reproductive life cycle, however, new trends of *increase* appear. These take E form for wives 25 through 29 and 15 through 19. Such movement, if rather stronger (with earlier zero year in the 1850s), characterizes the rise of English fertility in general between the 1720s and the 1810s--and also the expansion of the English population in this period (Tab. 5.1). It also resembles E trends for younger Swedish wives from the 1770s or so into the 19th century, though no such E-type increase in overall fertility or population emerged in that Scandinavian country. For some reason, however, among English women between their 20th and 25th and 40th and 45th birthdays increases followed G paths--a pattern found, though more steeply, for Swedish wives between 35 and 45 and for German women under 30. What are the origins and the implications of these two different, accelerating and decelerating patterns of increase in fertility, E and G, while the populations of Geneva, many French communities, and both Catholic and Protestant Hungarian villages consistently experienced C-shape age-specific fertility decline?

Later in the 19th century, C-type decreases reappeared in Swedish age-specific marital fertility. Unlike the years before the 1780s, at least among women over 24 older groups now had earlier and steeper declines than younger ones. Wives 15 through 24, however, display new E trends of increase. In the German villages, meanwhile, 19th-century women who had reached their 30th birthday similarly experienced C-form contraction in fertility whose steepness increased with age even as age-specific reproduction for younger females gained--here in G fashion. For Protestant women in Hungary, in contrast, while there was also a difference in pattern above and below 25, the C trends for older wives were more simultaneous than sequenced and young wives also display decline in fertility--but in D shape rather than C.

In Herstal, a community in the eastern Belgian province of Liège, from about 1850 to 1910 fertility for all ages of wives tended to contract in C form (Leboutte 1991, 285). For those

25 and older, these C patterns are only slightly earlier and steeper than those found for Sweden during the same period (Fig. C.8). For those 20 through 24, however, the Herstal trend was also C--in contrast to the Swedish E. On the other hand, the reversions from flatter to steeper C paths for women of Herstal in their 30s closely presages somewhat later transitions of this regressive type in Sweden for several age groups in the first years of the 1900.

Meanwhile, as of 1848 the population of Sweden began to expand in H form--approximately as in England. That of Germany enlarged this way from 1816 through 1864, then reverted to E-type increase. The people of Denmark, on the other hand, multiplied most like expansion in England between about 1730 and 1890, via E to 1801 and in H fashion twice thereafter (as did the Belgian population in the 19th century. Demographic growth in Hungary, however, from 1817 through 1880 followed a more strongly decelerating G path that largely resembled the closely curbed growth of France from 1826 forward (Harris 2001, 148-49). In the 1800s as in earlier eras, the age-specific behavior of fertility seems not only to demonstrate further the pervasiveness of G-related trends in many types of demographic change but also to provide useful clues as to what made the experience of one population resemble or differ from another.

How older married women tended to reduce fertility sooner and more sharply than younger ones is one tool for identifying dissemination of conscious family limitation among couples. The issues are complicated, however. They involve both ‘spacing’ of births, which slows the accumulation of children down, and ‘stopping,’ acting to see that more babies do not appear. Various measurements employed for estimating fertility control have weaknesses (Ewbank 1993). The evidence of Coale’s ‘*m*’, which has been used widely with historical data, serves nonetheless to suggest the relevance of G-based patterning--in this case, mostly G itself--for capturing how a demographic change of that nature spreads through a population.

Figure 5.4 has suggested that among several European elites *m* already increased in G fashion during the 17th and 18th centuries. Figures 5.9 and 5.10 indicate possible patterns of the same shape into the 19th century for the German villages studied by Knodel (1986, 356), Hungarian communities examined by Andorka (Coale 1986, 15), and two German Jewish locales (Livi Bacci 1986, 193). Table 5.8 lists particulars of these probable and merely conjectured curves, including their height at the zero year. Figures 5.9 and 5.10 plot some of the data.

Two Calvinist communities of southern Transdanubia below Lake Balaton in Hungary, on the one hand, and two Protestant villages of East Friesland at the northwestern corner of Germany along with one of Württemberg in that country's southwest, on the other, display expanding fertility control into the early 1800s that may have taken G form with base year about 1770. Though later and lower than the paths of increase in *m* for urban elites in Figure 5.4, these patterns resemble those of the overall population of Geneva and of Jussy in the countryside nearby (Ewbank 1993, 349). For the Swiss city, a first G trend in *m* occurred between 1700 and the 1770s, with its t_0 in the vicinity of 1710 at about the level of .17 (estimated). This, in timing though not in level, resembles the second observed advance in the elite of Florence between 1725 and 1775 and gains for the Belgian aristocracy between 1715 and 1790 (Fig. 5.4 and Tab. 5.4).

A second possible G-shape rise for Geneva between the 1770s and the 1820s, however, would have its base around 1772 at about .36. This movement closely resembles patterns for Hungarian Bakonya and Alsónyék, two Calvinist communities of southern Transdanubia. A first, hypothesized G trend for Jussy between about 1790 and the 1820s, meanwhile, would be anchored at approximately .17 near 1770, the level where Geneva stood two generations before, this movement resembles contemporary modest increases in German Öschelbronn, Werdum, and Mittels (Tab. 5.8).

Two other Calvinist communities of southern Transdanubia, Besence and Vajzló, display rather later increase in fertility control. If their change between 1769 and 1805 indeed took G shape, the trend would be based around 1801--at a level halfway between that of the three first German villages in Table 5.8 and that of the next group of central European communities. Comparably, from the 1820s to the 1870s the advance of *m* in Jussy would have had a base point of about .27 in the vicinity of 1810, if the change there took G form.

A third tier of communities in Table 5.8 display G-shape or possibly G-shape increases in fertility control based between 1832 and 1850. What is the second such trend for Besence and Vajszló is by far the highest, reaching a level of .80 by the middle of the 19th century, which rivals that for the elites of Milan, Belgium, and Geneva (Fig. 5.4). Approximately parallel G trends in Sárpilis (another Calvinist community of southern Transdanubia), three Catholic villages of Baden studied by Knodel, and Jewish Nonnenweir (Livi Bacci 1986, 193) were lower.

Across the later 19th century comparable G-type expansions of fertility management then appeared in six villages examined by Knodel. In Öschelbronn, *m* advanced once more--after D-shape reduction for some reason across the first half of the 1800s. For Middels, a second G-form gain was no greater than first trends elsewhere. More distinctive were movements in the German Jewish community of Altdorf (Livi Bacci 1986, 193) and in a group of four Protestant villages in Waldeck. In these populations, *m* increased very rapidly from the middle of the 19th century into the 1880s, possibly in G paths targeting levels of t_0 by the 1890s and the 1910, respectively, that rivaled those for the spread of fertility control in Besence and Vajszló and in various urban elites of Figure 5.4 at comparable local stages of change during earlier eras.

The proposed patternings summarized in Table 5.8, especially these later ones, rest upon very sparse evidence. It is suggested, however, that--though fragmentary--if taken along with the elite evidence of Figure 5.4, they at least present outlines of how family limitation spread across Europe between about 1600 and 1900 in successive G-shape movements. That form of expansion in fertility control existed well before the general demographic ‘transition’ of the 19th century, not just during it. Increase of *m* in this fashion, furthermore, transcended political boundaries, religious divisions, social strata, and--as Table 5.8 indicates for the German villages--also systems of inheritance.

In southern Hungary, for example, from southern Transdanubia below Lake Balaton eastward here and there as far as the Romanian border lay clusters of villages known (by contemporaries as well as by historians) for limited reproduction already by the 19th century. Paul Demeny (1968, 520) emphasized the variety of cultural settings in which such early low fertility in Hungary occurred: Calvinist communities in southern Transdanubia, German Catholic settlements in the Banat region to the southeast, and Greek Orthodox Romanian locales still further east in Krassó-Szörény. In the latter two areas, nationality was important. Hungarians (Catholics) and Serbs (Orthodox) lagged in reducing marital fertility while German Catholics and Orthodox Romanians led the way. The Calvinists of southern Transdanubia had a special history, having sustained life in the marshes under generations of Turkish domination and warfare before ultimate Hungarian conquest and resettlement. Subsequently in-migrating Catholics who settled near them, however, seem to have taken up fertility control hardly any later. What all areas shared was administration as a Hungarian military frontier in which "at least four major nationalities and at least three major religions" lived within a single political unit (ibid.). As among Knodel's German villages, broad religious categorizations could take on rather different significance for fertility from one context of living to another.

While the Hungarian communities of southern Transdanubia, which have been treated as an exceptional 'forerunner' case within Europe (Coale 1986, 14-16), clearly took up fertility control sooner--and further before the 19th century came to an end--than any of the German villages studied, the ways *m* rose in those two disparate parts of central Europe display certain similarities. Where enough data exist, first of all, the G path is shown to be the form that adoption followed. Further, within each disparate geographical region a local sequence of the possible or likely G trends along which *m* was elevated appears. Which communities adopted fertility control when and how fast, meanwhile, was seemingly shaped by local circumstances in which the cultural element represented by religion was not by itself determinative but instead interacted with other particular conditions of the communities involved--a finding in line with current thinking about the dynamics of fertility change.

Under varying combinations of religion, nationality, inheritance, isolation, economic resources, and government, nevertheless, *m*--whatever its local level or timing--seems to have diffused through populations in G form, reinforcing other findings uncovered so far, in both this and the preceding volumes of our study, as to how populations absorb many kinds of change. The practice of family limitation, that is, spread in G fashion across one place after another in Europe much the way that one population after another grew (Harris 2001, Ch.'s 2 through 7), cities and smaller communities within them evolved (ibid., Ch,'s 8 and 9), one colony after another took up African slavery to replace European labor in G manner (Harris 2003, 306-21), or inventions have been adopted in industries (Fig. X.x). It is just another case of how many kinds of change, including demographic ones, repeatedly disseminate through populations this way.

In the national populations of Europe during the 19th century and early 20th century, fertility was significantly associated with infant mortality (Ch. 4). Considerable local variation appears, however, in contrast to how for Germany as a whole marital fertility closely followed infant mortality from the 1860s into the early 1900s (Figs. 4.1d, 4.3c, Tab. 4.1).[44]

In a sample of German villages, the probability of dying under the age of 5 ($_5q_0$) shrank in C fashion from 1725 through 1812 with t_0 at 1873. Another C trend appears for the period from 1862 to 1910, with zero year projected at 1956 (Fig. C.9; Knodel 1986, 348-49). Table C.5 tentatively relates movements of early childhood mortality, marital fertility, and fertility control for individual villages and groups of them. From 1863 through 1937, meanwhile, for Germany infant mortality declined along a C path with t_0 at 1918. When all parts of the country are trended, including the nation's urban centers (where 19th-century advances in public health can be expected to have been more concentrated than in rural areas), the C-shape decrease in early mortality comes earlier and steeper than the movement in just Knodel's villages.

From about 1812 to 1862, though, the village sample collectively shows not a C path but what appears to be an E trend for death under 5 with target year around 1934 (Fig. C.9). During this half-century, mean fecundability rose along an E path, too, while childlessness and postpartum susceptibility declined in opposite C fashion (results perhaps of the tuberculosis that so plagued Europe in the early 19th century and/or the venereal disease likely to have been spread during a quarter-century of continental war). Rural childhood mortality, in short, increased along with fertility--notably for women in their 20s in G rather than E fashion (Fig. 5.8).[45] Similar E patterns for early death during this era appear for the whole states of Baden, Bavaria, Württemberg, and Prussia, though not in all localities studied. G' patterns likewise appear--as also in Württemberg and Baden and perhaps Germany as a whole (Figs. C.9, 5.11, 4.3c).

Between the middle of the 18th century and the end of the 19th considerable local variety occurred in patterns of early mortality among communities in the territories that later became Germany (Figs. 5.11, C.9, C.10: Knodel 1986, 348-49; W. R. Lee 1979, 186-87). Table 5.9 summarizes these movements in various G-related shapes for infant ("I") or early childhood ("C") mortality in various parts of Germany and Flanders, and in Germany, Belgium, France, the Netherlands, Denmark, and England as a whole.

Earlier, across the second half of the 17th century, in northern Italy the death rate for infants seems to have decreased to about 1700 or 1710 in C fashion in several communities--a delayed manifestation of the C path found in England between 1580 and 1640 and but much like the trend for New Castile from 1630 through 1670 (Tabs. 5.1, C.4). Using the northern Italian urban elites as an indicator (Tab. 5.3), furthermore, in each of these three populations C-shape reduction in reproduction accompanied early mortality downward in a C path.[46]

In some of northern Italy, C decline in infant mortality was followed by a temporary reversal in G' shape during the early 1700s (Pinto and Sonnino 1997, 501).[47] In Fiesole outside Florence, however, infant mortality worsened quite steadily in G form between the 1630s and 1700. This pattern, with base year in the vicinity of 1608, resembles the 1640-1730 G path for M_i

in England with its t_0 at 1596 (Tab. 5.1). In New Castile, meanwhile, from 1690 through 1740 new decrease in C fashion also appeared, a pattern to which English losses switched from 1710 through 1750. In fertility, however, it was New Castile that shared with northern Italy new C-type reduction during the first several decades of the 18th century, while in England reproduction advanced in G fashion from 1661 through 1726 (Tabs. 5.1, 5.3, C.4). Subsequently, early mortality declined again in C form in England from 1750 through 1810, a pattern found for France, where fertility decreased in parallel C fashion--and several German communities, where it frequently did (Tab. 5.9; Tabs. 5.1, C.5).[48] This movement, however, was in England counterposed by E-type increase in fertility (resulting in population growth of that shape). In New Castile, early death and births per family became more frequent together in G form.

From the early 1800s into later decades of the 19th century, in Knodel's Bavarian villages marital fertility then rose in E shape generally along with mortality before the 5th birthday (Tab. C.5). While in the communities of Baden childhood death expanded collectively in a similar accelerating manner, fertility increase in three of the four individual villages instead took G shape and in Grafenshausen declined in opposite C form. I_g gained in similar G fashion in the four villages of Waldeck and the two in Friesland, but not in Öschelbronn. These G trends for fertility in several German villages ran opposite to change in contemporary England, where TFR (but not yet I_g) *fell* via D in this period as M_i instead rose in G fashion (parallel with the frequent G trends of marital fertility in German communities). Both the local German movements and the national trends in England, however, contrasted with patterns of this era in France, where infant mortality improved via C and TFR accompanied it down, or in Sweden, were C-shape decline in fertility lagged behind such reduction of that shape in infant mortality.

Among the Calvinist villages of Transdanubia (Andorka 1979, 22), in Sárpilis and Besence decadal rates of infant mortality seem to have fallen via C from about 1800 into the 1880s toward zero years in the 1890s. Fertility for women 25 through 39 declined in parallel fashion for at least part of this time in both communities, though more in advance of infant mortality in Sárpilis than in Besence. In Alsónyék, in contrast, from the 1790s into the 1880s infant mortality rose in G form. Here, for women between 15 and 30 age-specific fertility also increased across the 19th century , though perhaps in E rather than G shape.[49] In all, a positive link between trends in infant mortality and changes in fertility may also have applied in these particular Hungarian communities, too, as they moved significantly to control fertility--a connection observed in Chapter 4 for many national populations of the 19th century.

As of the 1860s, trends in the Bavarian villages of Knodel began to resemble those of England, France, and Sweden for the late 19th and early 20th centuries. Childhood mortality and marital fertility came down together in C paths that comparably targeted the 1930s. In the villages of Friesland, Baden, and Waldeck, and in Öschelbronn, however, a G' bulge in mortality under 5 seems to have appeared (Fig. 5.11). In the Waldeck communities and Öschelbronn marital fertility also may have surged in comparable G' fashion, a parallelism not found elsewhere. What kind of mortality cut like this into the rural young temporarily in the years around 1860 in all sampled populations except in Bavaria? And why did marital fertility in Öschelbronn and the villages of Waldeck respond to this surge in losses of children while in communities of Friesland and Baden it did not? Religions and types of inheritance overlap for these groupings, as in the timing and level of fertility control (Tabs. C.5, 5.8).

In all, local, regional, and national trends of infant and/or early childhood mortality are found to have taken G-related form in Europe from the 1600s into the 1900s, and can be insightfully compared or contrasted to each other in these terms while connected with movements in fertility that did or did not resemble them. What kinds of stimuli temporarily drove up infant or childhood mortality in G' shape or generated the observed geographical groupings of longer C- or D-type decline and G- or E-form increase? It would seem fruitful to explore, where possible, what diseases, famines, or pressures to abandon or neglect babies or young children (Fig. C.4) might have sculpted these movements. The distributions of the trends are not, apparently, simply explained by religion or patterns of inheritance. What conditions of health or economy might have driven early death these ways, both in places where patterns were shared and in more exceptional instances?

Local European evidence, finally, casts further light upon the what generates surges with G' shape that emerge in demographic and related economic or social change. Such patterns were *not* observed in the survey of growth and decline for various types of populations presented in Volume I (Harris 2001). Trends of G, D, E, H, F, and sometimes C form appeared instead. Similarly, various kinds of lasting demonomic change examined in Volume II (Harris 2003) took one of these paths rather than G' shape. Such durable developments included shifts out of agriculture into other economic activities (224-43), increase of scale in farms and proletarianization of the agricultural work force (241), urbanization (183-303), composite migration flows both free (32, 44) and forced (96, 99, 102), expansion of settlement into new territory (212), natural increase and creolization in planted populations (321-360, 409-505), the displacement of European labor by slaves (307-14), and price trends for labor (375, 384) as well as for agricultural goods and manufactures or overall colonial costs of living (Harris 1996).

G' patterns, in contrast, first were encountered in migrations of free or bound persons to or from particular places (Harris 2003, Ch.'s 1 and 2). This included movements into individual cities or towns (Ch. 3). Migrations in this form could temporarily shape the makeup of the broader human flows, particularly in their initial stages, or set G' outlines for the early composition of populations--both free (Ch. 6) and enslaved or contracted (Ch. 5; 416, 494). But these imprints did not last. More recurrent G' patterns in era after era occurred in ratios of prices for slaves--from different exporting parts of Africa or in different receiving colonies (385), or between the trades of European nations (381). These were generated by the up-and-down or back-and-forth movements of commerce. Other particulars of this traffic in humans, including length of voyage, density of packing, and loss of life for the 'cargo,' also reflected G' aspects of the market (391, 394, 396).

That other historical economic contexts could contain such G' movements is illustrated by data for the western end of what is now Belgium (Fig. D.2). Though economic series for England in Chapter X do not obviously display G' patterns, in East Flanders wages for day laborers and for weavers, their ratio to each other, and rents expressed in days of work required from the 1600s into the 1800s all tended to follow a series of G' fluctuations across their long-term trends.[50] In all, the G' pattern seems, in the economic context of populations, to have been connected with windows of new opportunity, relatively short-term shifts in markets, and the like.

Such association of the G' pattern with 'shocks' or swings of fortune also seems appropriate for the demographic situations in which it has been encountered in the present volume. First of all, it has occurred most of all in trends for many series of mortality,[51] which is known--especially before quite recent times--to be marked by recurrent crises. It has also appeared in nuptuality and celibacy, which are sensitive to fluctuations in the economic environment.[52] In the realm of fertility, while evident for I_g in several countries of Europe during the 19th-century era of industrialization and again following the Great Depression and World War II (Figs. 4.1a through 4.1f; Tab. 4.1), the G' pattern has been most generally evident for births outside marriage, which seem to reflect swings in the conditions for setting up a legitimized sexual relationship.[53] Table C.6 relates G' movements in marital and extramarital fertility to similar patterns for the proportion of males working in agriculture and low point between G' surges in secularization for most Flemish provinces plus Walloon but heavily industrial Liège during the later 1800s and early 1900s. Like infant mortality, abandonment or neglect of babies and a flaunting of religious proscriptions against marriage during certain holy seasons display surges of this G' shape (Figs. C.4 and C.6).

G' trends for marriage during religiously proscribed periods and for illegitimacy seem to be related to each other. In three communities of Languedoc with the most extended and unbroken data series (Molinier 1973, 460-61) across the later 18th century the proportion of reproduction that was extramarital appears to have been headed in G' trends toward crests around 1800 (Fig. C.4).[54] These movements closely parallel what has been posited (before the work of Molinier was encountered) as the G’ pattern for marriage during March and December in Languedoc and Provence (Fig. C.6). In Lille (Imhof 1975, 1: 536), meanwhile, the proportion of births from 1758 to 1788 that were extramarital projects a G’ peak at 1797 (Fig. C.7). This is about a decade earlier than the G’ curve for secularization in Nord (of which Lille is the capitol) and Picardy (Fig. C.6). Illegitimacy in Angers, a central place of the lower Loire (Imhof 1975, 1: 537), is calculated from 1752 through 1788 to have followed a similar G’ trend with maximum around 1809 (Fig. C.7).

In contrast, fertility control (as measured by *m*) seems to have spread across populations in the continually increasing G form, without G’ reversal. The same was true in most cases for age-related fertility--though not for Sweden, for example, during the ‘baby boom’ era that followed World War II era (Figs. 5.2 and C.8). In this period, marital and total fertility in several European countries rose and fell in G’ fashion (Figs. 4.1a through 4.1f).

In all, it appears as if secularization and illegitimacy moved together in France during the later 1700s. These G’ trends, moreover, began well before the Revolution; they should not be attributed to that event. The pressures that increased illegitimacy, according to the timing, were a part of the changing values and conditions that generated revolt, not a consequence of it.

Further evidence comes from Belgium. G’ bulges for secularization in some parts of the country, fertility for Belgium as a whole, and illegitimacy in Lille, just over the French border, resemble surges of this type that appear in Flemish wages and rents (Figs. C.6, 5.3, C.7, and D.2). Not surprisingly, economic vicissitudes appear to be connected with extramarital births and attitudes toward traditional norms for marriage. Broadly speaking, G’ surges in illegitimacy--and in some places also marital fertility--coincide with movements of that shape in employment and in secularity for several provinces and urban areas (Tab. C.6).

Locally, in East Flanders G’ surges in premarital conception closely paralleled movements of that shape in secularity--with successive crests in the vicinity of 1670, 1736, 1812, and 1888 (Fig. 5.12, Table 5.10). Childhood mortality maximized comparably around 1740 and 1804, but next peaked relatively early by comparison--about 1841. During the 17th century, meanwhile, the crude marriage rate and the percentage of births that were illegitimate took what might be G' paths resembling those for secularity and premarital conception. For much of the 1600s these G' movements roughly paralleled a surge of that shape in the real wage for day laborers. The cost of rents, meanwhile, crested relative to a day's wage in G' form as the population of East Flanders swelled in non-receding G fashion, producing a parallel longer-term shift of population to towns and cities (Fig. D.2). Secularity, premarital conception, the frequency of marriage, and a rise in rents all peaked following a 17th-century increase of population pressure, which had expanded urbanization.

Subsequently, from the later 1600s into the early 1700s, wages for day laborers and weavers--and also rents relative to wages--surged again in G' form. In this period, simultaneous 1/G' dips in per capita income from both agriculture and rural industry suggest that the heightened level of population strained resources, as evident from the rise in rents even compared with elevated real wages (Tab. 5.10). As of about 1700s, these combined developments helped trim urbanization in East Flanders--a decline which apparently took D shape into the middle of the 18th century (Fig. D.2).

During the first half of the 18th century secularity, premarital conception, and (rather earlier) the crude marriage rate accompanied real wages in approximately parallel G' movements. Now, however, per capita income surged in contemporaneous G' form. This was helped by the fact that the population of East Flanders was smaller around 1700 than thirty years before (Fig. D.2), in part thanks to a G' surge in mortality for children. Illegitimacy, however, now fell to a low in the 1740s opposite the G' bulges in the real wage, secularity, and premarital conception as--with reduced population--rents cheapened in 1/G' fashion relative to wages for the most ordinary workers, and marriage could become more frequent.

These conditions opened a window for sustained demographic increase in H form for East Flanders across most of the 1700s. Urbanization, however, did not benefit from this growth until after mid-century. Discrepancies in opportunity during these later years pushed down real wages for day laborers, elevating in G' fashion the cost to them of rent in hours worked and the relative earnings for weavers.

As the long-term G-shape rise of wages into the middle of the 18th century shifted to C-type decline, urbanization began to climb in accelerating E manner into the early 1800s. The E-shape growth of population during this period depressed wages and pushed relatively more people into cities. These trends resembled the ones found in England:

	East Flanders[55]	England[56]
Population	1750-1831 E 1852	1726-1806 E 1822
% Urban	1750-1850 E 1853	1750-1806 E 1864
Real Wages	1747-1847 C 1857 DLab.	1675-1805 C 1855 Farm,S
	1747-1847 C 1830 Weav.	1735-1775 C 1828 F,NM
	1738-1788 C 1819 Urban	1750-1804 C 1849 C&M
Urban/Rural Wages	1763-1838 E 1837 DLab	1715-1795 E 1851
	1763-1838 E 1852 Weav.	

Another, rather different similarity to English trends involves how illegitimacy in East Flanders over the long term rose approximately in H fashion from about 1760 to 1860 (Fig.

5.12). In England, such a tendency had appeared between about 1650 and 1760 (Fig. 1.4). The Flemish H trend succeeded a G’ pattern through the later 1600s and early 1700s that had maximized around 1680 compared with a G’ surge in England between 1568 and 1648 with a crest in the vicinity of 1600. For two centuries, in other words, the rate of illegitimacy in East Flanders echoed movements of that demographic measure in England about a hundred years before. In each case, furthermore, the H trends were concurrent with H-shape expansion in the population that was much flatter (earlier in base year) than the trajectory for illegitimacy. Did the reason for such a protracted, lagged parallelism lie in the timing of cultural or of economic change in the two societies? Subsequently, in contrast, through the middle of the 1800s quite contemporaneous G’ surges appear for extramarital fertility rates (I_h) in East Flanders and in England (Figs. 5.12 and 1.4).

As the E trends in population size and urbanization for East Flanders maximized during the first half of the 19th century, secularity, premarital conception, childhood mortality, and illegitimacy crested in new G’ surges, even if the crude marriage rate and real wages for both weavers and day laborers rose comparably (the former once again pushing above the latter in G’ fashion). Per capita income surged comparably. With population pressure, however, rent and rent per day worked nonetheless became more expensive in G’ form, while the wages of rural workers dipped via 1/G’ (Tab. 5.10).

During the second half of the 19th century, G’ surges in childhood mortality, illegitimacy, and non-marital fertility appeared opposite to 1/G’ sags in wages. Rather later G’ rises in secularity, premarital conception, and extramarital fertility occurred even while nuptuality surged similarly. Surveying more broadly, marital fertility (I_g) took G’ form cresting during the third quarter of the 1800s in Antwerp and Ghent, Brussels, the Flemish provincial towns, Liége, and the industrial towns of Hainaut province, but not in the Walloon provincial centers (Tab. C.6). Meanwhile, the Walloon (francophone) provinces of Namur, Luxembourg, and Hainaut followed neighboring France and Luxemburg with C trends for I_g across the later

19th century, while the Flemish provinces, half-Flemish Brabant, and industrial (but Walloon) Liége display trends of the G' shape, making the Belgian pattern resemble those of the Netherlands, Germany, Denmark--and England and Wales. Except for Limburg, Namur, and Luxembourg--on the eastern fringe of Belgium, where it was falling via D--the proportion of males employed in agriculture also peaked in G' fashion in the middle of the 19th century. A low in secularity, between G' movements, tended to be reached concurrently. Quite general to all provinces, and neighboring nations as well (including England and Wales), were G' surges in extramarital fertility (I_h), though in western Belgium the G' crests tended to come earlier, and be followed more frequently by later movements of that shape--or alternative paths of increase (Tab. C.6).

In this era of the later 1800s, meanwhile, both population increase and urbanization in Belgium and in England and Wales followed very parallel H paths--after stronger English growth across the first half of the 19th century (Harris 2001, 148; 2003, 277). Though wages rose with these largely industry-supported tendencies in both countries, in Britain they climbed faster earlier and flattened out in G form, while in Belgium they accelerated upward via E after C-shape declines finally ended, up to about a half century later than in England (Figs. X.x, D.2).

In spite of some similarities in long-term trends that have been cited, finally, G' and 1/G' movements are much less frequent in the demonomic patterns of England than those for Belgium (Tabs. 1.1, 1.2, 1.3, 1.4; Fig. D.2). The one place that they do appear with some regularity is in adult mortality (Tab. 1.5). Especially, visible impacts of these shapes upon the English economy seem absent (Ch. X). The implication is that while mortality among adults may have moved in this shorter-term fashion in both populations, the demonomic regime in East Flanders from the 1600s into the 1800s was more Malthusian in nature than that of England, with population affected more by relatively short-term economic events. Along with long-term trends found to lag behind comparable changes in England or to diverge from them, this absence suggests that England 'escaped' the Malthusian trap appreciably earlier than East Flanders in spite of pioneering economic change in that Belgian region, both agricultural and protoindustrial, during the early modern era.

In several ways, findings for particular social groups, regions, and communities flesh out beyond limited nationwide evidence a framework of comparison and contrast for understanding better the manner in which fertility and related early mortality evolved across Europe during the 16th, 17th, 18th, and 19th centuries. These patterns, and how they were or were not shared, would seem to highlight better the ways that changes in economy, culture, and natural environment generated or reflected the demographic movements of this long epoch of early modern and modern history. Where the historical evidence makes it possible, these implications are worth testing.

NOTES

1. Since these decelerating H trends are all roughly parallel, the earlier though abbreviated movements in the Low Countries and Germany have higher average rates of growth than the later-starting and longer-lasting time segments for Sweden and for England (where some decline between 1656 and 1686 is included in the average).

2. Even with rates of infant mortality and fertility in New Castile moving much like comparable measures in England up to the early 1700s. The initial discrepancy between the levels of fertility and mortality in New Castile was simply narrower (Livi Bacci and Reher 1993, 75-76).

3. The stagnating Netherlands now constituted the low exception, with average annual growth of only 0.10 percent (de Vries 1984, 36; de Vries and van der Woude 1997; Israel 1995).

4. Though the populations of various *regions* within Austria-Hungary did expand this way (Harris 2001, 212-13, 216).

5. And a multiple of roughly 6.7 for Sweden between 1580 and 1943, where growth took H shape to 1720 and after 1848, but in between a series of rapidly decelerating G-type increases--as in France.

6. Among economic drawbacks Crouzet stresses a low level of agricultural productivity in the 18th century and postrevolutionary “agricultural structures” that were not favorable to modernization.

7. Using an ‘urban’ threshold of 2,500, the calculations of Lepetit and Poussou (1988, 203) indicate an E trend for urbanization from 1811 through 1861 (with zero year about 1885) that closely resembles our 1700-to-1850 approximation (t_0 at 1869); but for 1851 through 1911 suggests a G pattern based at about 1824 rather than an H rooted in the vicinity of 1786 during what Crouzet considers a lagging second phase of French economic modernization after stagnation near mid-century (2003, 235-36).

8. Likewise by 1.83 compared with 1.16 in France.

9. In Sweden the population multiplied on average at an annual rate of 0.48 percent between 1720 and 1848 compared with 0.35 in France between 1720 and 1827 and 0.57 in England during the E-shape interruption of H-type growth there from 1726 through 1806.

10. Multiplying at an average annual rate of 0.73 percent from 1848 to 1943 compared with about 1.14 percent for the English population between 1806 and 1939 and just 0.22 percent in France, where between 1826 and 1939 expansion followed only a single more quickly decelerating G path for over a century.

11. A sharply shrinking number of parishes with local mortality crises after about 1560 reinforces the death rate evidence of Fig. 1.1 (Dupâquier 1997, 250; from Wrigley and Schofield).

12. The evidence from London indicates that while deaths from plague were indeed severe in the early 1660s, they constituted only a part--if an actively fluctuating segment--of the steady climb of mortality there during the first three-quarters of the 17th century (Houston et al. 1997, 378).

13. For example, the G' pattern of in-migration to Norwich (Harris 2003, 185).

14. As computed there from Coale and Treadway, the crest for that mostly downward G' segment was said to have its maximum, also 0.047, at 1848. In all, a single G' trend of I_h from 1833 through 1901 appears to have unfolded.

15. More detail appears in Ch. X.

16. Population estimates of de Vries (1984, 36) at 1500, 1550, 1600. and 1650 and of Dupâquier (1997, 446-49, full territory) suggest G-shape growths based back in the vicinity of 1460 for 1500 to 1600 and around 1540 for the years from about 1605 (as Henry IV was consolidating France after decades of civil war) to 1670. Between 1550 and 1650 the population of France increased by only 5 percent compared with 53 percent for Sweden and 75 percent for England.

17. Using the 10,000 level for 'urban' (de Vries 1984, 39) rather different percentages emerge but still a comparable picture of much more advance in urbanization for England than for France between 1500 and 1700.

18. The growth of Paris and a few lesser centers, principally in the northwest (Amiens, Le Havre, Cherbourg, Brest, and Nantes--and probably Dieppe, Caen, and Rennes), while other cities (even also situated along the Atlantic rim) stagnated, suggests significant local variation in development (Harris 2003, 264-68).

19. The hollow circles represent averages for the two measures designated by solid triangles (Weir 1993, 151, 157).

20. The Paris basin and the Massif Central display additionally elevated levels with the Revolution, but nonetheless show G’ fits for the years around 1766 and 1815 that crest in the vicinity of 1800 along with patterns for Nord and Picardy, on the one hand, and Languedoc and Provence on the other.

21. Among the three Flemish regions, data for just 3 or 4 of the otherwise more widely covered communities of East Flanders and the sandy soils of West Flanders are known around 1812 (1800-1824) and 1832 (1825-1839)--nothing from the coast and polders area or the Antwerp campine. The high value of the former period and the low index of the latter are averaged for graphing in Fig. C.6. Exceptionally high levels for Brabant around 1832 (for just one village) and low value for Flanders for 1841 to 1847, represented by hollow triangles, are not utilized in the curve fitting.

While data for the early 1800s is lacking in the coast and polders and in the sandy areas and the Antwerp campine, from 1782 to 1795 the index clearly climbed in both these regions, too, though not as steeply as in the sandy soil area and East Flanders. Inspection reveals, furthermore, a G’ surge in the town of Verviers (in eastern Liège) from 1782 through 1844 that peaked near 1827, and possible G’ movement between 1812 and 1844 with peak in the vicinity of 1823 in Bruges at the other, western, end of Belgium. For the city of Liège, a G’ pattern between 1762 and 1828 may come earlier, and have an excessively high value in the 1790s (Lesthaeghe 1991, 279)--as found in most of the regions of France.

22. From 1896 through 1925 or 1933, that index rose along an H path with zero year about 1806. If, on the other hand, calculations for 1805 and 1815 were included, t_0 for an H fit would lie in the vicinity of 1770 (Fig. 5.1b), which makes the two estimates thus bracket the 1786 for urbanization.

23. As noted, from 1580 through 1720, the population of Sweden (within its old boundaries) multiplied at an average annual rate of 0.43 percent compared with 0.37 for England between 1561 and 1726 and just 0.11 for France between 1550 and the 1720s.

24. Judging by the crude marriage rate.

25. Annual average increase for the Swedish population was 0.48 percent between 1723 and 1848

compared with 0.57 percent for England between 1726 and 1806 and 0.34 percent for France from about 1720 through 1827.

26. At an average 0.73 percent rate between 1848 and 1943 compared with 1.19 percent in England from 1806 to 1939 but as little as 0.22 percent in France between 1826 and 1936.

27. Nuptuality does not seem to be well known for Belgium in the early 1800s, though after 1829 the level appears to have been flat for a while (Deprez 1979, 270). How did a surge in fertility take place there *within* marriage during the early 19th century? Was there, for example, more--or better--employment than in England and Sweden, of a sort that allowed *young* women, the most fertile age group to wed? Was such opportunity generated in agriculture, protoindustrialization, or the new industrial economy? From about 1725 through 1913, in Flanders movements of the crude marriage rate resembled trends in real wages for day laborers (Devos 1999, 116; Fig. "D.2"). Meanwhile, the proportion of women age 50 who had never married between 1856 and 1890 may have peaked in G' fashion about 1866, or among those of average age to marry about 1839, about where a possible 1/G' dip in real wages for laborers troughed.

28. A movement found both in western Flanders and Brabant and in eastern Herstal (Devos 1999, 118; Leboutte 1991, 283)--and also in Italy (Livi Bacci 1977, 100). But it was roughly opposite to the lows for England and Scotland--and the Netherlands--in the 1870s (Anderson 1999, 76; Deprez 1979, 273).

29. The most notable departure in pattern between the two measures is for the British peerage during the 17th century.

30. For women married only by 25, the Geneva curve had its t_0 at 1689, almost exactly like the $TLFR_{20}$ trends for the other two groups.

31. Fig. 5.5 in the next section. The C trend for manual families from 1680 through 1780 declined more slowly, along a C path with zero year only at 1817, much like the whole city population from 1715 through 1774 (Perrenoud 1990, 247; Harris 2003, 204) though the weighted average of Bardet (1990, 267) for the city comes down somewhat more tardily (t_0 at 1832 rather than 1820).

32. Milan, however, lay in the industrial heart of Italy, and the acceleration of births and fertility in

England in this period seems to have been rooted in consequences of industrialization and urbanization related to it. Italian industrialization significantly lagged that in England, which could make such a later E curve at least plausible until more and better evidence is available.

33. Graphed in Fig. 2.2g of Ch. 2.

34. *Two* “nations of shopkeepers?”

35. Including Normandy, France as a whole, and aggregated data from four ‘quarters’ of the country.

36. Previously, during the last three-quarters of the 17th century, the number of children borne had risen--except for those wed between 15 and 19, whose completed families already shrank in C fashion.

Unfortunately, the last full paragraph on page 203 of Volume II (Harris, 2003) misreads the upper pair of plots in Fig. 3.6a for Rouen and Geneva. What these patterns represent, instead, are averages for completed family size for those married 15 to 19 and 20 to 24 (i.e., all wed before 25) in order, crudely for the time being, to delete the effect of substantially later marriage upon the trends for all women regardless of how old they entered unions. The parallelism of the two sets of curves presages what Fig. 5.6 here demonstrates: all women were experiencing these reductions together, no matter what their age at marriage.

37. After some increase for most groups following the period 1625 to 1644, among those wed in the third quarter of the 17th century (midpoint 1662), for example, women married under 20 had on average 9.63 children compared with 9.43 for females wed 20 through 24, 7.05 for the group marrying 25 through 29, 4.31 for women 30 through 34, and 2.78 if they started a union only at age 35 or older.

38. The categories of 15 through 19 and 10 through 14 years together.

39. In order to obtain for Fig. 5.7 an approximate sense of reproductive contraction by age that was shared by Geneva women who married at a range of different ages (Perrenoud 1990, 249-51), age-specific fertility for those wedded from 15 to 19, 20 to 24, and 25 through 29--together, the large majority of females who were ever married--is averaged (without weighting for the three groups in this tentative exploration).This shortcut to simplify calculations and comparisons appears to be justified by background graphing that shows how age-specific fertility in Geneva for those married under 20, 20 through 24,and

25 through 29 all generally declined in comparable C form within each of the age-cohorts examined.

40. In Florence, for women 40 through 44 the rate was very low by 1650 or so, and then remained mostly flat. In Geneva, the potential C for women 40 through 44 dropped off earlier than the one for those 35 through 39 (zero year around 1703 rather than 1727) or the average for that age bracket in Florence and Milan (1737)--graphed but not shown.

41. Lachiver reported legitimate fertility for all ages at marriage.

42. For this rough demonstration, separate rates for villages are simply averaged. A third Catholic village, Velem--which was located in *western* Transdanubia near the Austrian border, out of the area that held the other settlements--is not considered. Age-specific rates are available there around 1773 and 1814; but these fail to show the kinds of reduction in fertility that are evident in southern Transdanubia. (Velem's movements--with high levels of fertility for most age brackets, comparatively little decline except for women 45 through 49, and delayed change throughout--generally look more like those of the German villages of Knodel.)

43. The Catholic ones are not documented at this time.

44. Not fitted in Fig. 4.3c is what may be an alternative G' pattern from 1878 through 1917 with zero year at 1878.

45. Fertility for teenage brides, meanwhile, ran consistently high across the 1800s in these village populations, while for women in their 40s, births declined (Knodel 1986, 356, 358). E movement is barely perceptible in the aggregate *age-adjusted* marital fertility stressed by Knodel.

46. Fragments of evidence from smaller northern Italian communities (Treviglio, S. Godenzo, Empoli, and Fiesole: Pinto and Sonnino 1997, 504), meanwhile, suggest decline in age-specific fertility for women 40-44 between the 1670s and the 1720s that *might* fit a C trend with t_0 about 1745. Only a much flatter downward tendency appears for women 35-39, however, while among those under 35 age-specific fertility actually *rose* during this period in those places. Greatly varying calculations of the *m* index of fertility control for these smaller communities on average decreased during this period rather than expanded (Pinto and Sonnino 1997, 504). The question becomes how much of northern Italian

society did fertility decline penetrate.

47. S. Ippolito and Armignano, Galcianna, Cento, and some villages around Bologna.

48. Though Figure C.9 shows almost no change between the 1770s and the 1880s for all 14 villages together, in Werdum, Middels, and the three Bavarian communities the C-shape decrease in I_g* in fact closely resembled comparable declines in I_g for the southeast Paris basin and southwestern France in this era, in level as well as timing (Tab. C.5, Fig. 5.1a). In the four Waldeck villages and in Württemberg's Öschelbronn, in contrast, marital fertility tended to *increase* during this period in opposite E form. Such mirroring divergence is what was happening to infant mortality and TFR (though not I_g) in the population of England from the middle of the 1700s into the 1810s. Württemberg was unusual among documented German regions for alone expanding demographically in E manner between 1759 and 1802--toward a zero year at 1830 (Harris 2001, 206), very much like the population of England.

49. In Vajszló, lumped with Besence for fertility rates, infant mortality also increased from the 1790s to the 1880s, perhaps likewise in G fashion though the decadal data wander considerably.

50. The ratio of wages for weavers to those for day laborers also show such movements during the era between 1432 and 1597 (Fig. D.2).

51. Figs. 1.9a through 1.9d and 1.10 with Tabs. 1.4 and 1.5 for England; 1/G' dips in CDR for several northern European countries in Figs. 2.1a through 2.1d, but virtually no G' or 1/G' in CBR in ch. 2; infant and childhood mortality for several populations in Figs. 5.11 and C.10, Tabs. 5.9 and C.4.

52. Figs. 1.4 and 1.5 for England; Figs. 4.2a through 4.2f for 20th-century European marriage 'booms'; Figs. 4.5a and 4.5b for the marriage of young women in particular; Tab. C.4 for trends in New Castile.

53. Figs. 4.4a through 4.4f; Tabs. 4.5, C.6; Figs. 1.4 and 1.7; Fig. 5.3; Figs. C.4 and C.7.

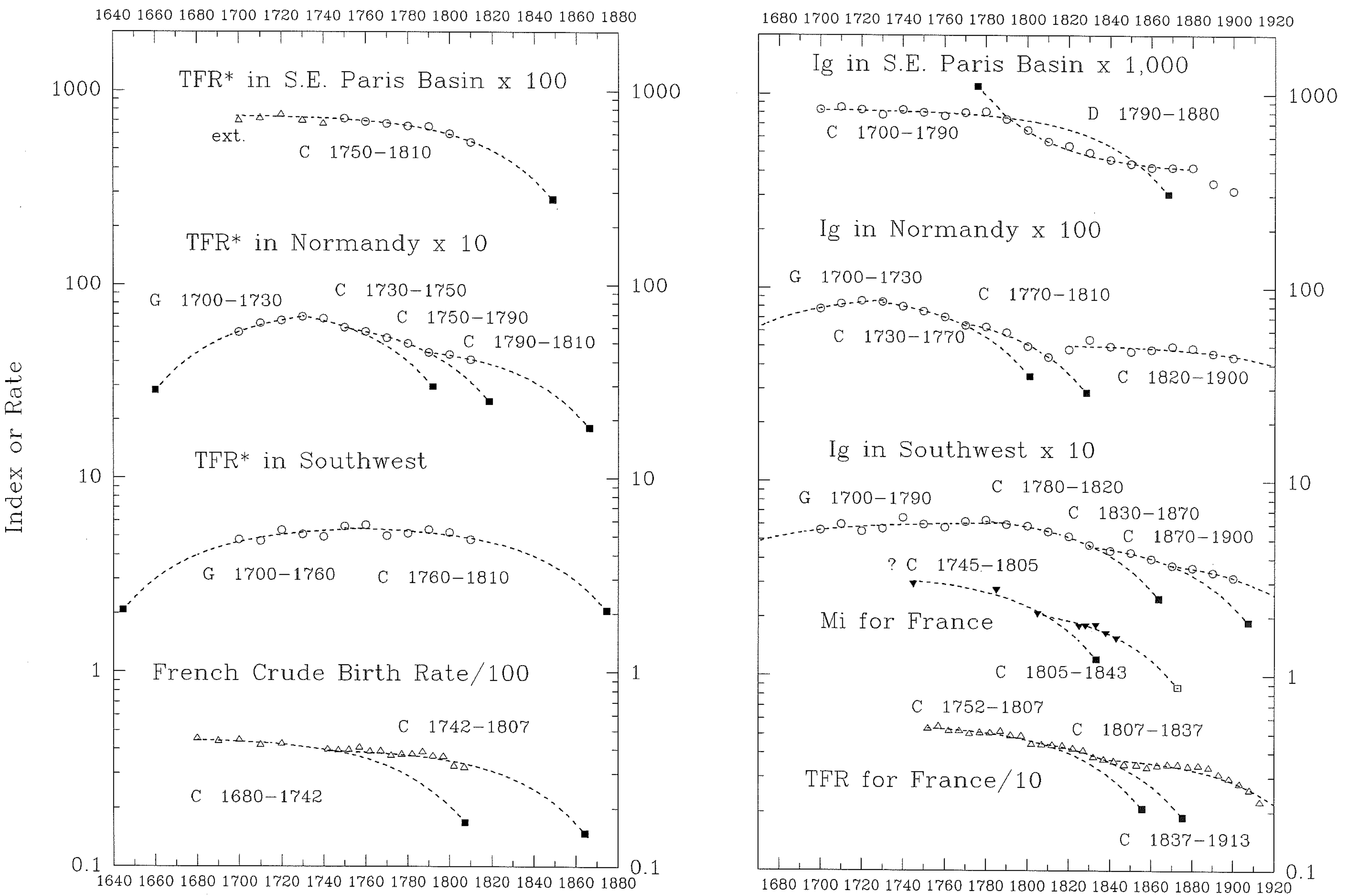
54. For Annonay, just the percentage of births that were illegitimate is tracked; for Serignan and Le Puy, abandoned babies are included as well.

55. Fig. D.2; Vandenbroeke 1987, 167; 1984, 916-24.

56. Tab. 1.1; de Vries 1984, 39,45; Harris 2003 225; Clark (farm wages in the South and in the north and Midlands separately ; Crafts and Mills 1994, 179-82; urban/rural = Phelps Brown-Hopkins/Tsoulouhas 19xx, 198-99.

Figure 5.1a

Fertility–Related Trends in France before the Modern Transition: Total and Marital Fertility, Crude Birth Rate, and Infant Mortality

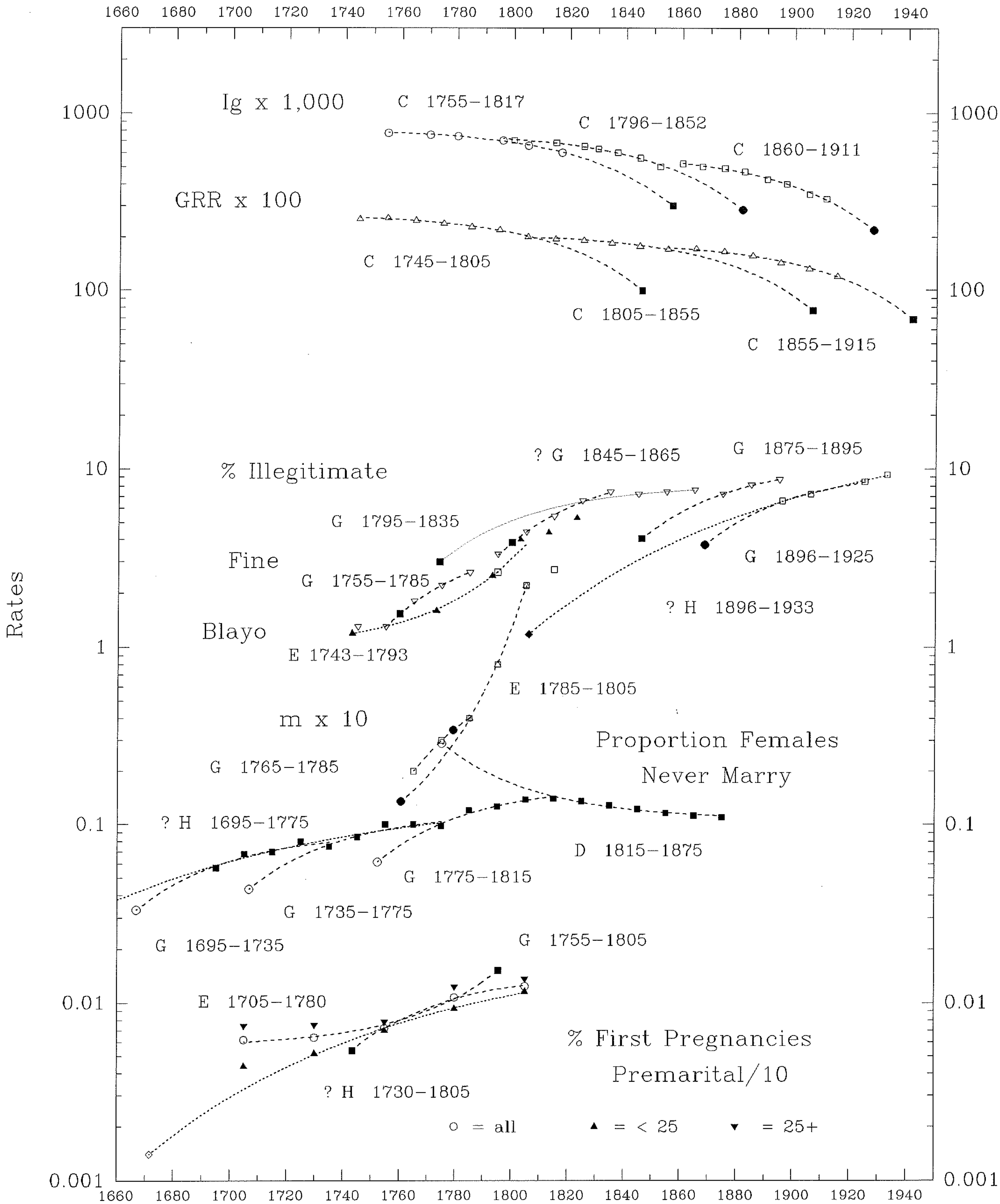


* family size for women married 20–24.

Sources: Fauve–Chamoux 1989, 11; Henry and Blayo 1975, 109; Dupaquier 1997, 449; Chesnais 1992, 323, 580–81.

Figure 5.1b

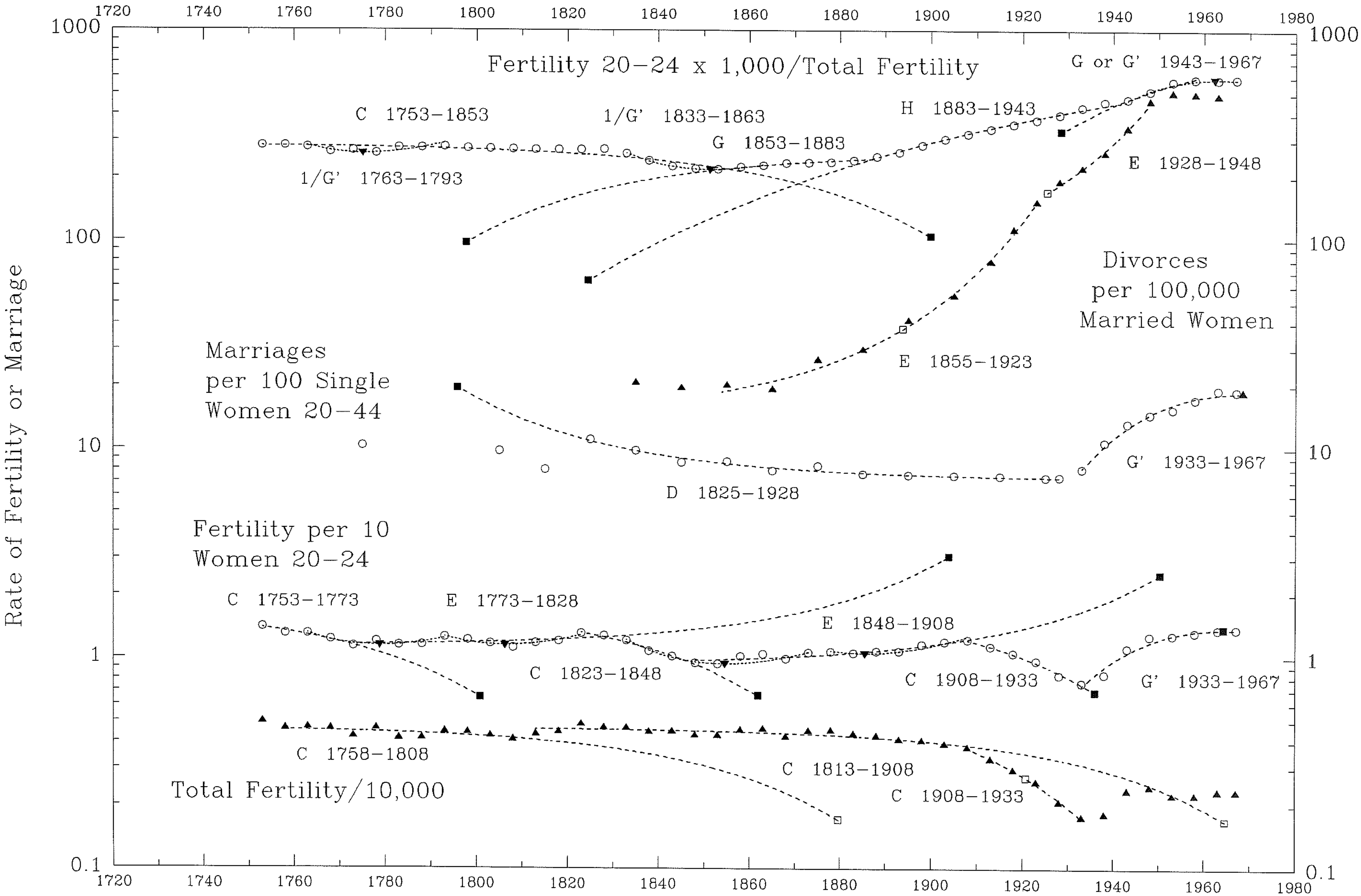
Fertility–Related Trends in France before the Modern Transition: Ig, GRR, Illegitimacy, Fertility Control, Celibacy, and Premarital Pregnancy



Sources: Wrigley 1985b, 42, 37, 49, 46, 50; Weir 1993, 151, 157; Fine 1988, 437.

Figure 5.2

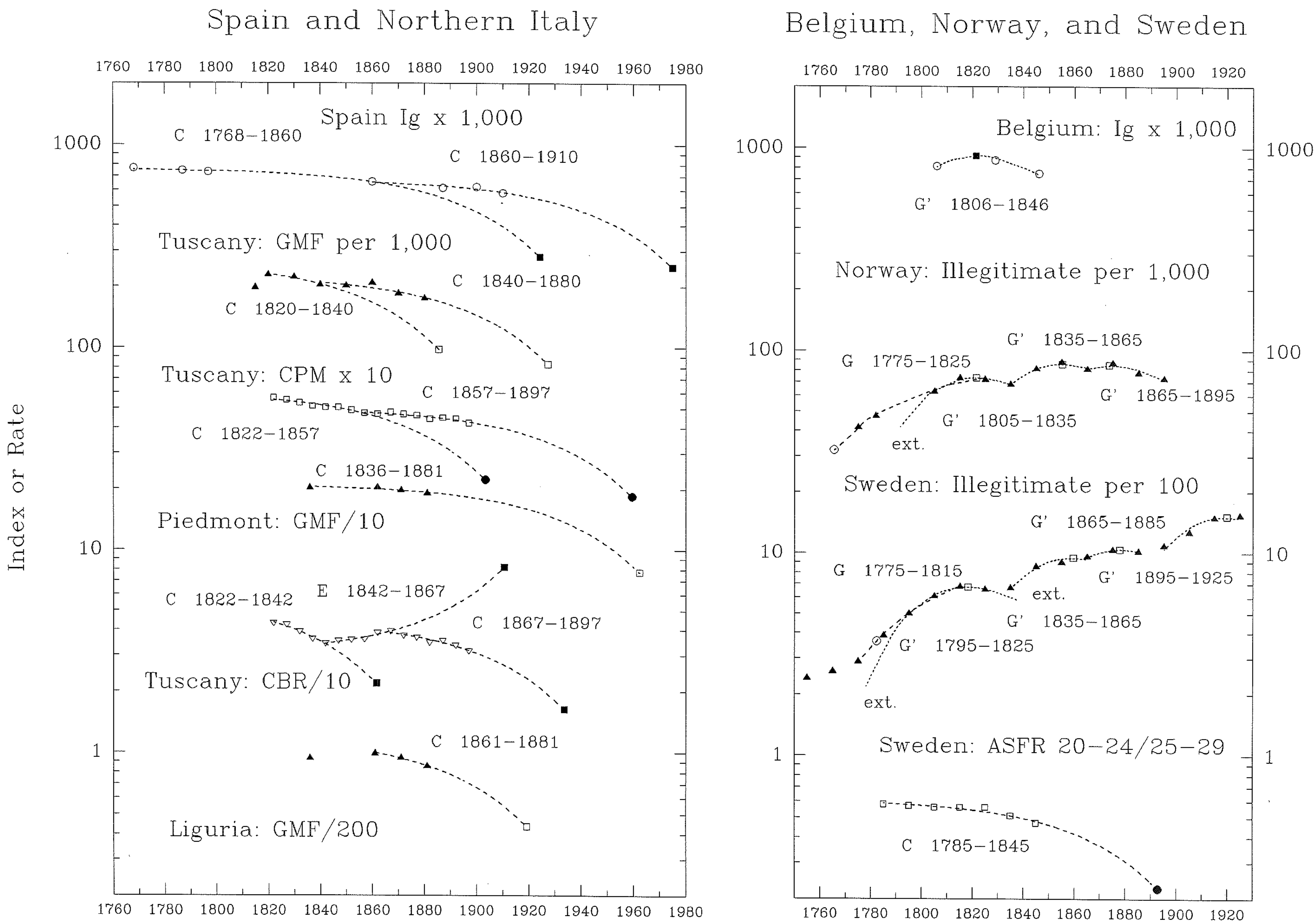
Additional Particulars on Swedish Nuptuality and Fertility



Source: Historisk Statistik, 105, 104.

Figure 5.3

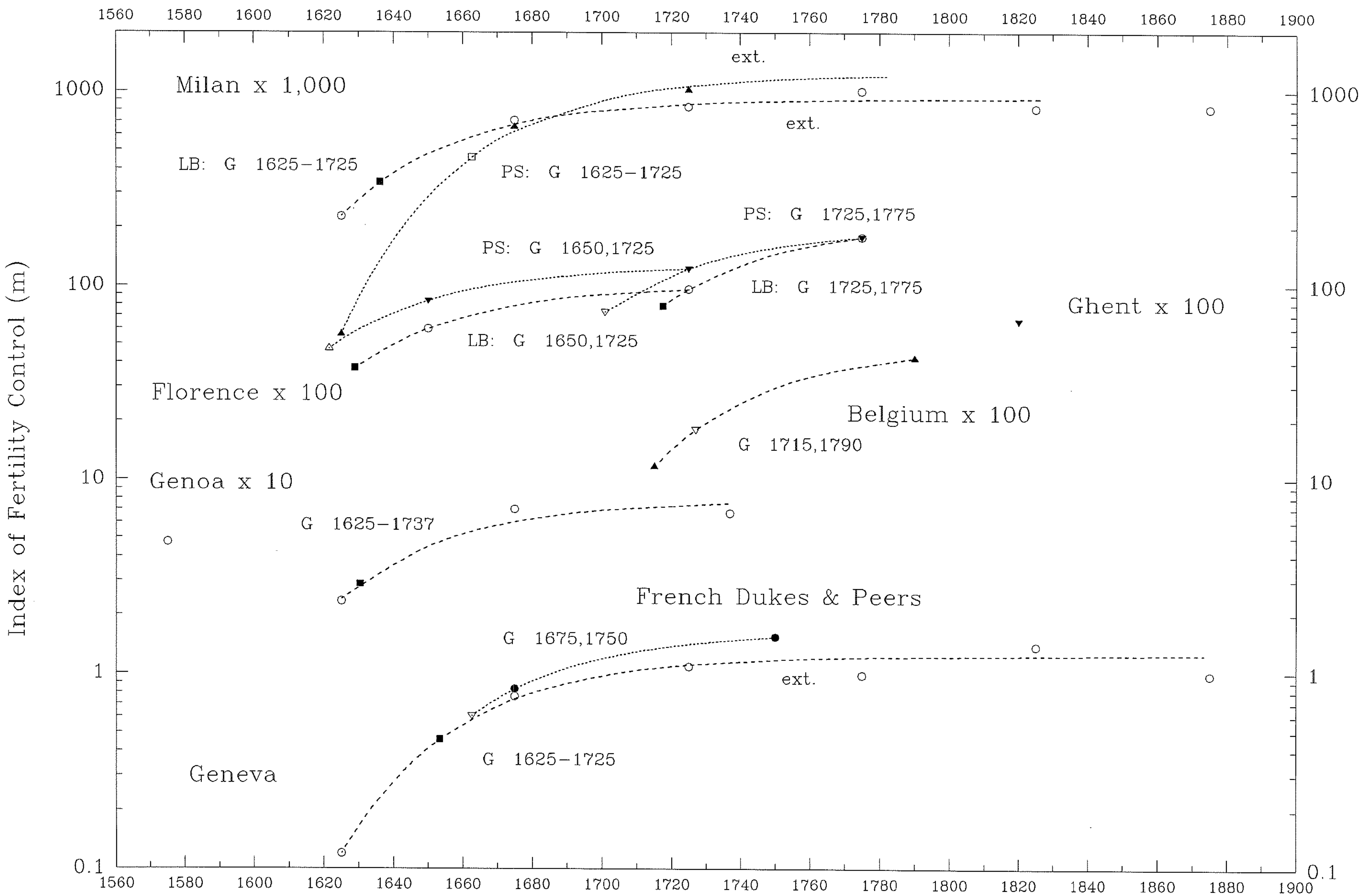
Fertility–Related Trends in Other European Societies before the Transition:



GMF = gross marital fertility; CPM = children per marriage; ASFR = age specific fertility.
Sources: Livi Bacci 1968, 530; Livi Bacci 1977, 30–31, 35; Deprez 1979, 272; Drake 1979, 317; Fridlizius 1979, 380, 376.

Figure 5.4

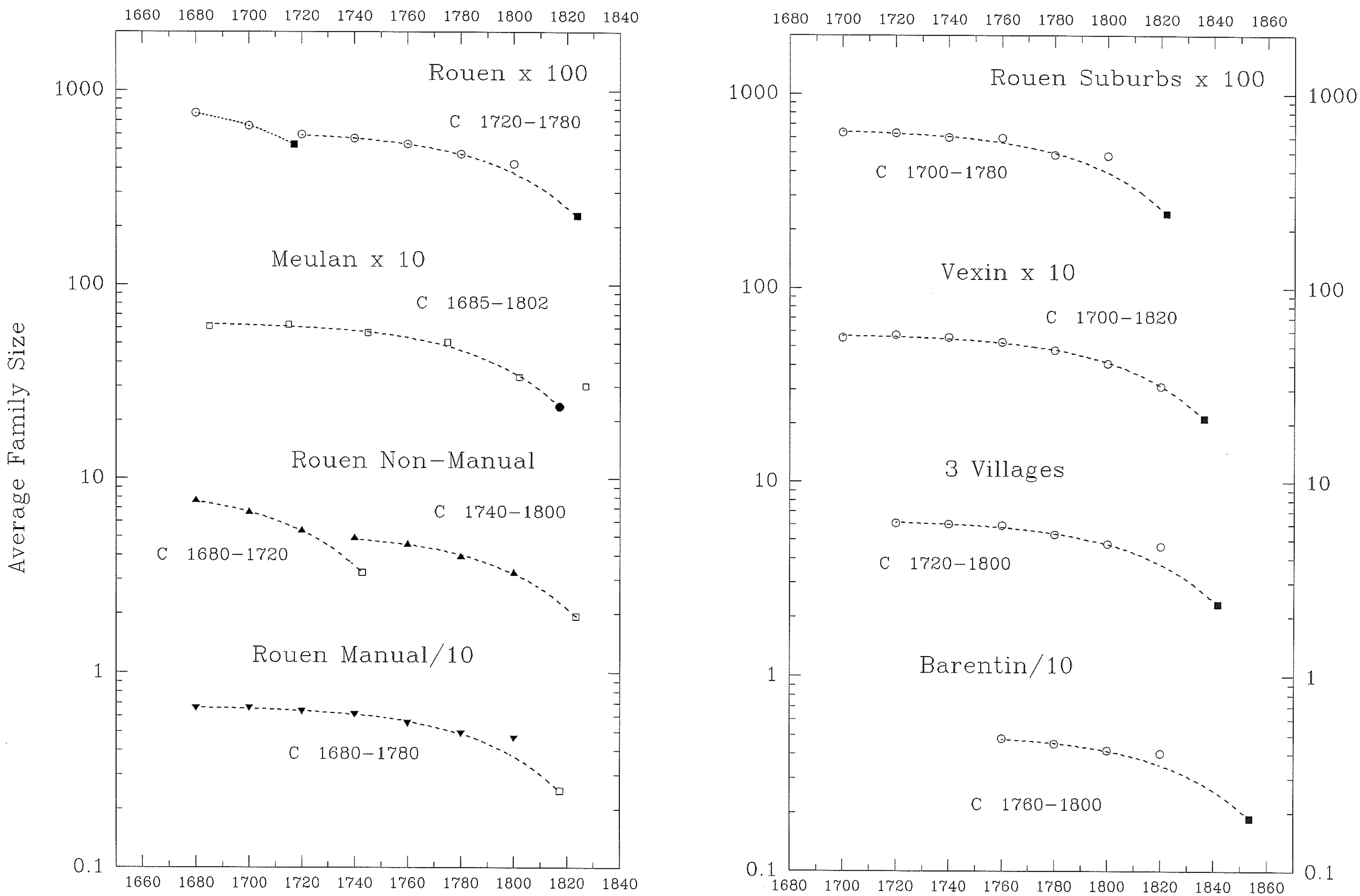
Early Trends in Controling Fertility among European Elites



LB = Livi Bacci; PS = Pinto and Sonnino.
Sources: Livi Bacci 1986, 185–86; Pinto and Sonnino 1997, 504.

Figure 5.5

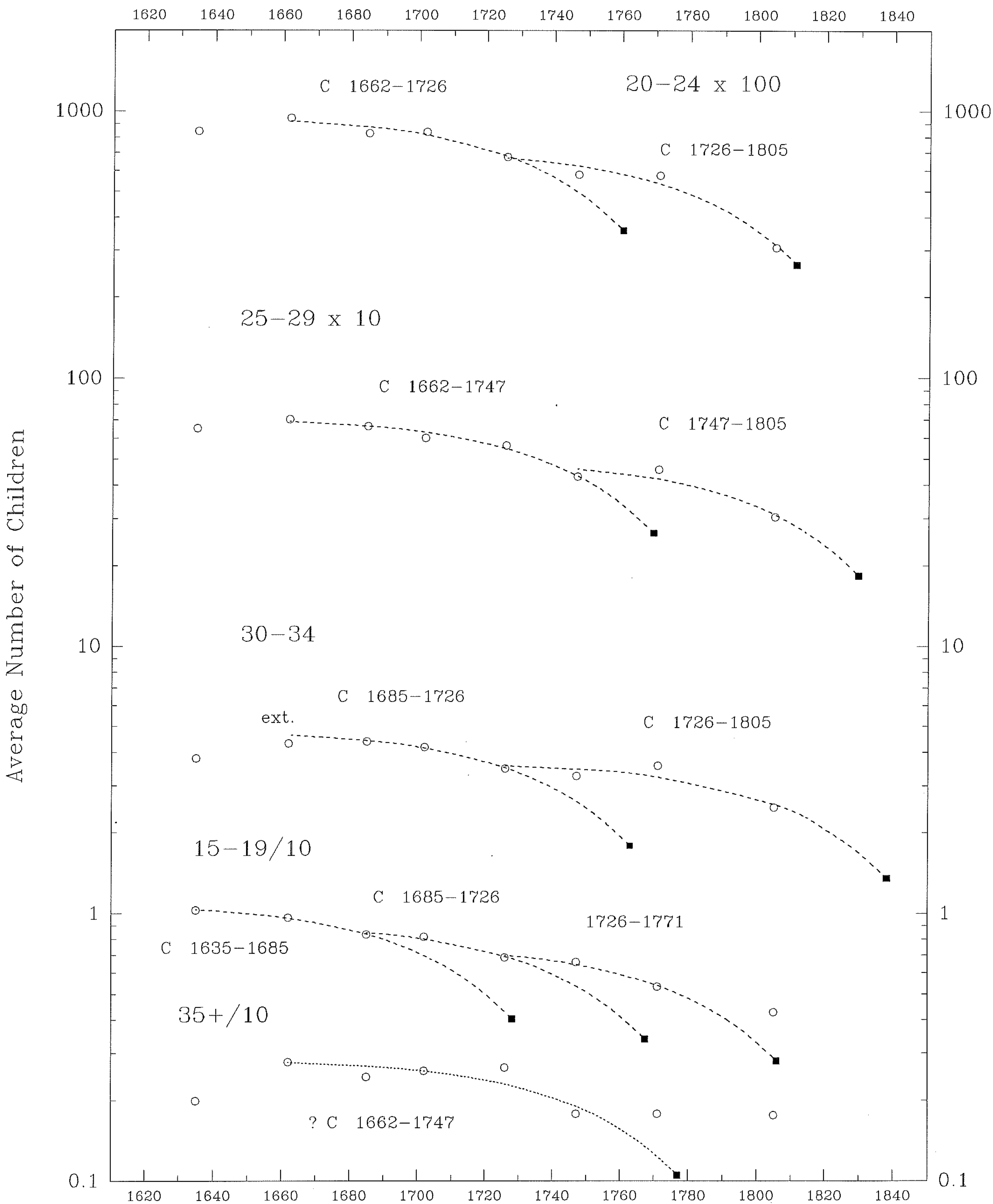
Trends of Family Size in 18th-Century French Communities



Source: Bardet 1990, 267–68, 274.

Figure 5.6

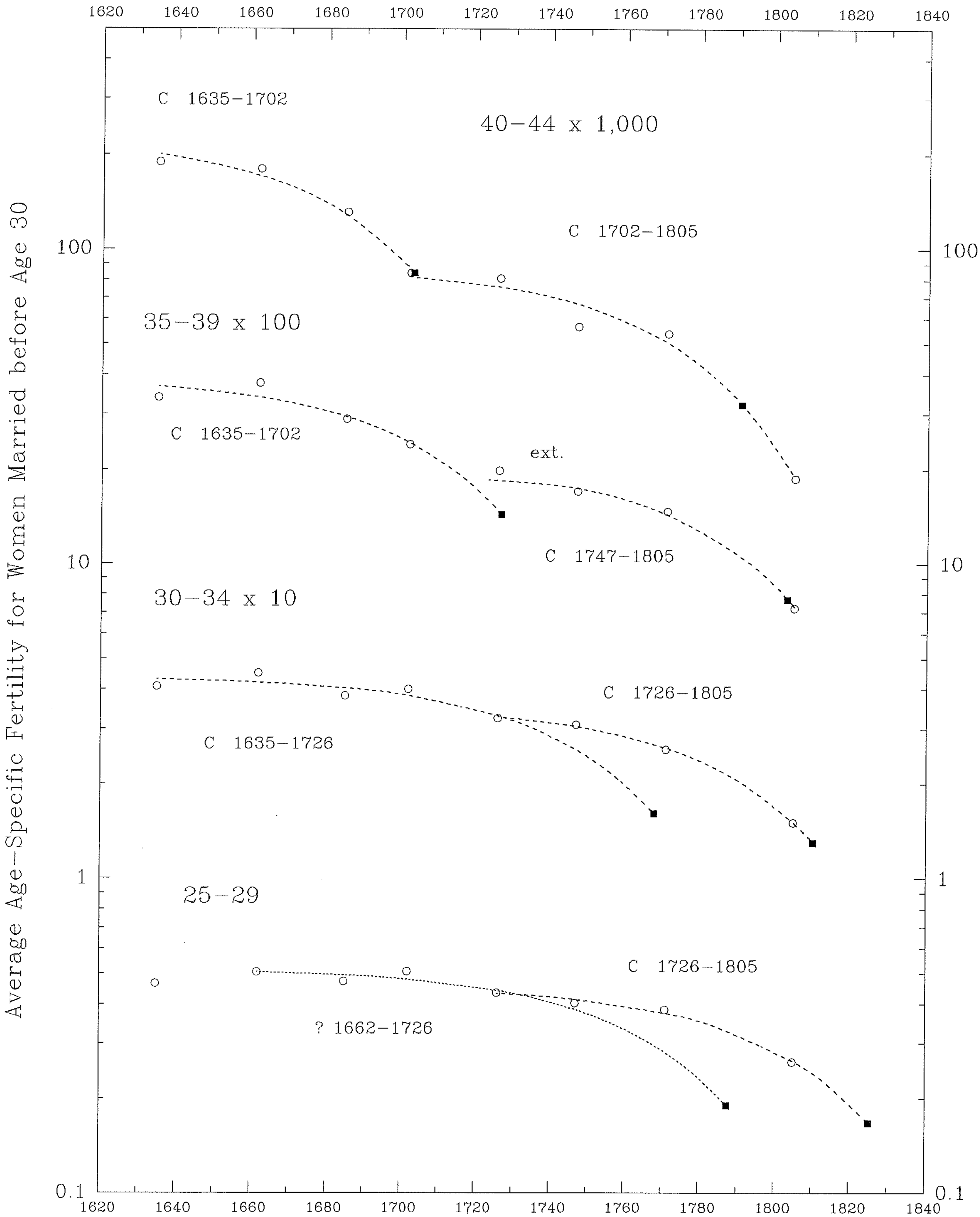
Completed Family Size of Women in Geneva Who Married at Certain Ages



Source: Perrenoud 1990, 249.

Figure 5.7

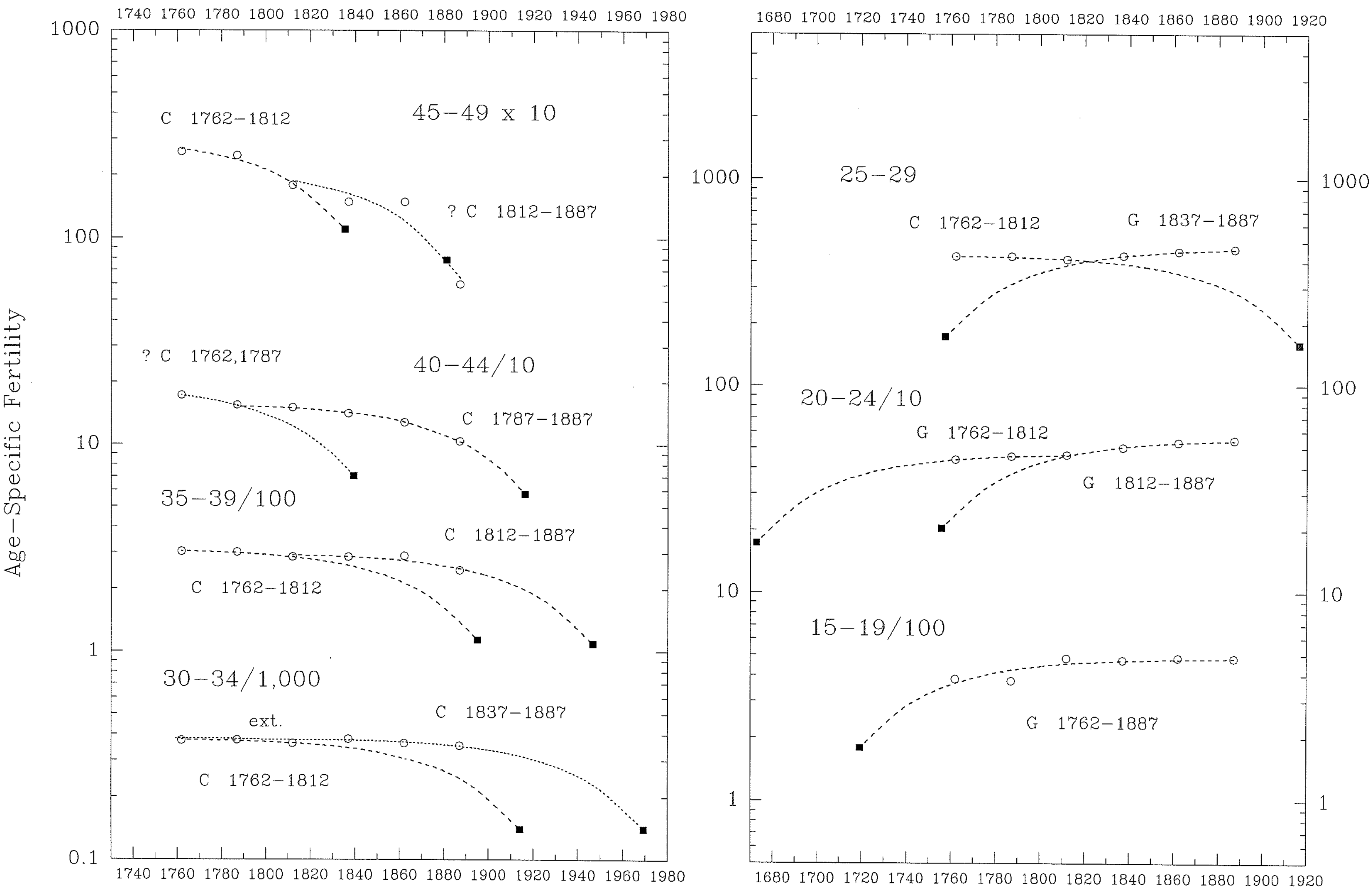
Approximate Trends of Age-Specific Fertility in Geneva 1635-1805



Source: Perrenoud 1990, 249.

Figure 5.8

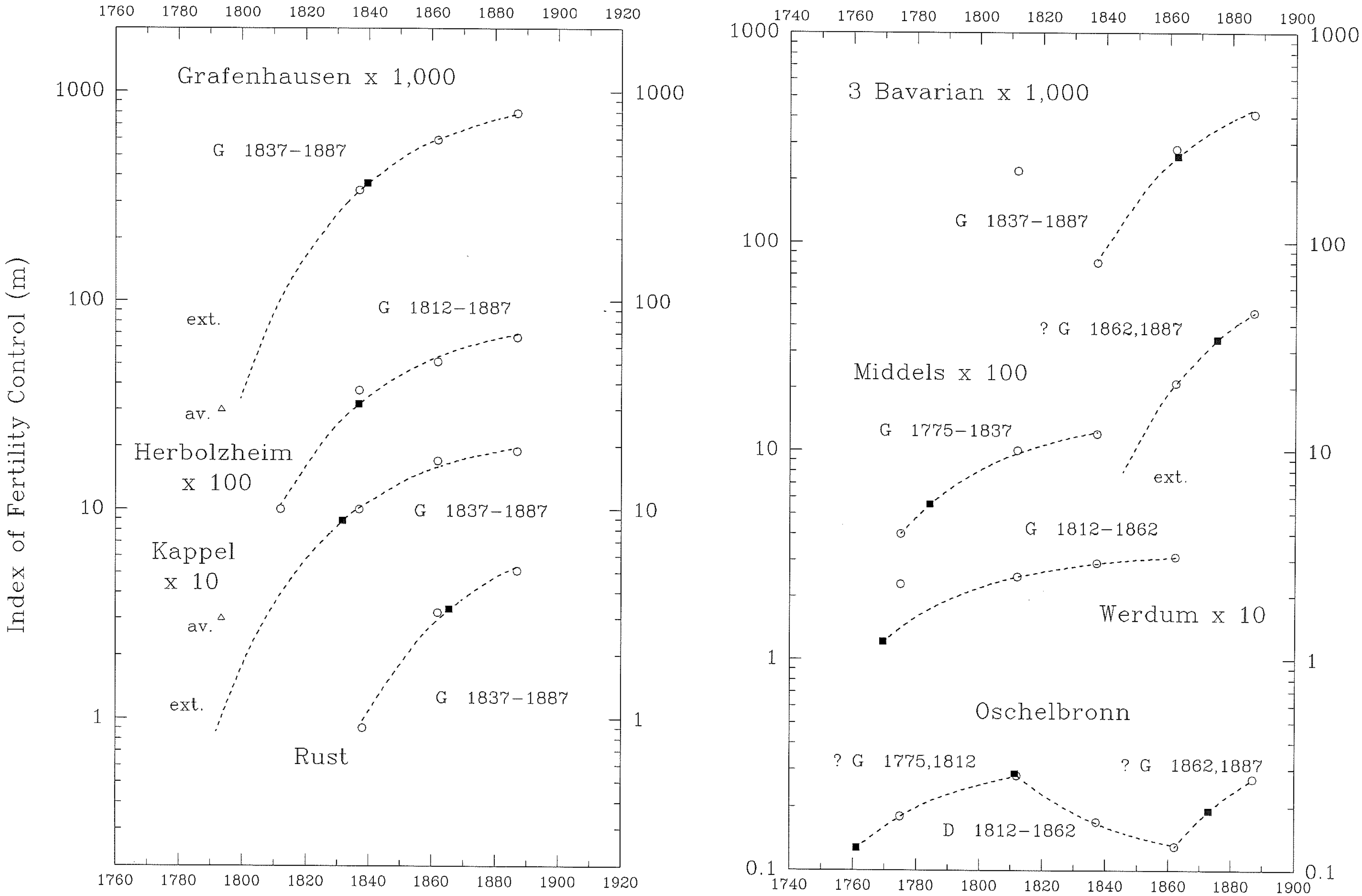
Age-Specific Marital Fertility in a Selection of German Communities 1762–1887



Source: Knodel 1986, 358.

Figure 5.9

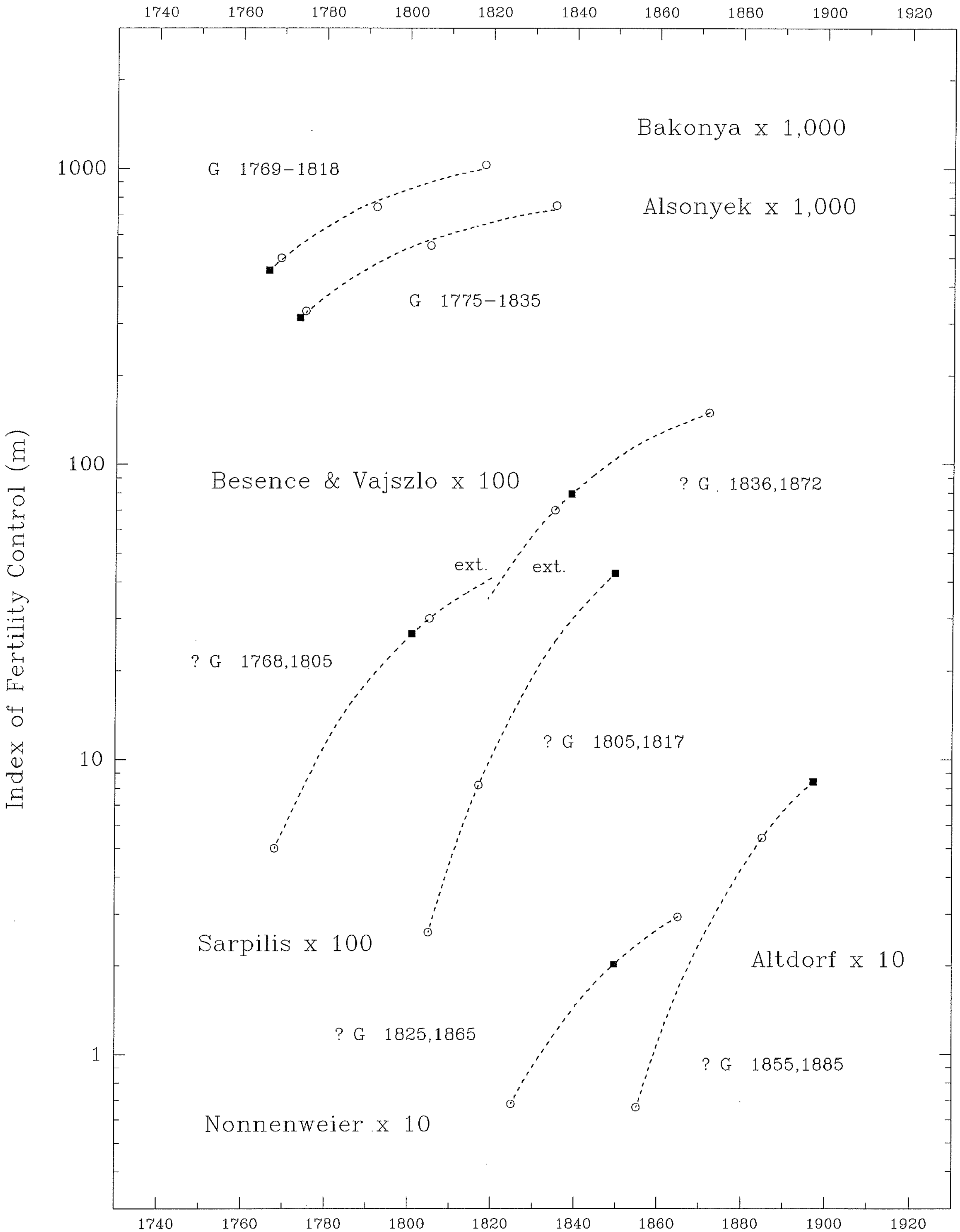
Fertility Control (m) in Knodel's German Villages 1775–1887



Source: Knodel 1986, 356.

Figure 5.10

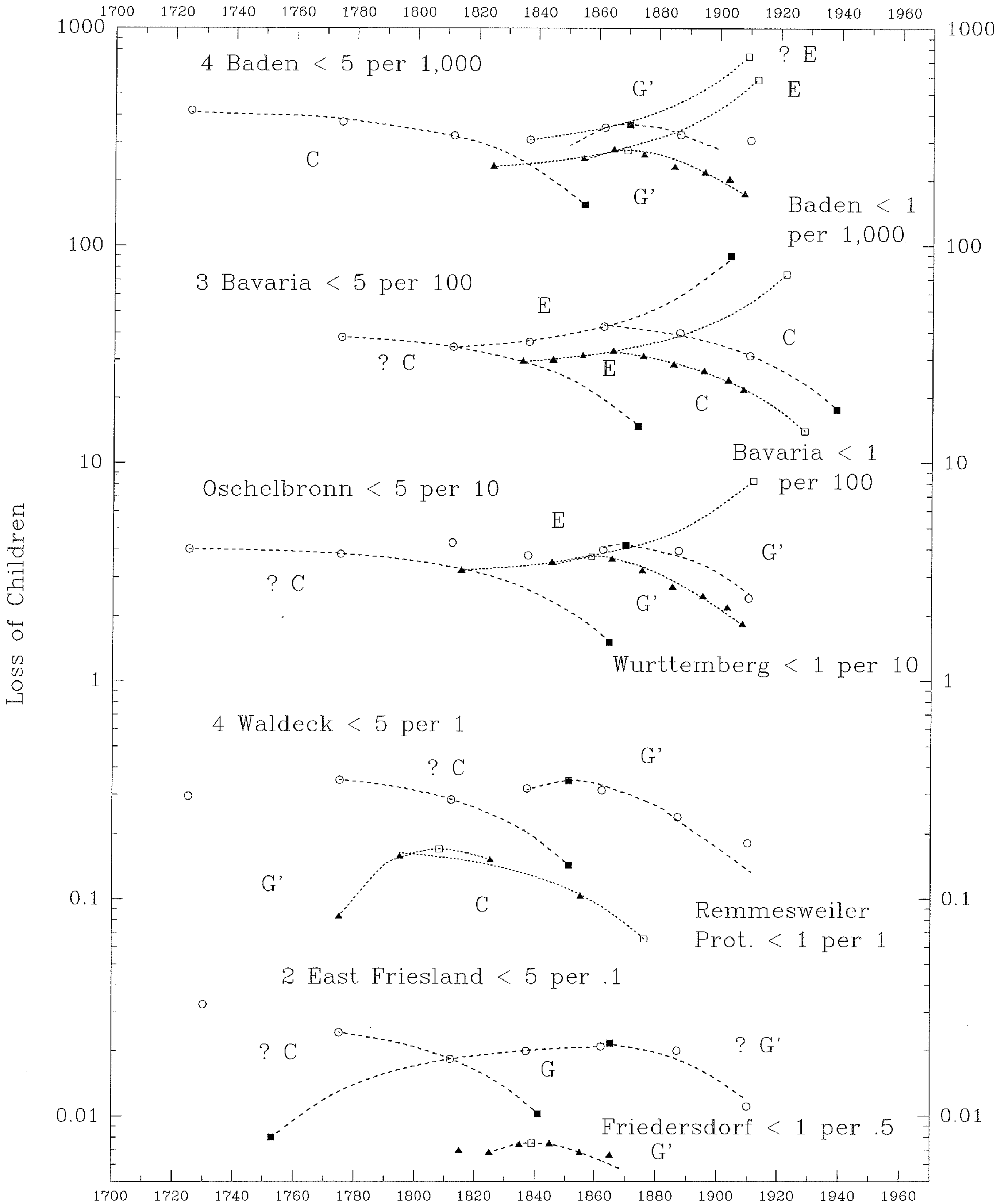
Fertility Control (m) in Four Hungarian Localities and Two German Jewish Communities



Sources: Coale 1986, 15; Livi Bacci 1986, 193.

Figure 5.11

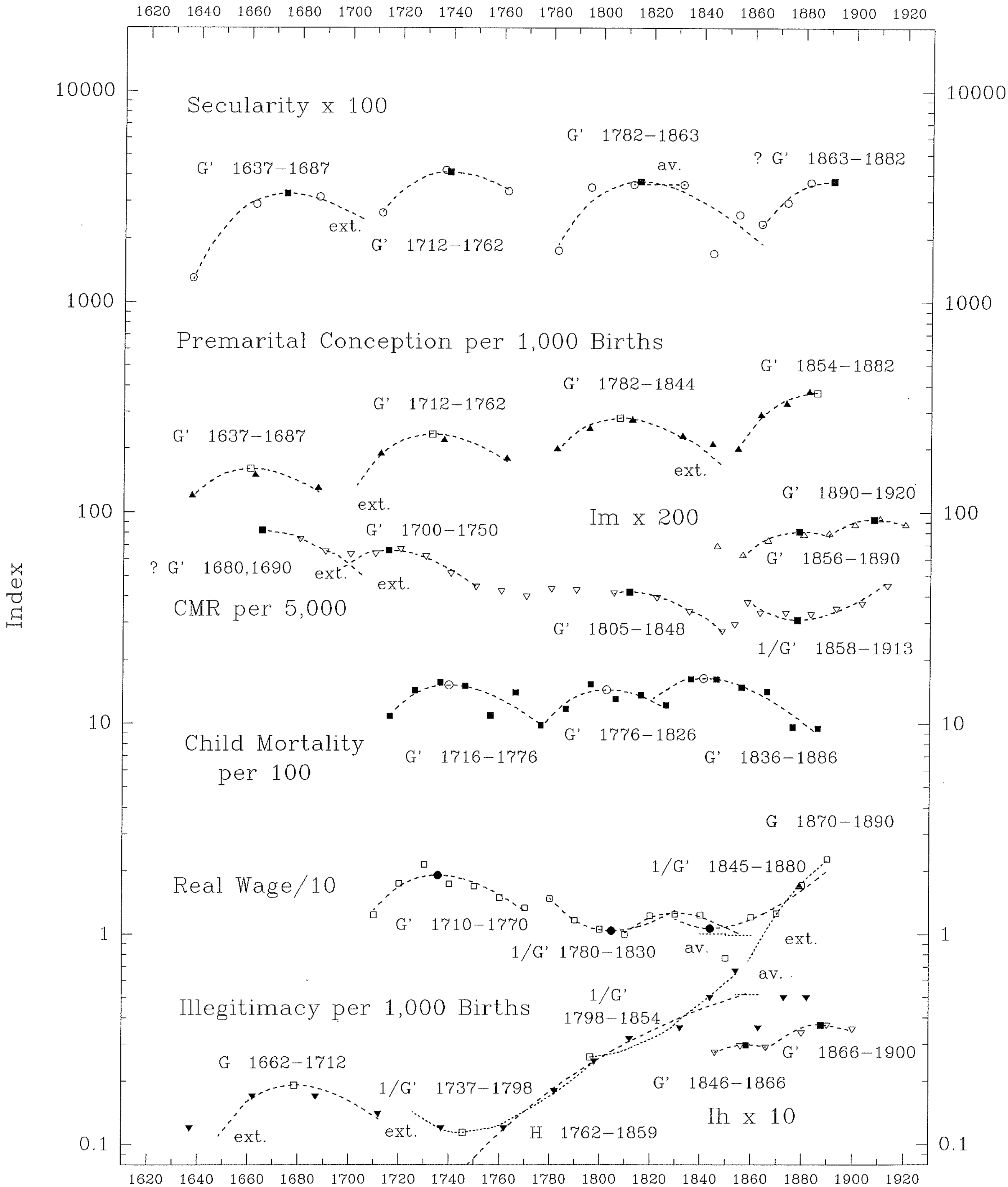
Infant and Childhood Mortality in Some German Localities



Span of trends given in Table 5.7; hollow circles = Knodel probability of dying by age 5; solid triangles = infant mortality under age 1 in other German populations.
Sources: Knodel 1986, 348–49; W. R. Lee 1979, 186–87.

Figure 5.12

Secularity, Illegitimacy, Child Mortality, Nuptuality, and Real Agricultural Wages in Flanders 1637–1900



Sources: Lesthaeghe 1991, 266; Devos 1999, 116; Devos 2003, 32; Lesthaeghe 1977, 57, 121.

Table 5.1

Three National Patterns of Demographic Change: England, France, and Sweden

M_i	I_g	I_f	TFR
ENGLAND:			
1580-1640 C 1700	flat	1558-1663 C 1712	1556-1661 C 1711
1640-1730 G 1596	flat	1663-1723 G 1624	1661-1726 G 1615
1710-1750 C 1791	flat		
1750-1810 C 1856	flat	1718-1818 E 1860	1726-1816 E 1851
1815-1848 G 1768	flat	1823-1858 /G' 1845	1816-1851 D 1787
1848-1957 C 1932	1881-1931 C 1928	1871-1931 C 1929	1851-1933 C 1926
FRANCE:			
	1700-1760? G 1630[a]		1700-1730s G 1652[b]
1745-1805 C 1833	1755-1817 C 1853[c]		1742-1807 C 1855
1805-1843 C 1873	1796-1852 C 1880		1807-1837 C 1875
1795-1845 D 1770[d]			
1858-1937 C 1933	1831-1911 C 1933	1831-1911 C 1940	1837-1913 C 1938
SWEDEN:			
1753-1823 C 1871			1758-1808 C 1880
1828-1888 C 1908	1800-1850 C 1970		1823-1913 C 1945
	1860-1900 C 1962		
1888-1957 C 1931	1910-1930 C 1920	1880-1930 C 1930	1908-1933 C 1941

[a] = average t_0 of Southwest 1700-1790 and Normandy 1700-1730; [b] = average t_0 of Southwest 1700-1760 and Normandy 1700-1730; [c] = Scania only; [d] = Bideau et al.

Sources: Figs. 1.1, 1.4, C.2, 4.3a, 5.1a, 5.1b, 5.2; Tabs. 1.4. 2.4a, 4.1, 4.2, 4.3; Harris 2003, 204; Chesnais 1992, 549-50; Bideau et al. 1988, 287.

Table 5.1 (cont.)

Three National Patterns of Demographic Change:

England, France, and Sweden

CBR	I_m	CMR	CDR
1556-1661 C 1710	1558-1663 C 1712	1556-1651 C 1684	1556-1681 E 1722
1656-1751 G 1602	1663-1763 G 1618	1661-1756 G 1607	1681-1731 /G' 1704
			1731-1761 /G' 1752
1726-1816 E 1862	1758-1818 E 1860	1761-1841 C 1895	1761-1831 C 1880
1816-1846 D 1779	1828-1868 /G' 1845		
	1851-1871 G 1780	1831-1871 G 1788	
1851-1933 C 1933	1891-1931 E 2015		1831-1923 C 1936
1742-1802 C 1859		1742-1827 C 1896	1752-1827 C 1853
1802-1848 C 1895	1831-1876 G 1735		
	1876-1901 G 1759		
1848-1912 C 1944	1901-1960 G 1847		1828-1912 C 1951
		1650-1710 G 1599[c]	1693-1743 /G' 1716
		1715-1788 C 1854	
		1803-1833 G' 1814	1743-1843 C 1881
1693-1933 C 1941	1880-1930 G 1771	1843-1893 C 1931	1843-1923 C 1941

Table 5.2

Comparing Some Western European Trends in Fertility

Marital Fertility (Ig)			
France		1841-1871 /G' 1856	1876-1911 C 1933 = .202
Southeast Paris Basin	1700-1790 C 1868 = .306		1790-1880 D 1775
Normandy	1730-1770 C 1801 = .344	1770-1810 C 1828 = .287	1820-1900 C 1967 = .188
Southwestern France	1780-1820 C 1864 = .248	1830-1870 C 1907 = .188	1870-1900 C 1946 = .151
Spain		1768-1860 C 1924 = .280	1860-1910 C 1975 = .243
Belgium		1806-1846 G' 1821	1846-1930 G' 1863
Netherlands		1859-1879 G' 1870	1870-1930 G' 1886
Denmark		1853-1880 /G' 1863	1870-1930 G' 1881
Portugal		1864-1890 /G' 1877	1900-1940 C 1959 = .301
Italy		1864-1881 /G' 1871	1881-1951 C 1959 = .274
Gross Marital Fertility (GMF)			
Tuscany	1820-1840 C 1886	1840-1880 C 1927	
Liguria		1861-1881 C 1919	
Piedmont			1836-1881 C 1962

Children per Lasting Marriage (CPM)

Southeast Paris Basin	1750-1810	C	1849 = 2.75						
Normandy	1700-1730	G	1660 = 2.84						
	1730-1750	C	1792 = 2.95	1750-1790	C	1819 = 2.29			
				1790-1810	C	1866 = 1.82			
Southwestern France	1700-1760	G	1645 = 2.06	1760-1810	C	1875 = 2.07			
New Castile	1700-1750	C	1840 = 1.55	1790-1810	C	1855 = 1.85			
	1750-1790	G	1702 = 1.75	1820-1850	G'	1834			
Tuscany				1822-1857	C	1903 = 2.22	1857-1897	C	1959 = 1.84

Sources: Tabs. 4.1, C.4; Figs. 5.1a, 5.1b, 5.3; Livi Bacci and Reher 1993, 75, 76.

Table 5.3

Total Fertility in European Elites and Associated Trends

UP:

European Ruling Families	1525-1625	G	1432 = 2.266
Geneva's Bourgeoisie	1575,1625	?G	1535 = 3.704
New Castile	*1640-1700*	*G*	*1562*

DOWN:

Genoa's Families	1575,1625	?C	1687 = 2.598
British Peerage	1575,1625	?C	1690 = 2.690
GRR for England	*1556-1661*	*C*	*1701*
New Castile	*1600-1640*	*C*	*1688*
Geneva's Bourgeoisie	1625,1675	?C	1700 = 3.848
Milan's Aristocracy	1625,1675	?C	1735 = 3.616
Genoa's Families	1625,1675	?C	1748 = 2.278
Geneva's Bourgeoisie	1675,1725	?C	1756 = 2.625
Geneva, Perrenoud	*1662-1714*	*C*	*1762*
Milan's Aristocracy	1675,1725	?C	1766 = 3.268
French Dukes and Peers	1675,1750	?C	1756 = 2.041
Rouen	*1655-1715*	*C*	*1755*
European Ruling Families	1625-1725	C	1775 = 2.295
British Peerage	1625-1725	C	1791 = 2.334
Florence's Aristocracy	1650,1725	?C	1790 = 2.562
Florence, Jewish CBR	*1681-1763*	*C*	*1790*
Genoa's Families	1675,1737	?C	1808 = 2.076
Leghorn, Jewish CBR	*1713-1788*	*C*	*1828*
Milan's Aristocracy	1725,1775	?C	1823 = 2.566
Rouen	*1715-1774*	*C*	*1820*
New Castile	*1700-1750*	*C*	*1840*
Florence's Aristocracy	1725,1775	?C	1842 = 2.285
European Ruling Families	1725,1775	?C	1849 = 1.984
Belgian Aristocracy	1715,1790	?C	1854 = 2.944
New Castile	*1790-1810*	*C*	*1855*

UP:

British Peerage	1725,1775	?E	1833 = 14.430
GRR for England	*1726-1816*	*E*	*1851*
Milan's Aristocracy	1775,1825	?E	1933 = 14.881
New Castile	*1750-1790*	*G*	*1702*

DOWN:

Geneva's Bourgeoisie	1775-1825	C	1863 = 1.925
Geneva, Perrenoud	*1747-1805*	*C*	*1820*
British Peerage	1775-1875	C	1888 = 2.377
Milan's Aristocracy	1825,1875	?C	1902 = 2.311
Modena/Verona, Jewish CBR	*1788-1886*	*C*	*1905*
Padua, Jewish CBR	*1839-1906*	*C*	*1904*
Florence, Jewish CBR	*1788-1843*	*C*	*1911*
Leghorn, Jewish CBR	*1788-1818*	*C*	*1905*
Leghorn, Jewish CBR	*1823-1848*	*C*	*1886*
European Ruling Families	1775-1875	C	1937 = 1.7266

UP:

Geneva's Bourgeoisie	1825,1875	?E	1966

Sources: Livi Bacci 1986, 185-86, 191; Perrenoud 1990, 247; Wrigley and Schofield 1981, 528-29; Tabs. 2.3a, C.4.

Table 5.4

Trends of Fertility Control in European Elites

	Livi-Bacci	Pinto & Sonnino
Florence I	1650,1725 ?G 1629 = .373	1650,1725 ?G 1622 = .471
Genoa	1625-1737 G 1630 = .288	
Milan	1625-1725 G 1636 = .340	1625-1725 G 1663 = .456
Geneva	1625-1725 G 1653 = .458	
French D & P	1675,1750 ?G 1663 = .608	
Florence II	1725,1775 ?G 1718 = .784	
Belgium	1715,1790 ?G 1727 = .181	

Sources: Livi Bacci 1986, 185-86; Pinto and Sonnino 1997, 504.

Table 5.5

Approximate Trends of Completed Family across France, with Geneva

Rouen I	1655-1715	C	1755 = 2.81*	Meulan	1685-1802	C	1817 = 2.36*	Normandy II	1790-1810	C	1866 = 1.82*
Geneva I	1662-1714	C	1762 = 2.52*	Vic sur Seille I	1752,1777	?C	1815 = 2.4	Bas Quercy	1800-1840	C	1870 = 2.3
				Normandy I	1750-1790	C	1819 = 2.49*				
				Rouen II	1715-1774	C	1820 = 2.18*	Bordeaux City	1800-1840	C	1903 = 1.7
				Geneva II	1747-1805	C	1820 = 1.88*				
				Ile de France V.'s	1752-1802	C	1820 = 2.4	Rural Gironde	1851-1911	C	1931 = 1.2
				Rouen Suburbs	1700-1780	C	1822 = 2.43*	FRANCE II	1851-1911	C	1937 = 1.4
				4 Garonne V.'s	1775-1820	C	1832 = 2.4				
				Vexin	1700-1820	C	1836 = 2.14*				
				N.E. Quarter	1755-1805	C	1838 = 2.4				
				N.W. Quarter	1755-1805	C	1839 = 2.2				
				Vic sur Seille II	1777,1802	?C	1840 = 2.0				
				3 Norman V.'s	1720-1800	C	1842 = 2.33*				
				S.E. Paris Basin	1750-1810	C	1849 = 2.75*				
				FRANCE I	1792-1831	C	1850 = 2.6				
				S.E. Quarter	1755-1805	C	1850 = 2.0				
				S.W. Quarter	1755-1805	C	1851 = 2.1				
				4 Morvan V.'s	1775-1820	C	1851 = 3.1				
				Barentin	1760-1800	C	1854 = 1.87*				

* Graphed and fitted in Harris 2003, 204, or Figs. 5.1a and 5.5. Remainder estimated by template from background graphing.

Sources: Harris 2003, 204; Figs. 5.1a and 5.5; Bardet 1988, 355-58, 364.

Table 5.6

Approximate Age-Specific Fertility Trends in Some French Communities or Local Areas and Geneva

Age:	3 E. Parisien Parishes	Meulan	10 Arthies Parishes
20-24	1752-1812[a] C 1852 = 210	1752-1827[a] C 1863 = 175	1765-1812 C 1832 = 190
25-29	1752-1812 C 1829 = 210	1752-1802 C 1828 = 190	1757-1812[b] C 1828 = 170
30-34	1752-1812 C 1823 = 170	1752-1802 C 1821 = 165	1780-1812 C 1823 = 190
35-39	1752-1812 C 1808 = 150	1752-1827 C 1828 = 120	1757-1812 C 1816 = 110
40-44	1752-1812[c] C 1828 = 64	n.a.	1780-1812 C 1804 = 50
45-49	1752-1804[d] C 1802 = 9.8	1752-1802 C 1793 = 8.0	n.a.

Age:	Suresnes	Flins	Verneuil
20-24	1747-1820[e] C 1845 = 210	1752-1802 C 1823 = 230	1752-1812[f] C 1840 = 180
25-29	1747-1800 C 1818 = 230	1777-1827 C 1819 = 190	1752-1812[f] C 1835 = 170
30-34	1747-1800 C 1810 = 200	1752-1802 C 1806 = 180	1777-1812 C 1836 = 150
35-39	1747-1820 C 1806 = 160	1752-1802 C 1800 = 145	1752-1812[f] C 1799 = 170
40-44	1747-1800 C 1794 = 83	1752-1827[g] C 1794 = 74	1752-1812[a] C 1820 = 55
45-49	n.a.	n.a.	n.a.

Age:	Donnemarie	Anet	*GENEVA*
20-24	1801,1820 ?C 1844 = 215	1760,1795 ?C 1850 = 180	1635-1805 C 1845 = 190
25-29	1801,1820 ?C 1823 = 230	1760,1795 ?C 1820 = 210	1726-1805 C 1825 = 167
30-34	1801,1820 ?C 1842 = 130	1760,1795 ?C 1811 = 180	1726-1805 C 1810 = 130
35-39	1801,1820 ?C 1860 = 58	1760,1795 ?C 1794 = 150	1747-1805 C 1803 = 77
40-44	n.a.	n.a.	1702-1805 C 1791 = 32
45-49	n.a.	n.a.	

[a] 1777 high; [b] 1780 low; [c] 1785 weighted average for 1765-1804; [d] 1804 weighted average for 1790-1819; [e] 1800 high; [f] 1797 high; [g] 1790 weighted average for 1765-1814.

Source: Lachiver 1973, 390; Fig. 5.8 and Perrenoud 1990, 249.

Table 5.7

Comparing Age-Specific Fertility in Several European Contexts

	England	Sweden	Geneva (France)	German Villages	Prot. Hungary	Cath. Hungary
15-19	1637-1712 C 1746					
20-24	1612-1662 C 1753					
25-29	1612-1662 C 1725					
30-34	1612-1662 C 1720					
35-39	1612-1662 C 1718					
40-44	1612-1687 C 1719					
45-49	1612-1662 *G* 1565					
15-19	1712-1763 *E* 1774		1662-1702 *E* 1734			
20-24	1662-1737 *G* 1607		1662-1726 *G* 1558			
25-29	1662-1712 *E* 1770		1662-1726 C 1788			
30-34	1662-1737 *G* 1596		1635-1726 C 1768			
35-39	1662-1737 *G* 1602		1635-1702 C 1727			
40-44	1687-1812 *G* 1655		1635-1702 C 1703			
45-49	1687-1737 *G* 1640		-			
15-19	1762-1812 *E* 1875	1758-1848 C 1843	1702-1747 C 1784	1762-1887 *G* 1719	1769,1806 C 1836?	1769-1817 C 1862
20-24	1762-1812 *G* 1644	1753-1773 C 1801	1726-1805 C 1845	1762-1812 *G* 1673	1769,1801 C 1842?	1769-1817 C 1840
"		1773-1828 *E* 1901				
25-29	1737-1812 *E* 1908	1753-1773 C 1808	1726-1805 C 1825	1762-1812 C 1916	1769,1806 C 1846?	1792,1817 C 1841?
"		1773-1833 *E* 1898				
30-34	1737-1787 C 1871	1753-1783 C 1830	1726-1805 C 1810	1762-1812 C 1914	1769,1806 C 1837?	1769-1817 C 1829
"		1783-1828 *E* 1891				
35-39	1737-1787 C 1859	1753-1788 C 1840	1747-1805 C 1803	1762-1812 C 1895	1769,1806 C 1827?	1769-1817 C 1835
"		1788-1878 *G* 1738				
40-44	1687-1812 *G* 1655	1753-1788 C 1845	1702-1805 C 1791	1762,1787 C 1839?	1769-1836 C 1812	1769-1817 C 1805
"		1788-1883 *G* 1746				
45-49	1762-1812 C 1898	1753-1813 C 1852	-	1762-1812 C 1835	-	-

15-19	1848-1913 *E* 1907	1762-1887 *G* 1719	1769-1836 *D* 1740
20-24	1823-1848 C 1862	1812-1887 *G* 1756	1806-1873 *D* 1790
"	1848-1908 *E* 1950		
25-29	1833-1908 C 1972	1837-1887 *G* 1757	1806-1873 C 1834
30-34	1823-1908 C 1950	1837-1887 C 1969	1806-1873 C 1883
35-39	1873-1908 C 1931	1812-1887 C 1940	1836,1873 C 1897?
40-44	1873-1913 C 1907	1812-1887 C 1881	up
45-49	1818-1853 C 1896	1812-1887 C 1881	-
"	1858-1938 C 1908		

Sources: Fig. 1.6, Tab. 1.3; Fig. C.8; Fig. 5.7, Perrenoud 1990, 249; Fig. C.11, Knodel 1986, 358; Andorka 1979, 17, 21.

Table 5.8

G-Form Trends of Fertility Control (*m*) in Ordinary European Populations Preceding and Leading into the Fertility Transition

Geneva*		1700-1777	G	1710 = .170
Bakonya (Southern Transdanubia)	C	1769-1818	G	1766 = .454
Alsónyék (Southern Transdanubia)	CV	1775-1835	G	1774 = .313
Öschelbronn (Württemberg)	P,p	1775,1812	?G	1761 = .128
Werdum (East Friesland)	P,m	1812-1862	G	1769 = .121
Jussy*		1790,1825	?G	1770 = .170
Geneva*		1777,1822	?G	1772 = .360
Middels (East Friesland)	P,m	1775-1837	G	1784 = .055
Besence & Vajszló I (So. Transdanubia)	CV	1769,1805	?G	1801 = .266
Jussy*		1825-1870	?G	1810 = .270
Besence & Vajszló II (So. Transdanubia)	CV	1836,1872	?G	1839 = .795
Kappel (Baden)	C,p	1837-1887	G	1832 = .088
Herbolzheim (Baden)	C,p	1812-1887	G	1837 = .318
Grafenhausen (Baden)	C,p	1837-1887	G	1840 = .366
Sárpilis (Southern Transdanubia)	CV	1805,1817	?G	1850 = .427
Nonnenweier (Germany)	J	1825,1865	?G	1850 = .202
3 Bavarian Villages	C,i	1837-1887	G	1862 = .259
Rust (Baden)	C,p	1837-1887	G	1866 = .333
Öschelbronn II (Württemberg)	P,p	1862,1887	?G	1873 = .191
Middels II (East Friesland)	P,m	1862,1887	?G	1875 = .341
Altdorf (Germany)	J	1855,1885	?G	1897 = .840
4 Waldeck Villages	P,m	1862,1887	?G	1914 = 1.500

* = estimated; C = Catholic; CV = Calvinist; P = Protestant; J = Jewish; i = impartible; m = mixed inheritance; p = partible.

Sources: Figs. 5.9, 5.10; Ewbank 1993, 349.

Table 5.9

Some Local and Regional Trends of Infant and Childhood Mortality in Europe 1725-1910

C-Shape Declines:

ENGLAND	*C*	*1715-1805*	*C*	*1816*
"	*I*	*1750-1810*	*C*	*1856*
FRANCE	*I*	*1745-1805*	*C*	*1833*
Mittelberg (Switz.)	I	1765-1845	C	1834 = .154
2 E. Friesland Villages	C	1775,1812	?C	1841 = .103
Mulsum (Stade)	I	1755-1855	C	1849 = .164
4 Waldeck Villages	C	1775,1812	?C	1851 = .143
Göhlen (Meckl.)	I	1762,1787	?C	1852 = .083
4 Baden Villages	C	1725-1812	C	1855 = .154
Leipzig	I	1775-1835	C	1857 = .144
Öschelbronn (Württ.)	C	1725,1775	?C	1864 = .151
3 Bavarian Villages	C	1775,1812	?C	1874 = .147
P Remmesweiler (Lorr.)	I	1795-1855	C	1876 = .065
FRANCE	*I*	*1805-1843*	*C*	*1873*
Bavaria	*I*	*1865-1908*	*C*	*1928 = .139*
3 Bavarian Villages	C	1862-1910	C	1939 = .176
NETHERLANDS	*I*	*1873-1932*	*C*	*1911*
GERMANY	*I*	*1863-1937*	*C*	*1938*
BELGIUM	*I*	*1893-1932*	*C*	*1938*
DENMARK	*I*	*1893-1957*	*C*	*1933*

G' Surges:

Flanders	*C*	*1716-1776*	*G'*	*1739*
ENGLAND	*15*	*1707-1755*	*G'*	*1726*
"	*C*	*1750-1790*	*G'*	*1768*
"	*15*	*1755-1795*	*G'*	*1771*
3 Karlsruhe Villages	C	1755-1825	G'	1788 = .232
C Remmesweiler (Lorr.)	I	1775-1825	G'	1792 = .158
Lohmen (Meckl.)	I	1762-1837	G'	1796 = .215
P Remmesweiler (Lorr.)	I	1775-1825	G'	1808 = .170
ENGLAND	*C*	*1800-1830*	*G'*	*1804*
"	*15*	*1805-1833*	*G'*	*1821*
Flanders	*C*	*1776-1826*	*G'*	*1824*
Göhlen (Meckl.)	I	1812-1862	G'	1831 = .227
Friedersdorf (Silesia)	I	1825-1845	G'	1839[a]
Flanders	*C*	*1836-1886*	*G'*	*1841*
4 Waldeck Villages	C	1837-1887	G'	1851 = .349
Württemberg	*I*	*1845-1908*	*G'*	*1858 = .371*
FRANCE	*I*	*1848-1878*	*G'*	*1864*
2 E. Friesland Villages	C	1862-1910	?G'	1865 = .217
Öschelbronn (Württ.)	C	1862-1910	G'	1869 = .418
Baden	*I*	*1855-1908*	*G'*	*1869 = .274*
4 Baden Villages	C	1862,1887	?G'	1870 = .361
GERMANY	*I*	*1878-1917*	*G'*	*1878*

G-Shape Increases:

ENGLAND	*I*	*1640-1730*	*G*	*1596*
"	*C*	*1690-1740*	*G*	*1663*
2 Oberhesse Villages	I	1765-1855	G	1711 = .048
Böhringen (Schwarzwald)	I	1755-1865	G	1713 = .127
GERMANY	*I*	*1838-1868*	*G*	*1725*
DENMARK	*I*	*1853-1893*	*G*	*1739*
2 E. Friesland Villages	C	1812-1862	G	1753 = .080
2 Oberbayern Villages	I	1785-1845	G	1764 = .197
Prussia	*I*	*1818-1845*	*G*	*1761 = .148*
BELGIUM	*I*	*1843-1863*	*G*	*1787*
NETHERLANDS	*I*	*1838-1873*	*G*	*1803*

E-Type Accelerations:

3 Bavarian Villages	C	1812-1862	E	1904 = .867
4 Baden Villages	C	1837,1862	?E	1909 = .744
Baden	*I*	*1825-1865*	*E*	*1912 = .582*
Württemberg	*I*	*1815,1845*	*?E*	*1912 = .826*
Prussia	*I*	*1835-1873*	*E*	*1912 = .446*
Bavaria	*I*	*1835-1865*	*E*	*1922 = .740*
Öschelbronn (Württ.)	C	1837,1862	?E	1936 = .974

C = estimated to die under 5; I = died in first year: 15 = died by 15; *Bavaria*, etc. = whole state (infant deaths per 1,000).

Sources: Tabs. 1.4, 5.1, 5.10; Knodel 1986, 348-49; W. R. Lee 1979, 186-87; Figs. 4.3a, 4.3b, 4.3c, 5.11, C.9, and C.10.

Table 5.10

Comparing G' and 1/G' Short-Term Fertility-Relevant Trends in Flanders

Secularity	1637-1687 G' 1674		1712-1762 G' 1739
Premarital Conception	1637-1687 G' 1660		1712-1762 G' 1732
Crude Marriage Rate	1680,1690 ?G' 1665		1700-1750 G' 1715
Nuptuality (I_m)			
" in Sart (Liège)			
Child Mortality			1716-1776 G' 1740
Illegitimacy		1662-1712 ?G' 1679	1737-1798 1/G' 1746
Non-Marital Fertility (I_h)			
Real Rural Wage (10-yr.)[a]			1710-1790 G' 1735
Real Day-Lab.'s Wage (rye)[b]	1647-1707 G' 1675		1707-1732 G' 1741
Real Weaver's Wage (rye)		1662-1712 G' 1693	1707-1772 G' 1741
Weaver/Day-Laborer (rye)		1672-1732 G' 1703	
Day-Lab. Days for Rent	1612-1682 G' 1656	1672-1732 G' 1696	1707-1797 1/G' 1733
Total Income per Capita		1670-1725 1/G' 1685*	1725-1770 G' 1738*
Agric. " " "		1670-1725 1/G' 1688*	1725,1750 ?G' 1735*
Rural Industry " " "		1670-1725 1/G' 1683*	1725-1770 G' 1740*

* estimated by template; [a] apparently in rye from Vandenbroeke 1988, 272-73 (Devos 2003, 32); [b] Vandenbroeke 1984, 922, quinquennial like real wage for weaver.

Sources: Figs. 5.12, D.2; Vandenbroeke 1988, 272-73; 1984, 922; Devos 2003, 32; text.

Table 5.10 (cont.)

Comparing G' and 1/G' Short-Term Fertility Relevant Trends in Flanders

Please note that PMGH drew a penciled line through the row with an asterisk; I could not find any explanation in his notes {MSW, 7 July 2015}

	1782-1863 G' 1815		1863-1882 G' 1890
	1782-1844 G' 1809		1854-1882 G' 1887
	1805-1848 G' 1811		
			1856-1890 G' 1878
	~~1812-1832 G' 1804*~~	~~1836-1864 G' 1838*~~	~~1864-1892 G' 1874*~~
	1776-1826 G' 1804	1836-1886 G' 1841	
	1798-1832 G' 1824	1832-1873 G' 1858	
		1846-1866 G' 1858	1866-1900 G' 1888

	1780-1830 1/G' 1805	1845-1880 1/G' 1844	
1742-1777 1/G' 1764	1792-1847 G' 1811	1820-1892 1/G' 1844	
	1792-1842 G' 1804		
1727-1797 G' 1759	1792-1847 G' 1797		
1727-1757 ?G' 1750*	1757-1797 G' 1795		

	1803-1835 G' 1814*		
	1803-1835 G' 1816*		
	1803-1835 G' 1812*		

Chapter 6

Trends in Overseas European Populations

The European evidence of Chapters 4 and 5 on characteristic historical movements in fertility and fertility-related developments serves to introduce many manifestations of G-related change in the replacement processes of populations. Insightful comparison, contrast, and generalization, however--both over time and cross-culturally--are further advanced by some examination of the usually less chronologically extensive, and often less precisely documented, particulars of historical populations elsewhere.

How have demographic developments in other parts of the world resembled or departed from the European experience so far encountered? What more is indicated from such comparison or contrast about the manner in which change in populations works, and the way that G-based trends might be universally imbedded in demographic processes? First considered are transplants of European population overseas, in particular former British colonies composed primarily of European stock rather than dominated demographically by indigenous peoples or imported Africans (as were may colonial enterprises). Then are examined mostly quite recent particulars for other societies around the globe.

SOME BROAD CHARACTERISTICS OF SOCIETIES STARTED AS BRITISH COLONIES

Figure 6.1 begins by graphing total fertility rates for whites in the United States between 1800 and 2007. It does this first with hollow symbols: circles for the seminal findings of Ansley J. Coale and Melvin Zelnik (1963, 36) and hollow downward triangles for a recent analysis by J.

{Please note that the Figures and Tables referenced in Chapter 6 are not interleafed in the text but appear at the end of the text (notes). MSW 31 July 2015}

David Hacker for the years from 1837 through 1878 (2003, 612; selecting ratios for women 15 through 49 from his presentation). The *filled* downward triangles then plot total fertility rates for all U.S. females, Canadian women between 1903 and 1983, and Australian females from 1908 to 1983 (Chesnais 1992, 549-50). Data for New Zealand seem available only starting in the 1950s. Filled *upward* triangles represent calculations of total fertility for the four countries at recent dates from the United Nations's *Demographic Yearbook* for 1992, 1995, and 2000 (409-19, 353-58, and 357-64 respectively) and from Goldstein et al. 2009 (669, 672). At the bottom of the figure, finally, are trended two forms of fertility *ratios* for white women in the United States from the classic analysis of Yasukichi Yasuba (1962, 32, 62). The hollow circles are for children under 5 relative to women 20 through 44 for the substantial era between 1800 and 1930. The hollow downward triangles present the ratio of children under 10 to females age 16 through 44 from 1800 through 1860, the shorter period that constitutes the primary focus for Yasuba's study. Taken together, these data depicted in Figure 6.1 offer considerable initial insight as to how fertility decline unfolded in 'New World' populations initiated under British colonization that before the end of the 19th century evolved primarily from people of northern European stock but increasingly diversified in national origin.

During the later phase of the internationally widespread 'fertility transition,' across the first four decades of the 20th century the total fertility rates (TFR's) for the populations of the United States, Canada, and Australia all declined in C fashion with zero year around 1940.[1] Table 6.1, furthermore, shows how these trends closely resembled the shape and timing of current atrophy for the TFR in France, but lagged a decade or more behind the C patterns for same the period in England and Sweden (with t_0's at 1926 and 1921). The bigger differences among these countries concern the *level* as of the earliest years of the 1900s from which TFR's fell: already only around 2.8 in France, but 3.4 in England and Australia, 3.9 in the United States and Sweden, and as much as 4.8 in Canada (Chesnais 1992, 545-46). In spite of these significant distinctions, nevertheless, largely *parallel* further movement predominates among both the European and the 'New World' countries cited.[2]

The delayed reduction of fertility level in English-speaking countries has been associated with higher per capita incomes achieved across the 19th century in Britain, the United States, and Australia--wealth rivaled only by Canada, New Zealand, Belgium, and the Netherlands (Caldwell 1999, 479-80). TFR in Belgium likewise remained as high as 4.0 about 1900, with 4.5 in the Netherlands. All four Scandinavian counties, however, also had TFR levels roughly from 4.0 to 5.0, as did Switzerland, Italy, Germany, and Austria (Chesnais 1992, 545-46); but, says Caldwell, they lacked the elevated per capita income. Exceptional wealth, in short, was not necessary to sustain high fertility. In explaining reduction, Caldwell seems closer to the mark when attributing the exceptionally low French level, already achieved by the early 1800s (Chs. 4 and 5), to "the moral and religious reassessment that occurred in the tumultuous years of the Revolution, and possibly an inheritance system, requiring partition among all children." The latter, "perpetuated in the Napoleonic code," appears to have been contributing to fertility decline in Normandy since about 1730, and to a lesser extent in the southeastern Paris basin and--after 1760--the Southwest (Fig. 5.1a), during an earlier era when the French may have led other nations in per capita income (Caldwell 1999, 479). The extent of the fertility transition from country to country in 'the West,' in short, seems less related to wealth itself than to the role of women and children in the activities that produced wealth, the significance of their non-employment for status systems, and the place of what are now often vulgarized as 'family values' in the local moral code, whether religious or secular (considerations that Caldwell does pursue for the English-speaking 'developed' countries).

Subsequently, from the 1930s into the 1950s, the total fertility rate in the United States, Canada, and Australia then surged back upward in closely parallel G' fashion as post-Depression 'baby booms' appeared in these countries (Figure 6.1; t_0's around 1968, 1964, and 1966). In New Zealand not enough data are available to ascertain the upward shape of the postwar baby boom. As is well known, however, these waves broke in the 1960s. Atrophy in TFR followed. In the United States and Canada quite abrupt collapse took the form of 1/G’, with zero years at 1999 and 2002 respectively. In Australia and New Zealand, on the other hand, subsequent ‘baby busts’ followed accelerating C trajectories (with t_0’s 1968 and 1964) rather than the more immediate 1/G’ shape found in the United States and Canada. Across the last years of the 20th century, finally, TFR in Canada, Australia, and New Zealand probably began a new phase of at first quite gradual C-shape decrease that targeted the vicinity of 2040. In the United States, in contrast--largely driven by the reproduction of immigrants[3]--the total fertility rate *increased* across the 1980s and 1990s, probably in G fashion with a base year around 1951.

In Europe, meanwhile--in nations also considered ‘developed’--across a geographical cluster composed of England and Wales, France, Switzerland, Belgium, the Netherlands, and the countries of Scandinavia, if one treats outlying data for the quinquennia around 1948 and/or 1943 as likely short-term aberrations of World War II and its immediate aftermath, TFR rose in all 9 of these populations from the 1930s into the 1960s via G (rather than G’) trends with base years in the early 1900s. Then total fertility declined in C fashion (not the 1/G’ of the U.S.A and Canada) with zero year in the vicinity of 1970. Finally, except in Scandinavia, where another lift occurred, total fertility in this northwestern zone of Europe during the 1980s and 1990s generally followed new, flatter C paths (App. C, Tab. C.7; Chenais 1992, 549-50; U.N. *Demographic Yearbook* 1992, 1995, 2000).[4]

While Germany and Spain, more flatly Greece, and more steeply Austria also saw TFR climb in G form into the 1960s or so, from there into the 1980s or 1990s in these other countries total fertility collapsed in 1/G’ shape rather than starting more slowly to accelerate downward via C. In each case such a proposed 1/G’ drop begins between 1968 and 1978 and lasts until about the end of the century.[5] Elsewhere in Europe, any upward postwar shifts did not build in G (or G’) form; instead--especially in Communist countries of the East--they began new C-shape decline, mostly by about 1950 (Tab. C.7).[6]

Overall, mid-20th-century increases in total fertility, though common, were not the same. English-colonized, mostly European-stocked ‘New World’ societies around the globe experienced better-defined G’-shape ‘baby booms’ than European countries, where TFR mostly rose during the postwar years instead via G (Fig. 6.1; Tab. C.7). Then, while fertility receded progressively via accelerating C in Australia and New Zealand (as in most populations of Europe during the later 1900s), the more abrupt 1/G’ (or D’, since D = 1/G) ‘baby busts’ of the United States and Canada resembled the way TFR fell off abruptly in Italy, Austria, Spain, Germany, and Greece.[7] Are these groupings coincidental, or are they related to distinct changes that were taking place in certain societies over the last third of the 20th century, for example a delayed but enthusiastic acceptance of contraception by a postwar generation of Catholic and Orthodox peoples, native-born in Europe but recently immigrant to North America?

What, then, were the international similarities and contrasts before the 20th century? Quite a little can be learned from what historical demographers have over the past several decades established about movements in fertility in the early United States--and even the British North American colonies that preceded them. Caldwell introduces some comparison with Australia, emphasizing the differences between decline in total fertility resulting from change in nuptuality that affected patterns in both countries during the 19th century and reduction in fertility within marriage (1999, 482-84).

Given the available historical data, analyses before 1900 have overwhelmingly focused on the white segment of the U.S. population.[8] For the period from the 1860s into the early 1900s, the total fertility rate for whites as computed by Coale and Zelnik came down only slightly sooner and more steeply in C fashion than the movement that followed from 1907 through 1937 (t_0 at 1929 rather than 1940; Tab. 6.1, Fig. 6.1). Recent calculations by Hacker (2003, 612) attribute a somewhat higher level to the white TFR in the third quarter of the 19th century, but appear to bend downward from 1862 through 1878 in a parallel way. That trajectory, furthermore, if extended forward (not graphed) would seem to hit where the total fertility rate begins new movement in the curves from Chesnais and Coale and Zelnik for the early 1900s. Were the computations of Coale and Zelnik just generally a little low up through 1900? On the whole, it may be reasonable to hypothesize that in fact a single C trend unfolded from the 1860s to through the 1930s which had its target year somewhere near the end of the 1930s.[9] That, as in Canada, Australia, and Sweden (after 1900), was the shape and timing of reduction in TFR in France from 1837 or sooner to World War I, while the C trends for this era were only slightly earlier in England and, to 1908, a generation later in Sweden (Tab. 6.1).

As discussed in Chapters 4 and 5, by the middle of the 19th century fertility in France had *already* fallen significantly below what other European countries experienced. Thereafter, in contrast, further movements were quite parallel. As of the early 1860s, TFR in France was 3.5 compared with 4.6 in Sweden, 4.9 in England, and 5.1 in the United States--4.7 according to Coale and Zelnik (Chesnais 1992, 543-44; Hacker 2003, 612; Coale and Zelnik 1963, 36). Already during the mid-1800s (as noted at the end of the century) it was the French *level* that was distinctive not the shape of trend that fertility in this population followed.

Prior to the Civil War, the total fertility rate for white women in the United States had also been declining in C fashion (as in France, but not England and much more tardily and gently in Sweden). The new calculations of Hacker from 1837 through 1862 simply parallel at a somewhat higher level the trend for computations of Coale and Zelnik from 1800 to 1867 (with t_0's at 1886 and 1888 respectively).[10] Contemporaneously, for the nation the white fertility ratio for children under 5 per 1,000 white females 20 through 44 likewise came down in C form between 1800 and mid-century, with t_0 at 1870, as demonstrated with hollow circles in the bottom portion of Figure 6.1, while in the weighted average for two national genealogical samples the trend between 1748 and 1815 declined via C toward a t_0 in the vicinity of 1850 (Yasuba 1961, 62; Wahl 1986, 396).[11] These trends for the white population of the United States, Table 6.1 indicates, resemble closely the pattern of total fertility decline in France between 1807 and 1837 (t_0 at 1875)--and earlier in Sweden and southwestern France between about 1760 and 1810 (Tab. 6.1). In the United States the downwardly accelerating C trend of this era just was not replaced by a new, flatter C pattern until the 1850s, as opposed to the new trends in the 1830s or the 1810s that appeared in France and Sweden. American TFR, it should be noted, was receding from a high level of about 7.0 at 1800 compared with more like 4.5 in those countries at that date (Figs. 5.1a and 5.2). The exceptions for the first half of the 19th century in Table 6.1 were: most notably, the way in which TFR in England declined in D rather than C form between 1816 and 1856, dropping off from a level of about 6.3, first quickly following the Napoleonic wars and then more slowly with time, to reach about 5.0 before further modern decline assumed the common accelerating C shape; and secondarily the virtually level, late-targeted (1965) C path that appeared in Sweden as of about 1810. [AUSTRALIA from Ruzicka and Caldwell 1977.]

Estimating from Hacker's graphing, furthermore, *marital* fertility (*Ig*) declined in C fashion between 1840 and the mid-1860s (t_0 approximately 1886) almost exactly like his trend for total fertility (2003, 615, 611; Tab. 6.1). This undermines his conclusion that curbing of marital fertility in the United States did not occur until the late 19th century (617). Instead of beginning in the second half of the 19th century the index actually stopped declining and leveled out across this era, one suspects mostly thanks to the greater reproduction of the massive later-19th-century waves of immigrants that so unnerved Francis Walker.

The decline of about 27 percent in U.S. I_g between 1841 and the Civil War, moreover, exceeds the 24 percent calculated for overall fertility in Australia between 1861 and 1881 and the 26 percent for the index of nuptuality there during that period, to which Caldwell attributes contracting total fertility as I_g for Australia actually *rose* slightly. The comparison (1999, 483) erroneously equates a new frontier society, Australia, with an old one that had been founded about 1600, not 1800. While it still had a frontier in the 19th century, the population of the United States grew mostly from a *national* pool of young adults in older settlements who had roughly normal sex ratios. The era of significant shortages of women for the American population as a whole was over in the 17th century, though some still thinly occupied areas of course had these characteristics on into the later 1800s.

The index of marital fertility in the United States had decreased to .61 by the Civil War, compared with .48 in France but .68 for England, .75 for Australia, and .80 for New Zealand (Figs. 1.4, 5.1b; Caldwell 1999, 482). ‘Early’ transition for marital fertility in the United States (as argued, for example, in D. S. Smith 1987) has more substance than is credited. As of the 1860s recorded national trends occupied the following levels:[12]

France	.48		
		United States	.61
Denmark	.65		
England & Wales	.68		
Italy	.68		
Portugal	.68		
Sweden	.70		
Ireland	.71		
Switzerland	.71		
Scotland	.75	Australia	.75
Germany	.76		
		New Zealand	.83
Belgium	.83		
Netherlands	.83		

French historical leadership in the reduction of marital fertility requires some clarification. The biggest comparative contraction there was during the first half of the 19th century: a post-revolutionary phenomenon. Between 1800 and mid-century, I_g in France shrank from .70 to .48 (proportionally some 31 percent), while the English rate--already at .67 by the beginning of the 1800s--*increased* slightly (to .68).[13] The U.S. index, however, declined from about .82 (its level at 1841) or somewhat higher to .61 (a .21 arithmetic contraction equal to that for France, or a slightly less 26 percent proportionally). That for Belgium rose from .81 to .83, much like the modest English increase. In the middle of the *18th* century, furthermore, the French index stood as high as about .80 compared with .63 for the English one. And still earlier, in the vicinity of 1700, the English rate already stood at .64 in contrast to approximately .78 for Normandy, the region of France with earliest signs of lessening marital fertility and .82 for the southeast Paris basin--though more like .67 in the Southwest, where further French decrease in I_g appeared the latest (only after 1830). In many ways this part of France was, until the middle of the 19th century, only weakly integrated into the culture, society, economy, or even language of the northern half of the country (   ). If Wilson and Woods are correct (Fig. 1.4), moreover, the English level of the low .60s had been attained by the *1540*s--or even sooner.

As British colonies became less and less ‘frontier’ farming enterprises benefiting from plentiful and undepleted land, the marital fertility of their populations--still primarily agricultural in nature--moved toward the long-standing English level of the low .60s. Such reduction in the homeland had probably been achieved during the early 1500s as England exploited, in her own way, the disseminating agricultural changes, urbanization, and occupational diversification of that era in northwestern Europe (Harris 2003, Ch.’s 3 and 4). Exceptions in American patterns, however, can be suspected for early and heavily industrialized areas such as southeastern New England, where population increase (via E) and fertility rose (via G’) somewhat through the middle of the 19th century--much as in England and Belgium, leaders of the new economy in Europe (Figs. 4.1b and 4.1a).

The distinctive, constant level of marital fertility in the low .60s since the 16th century for England, as remarked in Chapter 5, was apparently emulated at or before 1700 by the .67 for *southwestern* France--not Normandy, which has been singled out for the first and strongest reduction in the 18th century, but from comparatively high starting levels. Variations in regional institutions across pre-industrial western Europe that might bear upon reproduction require more comparison and contrast, as is suggested also for central Spain and perhaps northern Italy by relative numbers of children per lasting marriage in Table 5.2.[14]

FERTILITY MOVEMENTS IN AMERICA BEFORE THE MODERN ERA

What can be said about the era before 1800 in the British colonies of the North American mainland and the revolutionary United States that thirteen of them formed? While the measures are not all directly comparable to the total fertility rate as presented in Figure 6.1, studies of the population of early America have provided evidence for considerable insight.

For one view, compilations of sketches on graduates of various colleges present some record of the number of children born to college alumni. Figure 6.2 begins by plotting the average number of births found for Harvard and Yale graduates in the published biographical compilations for these two New England colleges. The tallies are dated when the men were 34, the average generational span where this could be calculated--or about 14 years after graduation (Harris 1969, 317). The numbers in each 3-year cohort are often small during the 17th century. From 1656 through 1709 (graduates with known number of offspring from the Harvard classes from 1642 through 1695), nonetheless, the number of children ever born seems to rise and then fall off in G’ fashion, especially if 1690-92 and 1693-95 then 1696-98 and 1699-1701 are averaged. Thereafter, from 1700 through 1754, the number of known births generally rises in G manner.

After a gap in New England collegiate evidence, over the next several decades for the Middlebury graduating classes of the earliest 1800s forward--the longest alumni series among those gleaned by Yasuba (1961, 46) out of previous studies for several colleges--the average total number of children ever born declined twice in C fashion. This happened first among graduates of 1805 through 1825, then among alumni of 1825 through 1855.[15] The second of these trends runs parallel with the C-shape reduction of children who survived to adulthood for Yale families out of classes from 1825 through 1875 (Yasuba 1961, 45; not shown, but graphed for background).

In the families of Hingham, Massachusetts, between the marriage cohorts that preceded 1691 and those of 1691-1715 the number of children per completed family dropped considerably (D. S. Smith 1972, 177).[16] If the two data points follow part of a G' trend, as for the Harvard alumni, the crest of such an early surge would probably have arrived in the 1650s rather than at 1681 (Tab. 6.1), though the difference between the age at marriage for early Hingham men (28) and the Harvard male generation (34) accounts for 6 of these years. Subsequently, Hingham marriages from 1703 through 1750 typically produced more children. If this increase took the kind of G form offered in Figure 6.2, the base year would be about 1686 compared with the 1665 of the Harvard and Yale alumni. Finally, Hingham marriages from the second quarter of the 18th century into the postrevolutionary years gradually began to produce fewer children, perhaps in the kind of C trend offered in the figure. Adjusting the Middlebury alumni by 5 years to give them the approximate age at marriage for Hingham men in the late 18th century, the collegiate C trends of 1810 to 1830 and 1830 to 1860 have zero years that bracket the 1858 for Hingham's movement of that shape.

The Middlebury men, like the Harvard and Yale alumni before them, came from--and subsequently formed families in--more than one local area within New England. The Harvard and Yale trends, for instance, by the early 1700s reflect the demographic adjustments of families living in a mixture of old and new settlements and communities from Maine to the Carolinas, not just coastal eastern Massachusetts.

Table 6.1, furthermore, shows how completed family size in four other Massachusetts towns followed the kinds of movements posited for Hingham. Differences in the timing of these trends elsewhere would seem mostly to reflect when communities were established and how much room they had to expand. In Watertown, an initial site of Puritan settlement like Hingham, the opening G' surge generally crested even earlier, at 1646 (Harris 1969, 319).[17] In a local population that was more rapidly circumscribed by competing new towns as the settlement of Massachusetts expanded, the 1676-to-1739 Watertown G trend that followed a similar G' surge was flatter than the one in Hingham, and the C-shape decline of reproduction through the middle of the 18th century steeper (each with earlier t_0's than in Hingham). Nantucket, a whaling settlement offshore, was not founded until appreciably later in the 17th century. A probable opening G' surge there appears to have peaked around 1712 and was followed by C-type reduction in completed family size that noticeably lagged behind the one in Watertown (Byers 1982, 21). From 1795 through 1835, a second C decline paralleled that for the families of Middlebury alumni. In Sturbridge--a community of the relatively deep New England interior, which was not first settled until 1730--if there was an initial G', it probably crested in the early 1740s and the C-form decline in fertility that followed ran still later than the trend in Nantucket (Osterud and Fulton 1976, 483).[18] While Deerfield was a frontier settlement already in the 1600s, it was repeatedly devastated by Indian attacks. Data there suggest a possible G' surge of fertility peaking as late as the 1760s, as the upper Connecticut Valley was finally opened to safe settlement with the conquest of French Canada. C-shape decline in completed family size that followed for women married from about 1750 forward then paralleled such change in Sturbridge, Nantucket, and Hingham (Temkin-Greener and Swedlund 1978, 31; 23 years are added to date of female birth to estimate average date of marriage).

Evidence from wills and balanced estate distributions in St. Mary's County, Maryland, meanwhile, show a possible G' crest around 1680 in the number of children mentioned, then G-type increase for marriages that probably took place on average from about 1702 through 1748 (Lorena S. Walsh, 1976 personal correspondence; 25 years are subtracted from date of inheritance to estimate date of marriage for comparison). This makes trends in completed family size in one of the first areas of settlement in Maryland resemble those for the earliest communities of New England.

Mid-Atlantic Quakers (from Long Island to Philadelphia) experienced shrinking completed family size among women of average age to marry between the 1730s and the 1790s along a C path that closely resembles those for New England populations in Table 6.2 (Wells 1971, 75). On the other hand, among several elite families with roots in Philadelphia, a place whose settlement lagged behind that of New England, New York, and the Chesapeake, the number of children ever born to completed families from 1737 to 1850 fell in C fashion with t_0 only around 1870 (Kantrow 1980, 27). Such movement resembles contemporary trends for New England college alumni and for women of Nantucket during much of the first half of the 19th century; but lack of evidence for the first few decades before 1737 prevents verifying the possibility of an initial G' trend. The path, however, is much like that found in composite genealogical records for New England women who married in this period (or starting perhaps as early as the 1660s). Their geographical spread presumably covers both early and secondary settlements (Main 2006, 41).

Adjusting to estimate an average age of 23 for women at marriage, furthermore, from 1873 through 1913 the number of children ever born per married female in Massachusetts (Uhlenberg 1969, 413) declined in C fashion mostly parallel with decreases of this shape in the total fertility rates of France, Canada, Australia, and the United States as a whole (Tab. 6.1). In Mormon families, meanwhile, comparable reduction in completed family size was taking place between the 1860s and the 1910s (Skolnick et al. 1978, 16), but timed rather earlier--more like fertility decline in England and Sweden. This followed prior G-shape increase in completed family size from 1840 through 1864--a sequence of trends for relatively new settlement that is familiar from New England and Maryland.[19]

The national genealogical sources tapped by Jenny Bourne Wahl (1986, 406), furthermore, display C-shape reduction in the number of children ever born to New England women of estimated mean age to marry (23 years old) between 1748 and 1841 that has its t_0 in the vicinity of 1852, or like the pattern for Main's collection. Fragmentary evidence around 1798 and 1829 for those residing in the Mid-Atlantic region and the South fits C trajectories with slightly later and somewhat earlier target years respectively. Her families east of the Appalachians, in other words, reduced family size parallel with several trends shown for New England, the Middle Atlantic, and perhaps also Maryland (judging by the white refined fertility ratio there). Then, for marriages estimated from 1829 to 1866, the number of children ever born in Wahl's genealogies for the Mid-Atlantic, accompanied by more weakly documented tendencies in the South and Midwest, contracted again in C form with zero year about 1890, lagging some two decades behind families of New England alumni, Nantucket, and the Philadelphia elite reported in Table 6.1 but parallel with the C-shape decline of total fertility among U.S. whites as a whole. Finally, family histories from the West show decline of C form in children ever born for women married between 1866 and 1910 with zero year around 1913, much like the pattern of change reported for Mormons in Table 6.1. While there are periods of little or no data in one region or another, and some movement in contrary or uncertain direction, much of Wahl's evidence from genealogies conforms to the shape, timing, and region of patterns of change in American fertility that the table derives from other sources.

Contemporary ratios of births to marriages suggest the typical successive movements of fertility through time also in three older Massachusetts towns and satellite settlements that were formed out of them or other nearby communities: Salem with Danvers; Andover with Middleton;[20] and Ipswich with Boxford (the lower half of Figure 6.2). Averaging the three pairs of towns (from Vinovskis 1981, 51) smooths out the variability of data for single communities and makes it possible to follow populations that were expanding beyond political boundaries as the territories allotted to the initial settlements of eastern Massachusetts were over and over again subdivided to include new towns in order to accommodate the needs of larger subsequent generations.

While the earliest evidence is rough, in each of the three pairs of communities a G' surge in the ratio of births to marriages seems to appear in the 17th century. The crest for Salem and

Danvers comes earliest, around 1662. This movement probably involves a timing contemporaneous with the early fertility wave hypothesized for Hingham.[21] Andover, on the other hand, was itself from the start a secondary settlement established by families from the first few towns formed in northeastern Massachusetts, who were dissatisfied with the land and other resources that had been allocated to them.[22] Ipswich, though early, became most fashionable only a little while after the initial wave of Essex County settlement, attracting John Winthrop's son and others up from their first homes in eastern Connecticut. Thus the G' crests in the ratio of births to marriages for these two other pairs of towns, which come around 1694 and 1688 rather than the 1662 for Salem, seem appropriately to reflect rather later pulses of settlement.

Thereafter, from the 1730s to the 1760s or later, births slowly gained relative to marriages in Salem and Danvers and in Andover and Middleton. In the former, the G trend that captures this movement had a base year rather like that for the number of children born to Harvard and Yale alumni during the first half of the 18th century. In the latter, the G pattern (though starting later) is timed more like the one for births in Hingham.

In Ipswich and Boxford, in contrast, though the ratio may have risen slightly from the 1720s into the 1750s, over the longer haul C-shape change begins to appear for the rest of the pre-national period (Fig. 6.2). This trend parallels the way that data from New Jersey, New York, Rhode Island, and Massachusetts show C-form decline in the ratio of white children under the age of 16 to white women 16 and older (Yasuba 1961, 71). The second C movement for Ipswich and Boxford, on the other hand, resembles the pattern for the atrophy of births in the families of Middlebury alumni in the classes from 1805 through 1825 (t_0's at 1842 and 1836). The rather abrupt first drop in the ratio of births to marriages in Andover and Middleton from 1765 to 1785, meanwhile, may or may not have C shape. While also relatively short, however, the segment of evidence from 1785 through 1815 supports a C trend with zero year in the 1870s. That makes it generally parallel with not only the 1825 to 1855 movement among the issue of Middlebury alumni but also the trend for births relative to marriages in Salem and Danvers--though somewhat later than what is indicated for Hingham families from only 18th century evidence (1858).

In all, college, local, and colony-, state-, and region-wide data that are available tell similar stories. In a newly transplanted European society that was primarily based upon the development of farms, fertility first surged in G' fashion to exploit the initial opportunity. After this 'baby boom' had passed, in the early 1700s more gradual and accumulative increase in reproduction of G shape was possible in many places. Though with somewhat delayed base years, these North American G trends resemble patterns of rising fertility during this era in England and France (Tab. 6.1). By the second quarter of the 18th century, however, C-type reduction of fertility was becoming general in older settlements.[23] Once again, these movements mostly resemble declines in western Europe. The contrast appeared in England, where fertility instead rose in E fashion opposite to the C paths for three zones of France, for Sweden, for New Castile and perhaps Tuscany, and for settlements in British North America (Tabs. 6.1, 5.2).

What dynamics that might elevate fertility were shared in the later 17th and early 18th centuries by northwestern Europe and British North America? In England, the demographic source was increasing nuptuality (Fig. 1.4), assisted by higher wages caused by a contraction in labor supply due to surging mortality. Comparable dynamics of change may have been shared contemporaneously in France, where population had also contracted in the later 17th century. In British North America, in contrast, a G trend in initial growth stopped decelerating in the 1670s and constant .03 increase followed (Harris 2001, 17). This could happen because new farm land was aggressively developed behind a continually expanding frontier of European settlement. How England produced the Industrial Revolution through demographic and economic interaction (including gain of E form in nuptuality), on the other hand, would appear to underlie the exceptional increase of fertility there through the rest of the 18th century and into the early 19th, which runs opposite to ubiquitous (though western Belgium proves not universal)[24] C-shape declines in western Europe and North America (Tabs. 6.1, 5.2).

Initial G’ increase in reproduction followed by G-type, steady but decelerating, gain and/or C-shape reduction may be general for new populations. In New Zealand, between 1864 and 1906 the percentage of children under 15 in the white population rose then fell in something like G’ fashion around a crest near 1880, then decreased via C to World War II (Harris 2003, 438). In later-settled farm states of the USA, meanwhile--notably Illinois, Michigan, Wisconsin, and Minnesota--G’ surges in the percentage of the population under 15 appear in early years. This phenomenon also emerged earlier as, following the Revolution and its termination of frontier attacks, peoples of the middle-Atlantic region expanded and spilled over the Appalachians. G’ patterns of youthfulness also crested in Colorado and perhaps Montana around 1900 (ibid., 478-79). G’ trends in the proportion of women, meanwhile, have been very common in late-settled states of the U.S.A. (483), but not always accompanied by G’ for percentages under 15.

Though is complicated by the importation of convicts, the normalization of the population of Australia across the first half of the 19th century may include a G’-type surge of women--and, by implication, children--as free immigrants became a larger proportion of the whole (Harris 2003, 443). Previously, in Dutch South Africa G’ movements in the number of immigrants, white women, and non-white women marrying into the white population peaked about 1720 and helped produce a modest G’ surge in the proportion of children in this population that maximized in the vicinity of 1735, in each case followed by increase in G form (446). Still earlier, in the French Canadian settlements along the St. Lawrence a swelling number of females and families among immigrants generated a bulge of births that peaked around 1680 but thereafter declined as a proportion of the total population (426-27).

In all, surges of fertility--with a tendency to take G’ shape--often have appeared historically with new agricultural settlement, or a shift to agricultural use of the land from other, demographically skewed and thinner exploitation such a fur-trading or mining. More females appear both in immigration and in residence, and those women have more children, in large part because of a surplus of males that pressures young female marriage. Did these distinctive demographic movements, and perhaps also the sequence to trends of G then C shape, also occur when western Europeans pushed eastward during the middle ages, or as Prussian, Hapsburg, and Romanov rulers of the 18th century, or Rhineland principalities of the 17th sought settlers for territories newly acquired?[25] As other historical societies reclaimed land for farming from wasteland, or sponsored recovery in territories depopulated by war, famine, and disease, one might expect comparable patterns in fertility. The phenomenon need not be just a New World one. Historically, that is, settlement or resettlement also almost continually took place in Europe and in Asia, though it may not be so readily documented.

With some significant differences in mechanism, a comparable phenomenon seemingly appears in peoples who were not voluntary immigrant farmers. In the evolution of Atlantic slavery, for instance, while the proportion of children among whites on Barbados (the mother island for British West Indian colonization) crested in G’ fashion about 1707 as the plantation system of life matured, total imports of Africans to Barbados, Jamaica (where established Barbadian planters were the core of early settlement), and the Leeward Islands rose in parallel G’ form (Harris 2003, 414, 330). Slave labor was not only a more reliable source of manpower for the initiating owner (resident or absentee); it also constituted a valuable inheritance for his children and, before then, an asset for borrowing in order to conduct or expand business. As the percentage of the population that was not white climbed via G’ along with importation,[26] natural increase for Africans on the ‘hearth’ island of Barbados from 1685 through 1705 also surged in G’ shape (338).

In slave populations of British colonies, meanwhile, the proportion of women among adults crested repeatedly in G’ fashion--first around 1675 in the West Indies and the Chesapeake, then about 1719 in South Carolina--before then expanding in G form (Harris 2003, 348-49, 352). Parallel with the first two instances, the percentage of women among adult imports of the dominant Royal African Company maximized in G’ shape in the vicinity of 1682 (ibid., 371-72).

Since prices for men were falling to a low in the early 1680s (379), the purchase of women was apparently more than just a desperate effort to find immediate labor, even if it meant acquiring less productive *field* hands. Their presence helped stabilize the slave population as numbers of Africans in the sugar colonies surged threateningly past residents of European stock; and, for the long term, their children added to the accumulating asset value of plantations. Later, when contract laborers from southern Asia swelled plantation labor forces after British termination of African slavery in the 1830s, the proportion of females among Indians going to the Caribbean rose then tapered off after the early 1880s much as the sex ratio for slave imports had done a century before (494, 372). In all, reproduction--if not always fertility rates per woman--can be seen to have taken G' shape for a while in quite diverse kinds of 'new'populations during their early years.

For later periods of settlement, work on three regions of Massachusetts between 1765 and 1860 strengthens a grasp on fertility developments over an era during which information on completed family size for Table 6.1 is available from only a few older towns. Also, it reveals something more about how the history of settlement and the evolving socioeconomic environment of New World life affected change in reproduction. First of all, the left panel of Figure 6.3a depicts--and Table 6.1 puts into comparative context--how the two successive C-shape declines in the white fertility ratios found for Massachusetts as a whole were mostly shared between the 1760s and the 1850s across three broad zones within the colony/state (Vinovskis 1981, 212).[27]

Some insightful variations from region to region stand out, however. In the West (the Connecticut Valley and the Berkshires), where the population was notably the most agricultural of all three divisions of the state in the early 1800s (the right panel of Fig. 6.3b) and new settlement back from the river continued quite late, between 1765 and 1790 the white fertility ratio was still rising somewhat. A speculative G path for that movement would have its base year in the vicinity of 1681, not unlike completed family size for Hingham marriages from 1703 through 1750 (Tab. 6.1). Then the first C trend for declining fertility, from 1790 through 1830, was a little earlier and steeper than contemporary atrophy of that shape for the South and Central regions. After 1830, on the other hand, it was the South region that stood out, with its second C segment of decrease flatter than similar trends in the other two parts of the state. In all zones, as of 1860 the fertility ratio rose somewhat.

The level of births for the foreign born amounted to about 1.7 times the one for native women. Their weight in the mix of potential parents surged with the immigration bulge of mid-century into Massachusetts, pushing up fertility for the total population. Comparably, fertility was steadily higher among New Englanders born during the later 1700s and early 1800s who *left* their communities of origin to settle elsewhere than among those who stayed behind--especially comparing persisting and migrating *farmers*. For those of age to marry in the 18th century, the contrast had been even greater (Adams and Kasakoff 1990, Graphs 1 and 2).[28]

In Massachusetts communities of less than 2,500 residents and in those holding from 2,500 to 10,000 people, decline of the fertility ratio via two C trends also was typical (Fig. 6.3a and Tab. 6.2). The exceptional imprint of urbanization shows up in the largest centers, with more than 10,000 inhabitants. Until 1840 that meant only Boston (placed by Vinovskis with Essex, Middlesex, and Worcester Counties in the “Central” zone). Here, fertility was periodically pushed downward in what seem to be two 1/G’ thrusts: for 1765 through 1810 bottoming around 1791; and for 1820 through 1860 lowest at 1843. (There is no information for 1850.) The second dip in this urban fertility ratio comes at the time when water-powered textile mills most strongly drew young New England women to work away from home in communities that held relatively few men until immigrants began to replace native females in the factories. As of 1850, Lowell on the Merrimack, for instance, with 33,000 inhabitants was the second largest city in the state (Dublin 1979, 20-21). In Boston, meanwhile, in increasing and often desperate immigration young Irish women could often find work more readily than men--but by becoming live-in servants, for whom a pregnancy could mean disaster (Handlin 1959, 61-62). The earlier dip in

Boston's fertility, between 1765 and 1810, probably reflects the stagnation of that city in the pre-revolutionary years as first economic activity thrived in competing maritime centers like Marblehead and Newburyport while an unusual number of widows and other women without men appeared in the city then as Boston underwent considerable disruption during the Revolution.

Figure 6.3b portrays trends in urbanization and employment in Massachusetts and the three regions chosen by Vinovskis. Table 6.2 relates these movements to patterns in fertility over time.

To begin, employment all across the state shifted out of agriculture in C form between 1820 and 1855. It did so earliest and furthest in the Central region. The most obvious local difference, however, stands out in the West, where the target year for the C curve comes only in the 1870s. Here 54 percent of the workforce was still in agriculture as of 1855, in contrast to 16 and 23 percent in the Central and South regions. In spite of mill development in several Connecticut River towns, western Massachusetts in the middle of the 19th century was still largely rural.

This regional distinction in employment shows up another way. The proportion of people engaged in manufacturing in the West was only 18 percent as of 1820, about half the level for the other two regions. Between there and 1855 the fraction expanded to 40 percent, doing so via a slowly decelerating H trajectory. In contrast, the percentage working in manufacture probably grew in accelerating E fashion in the Northeast ("Central") and South, surging toward target years near 1861. As of 1855 no less than 66 percent of the population of the Central zone was in manufacturing, 55 percent in the South..

These distinctive patterns are not unique to Massachusetts. On the one hand, between 1830 and 1890 the fraction of the population of the Old Northwest (Ohio, Indiana, Illinois, Michigan, and Wisconsin) in non-agricultural employment increased in H form from a base year in the vicinity of 1815 (Harris 2003, 212-13). As of 1855, about 40 percent of the workforce was not in farming, some 60 percent was still so engaged. The western, inland part of Massachusetts, in other words, saw its occupational structure evolve in a manner that closely resembled change in this northern trans-Appalachian region where expanding and maturing family farming was also producing more and bigger towns along with growing non-agricultural employment, but was not as far along in this process of economic change as industrial coastal Massachusetts. On the other, the E-shape expansion of employment in manufacturing evident in the Central and South regions of the state closely resembled--with zero years perhaps two decades later--the pattern of that shape for English industrialization which it transplanted across the Atlantic (Fig. X.x).

The left panel of Figure 6.3b indicates, meanwhile, how when centers of 8,000 or more inhabitants began to appear in the West their proportion of this regional population of Massachusetts likewise enlarged in H fashion, a movement distinct from the G' patterns in the South and Central parts of the state. This H path is also how urbanization expanded in the United States as a whole for a century after 1830 (Harris 2003, 211-12), with base year a little later than for the West region of Massachusetts (1835 vs. 1810) since the occupation and development of territory all the way to the Pacific Ocean was involved.

The evolution of the inland end of Massachusetts, in other words, turns out to be in fundamental ways quite typical of further growth and socioeconomic change in settlement for the United States. It was the eastern, coastal portions of the state that were exceptional in their early 19th century development, more like changes in Britain.

In the Central and South regions, as in Massachusetts as a whole, while the percentage of the workforce in manufacturing accelerated upward in E manner between 1820 and 1855, in the shorter period from 1840 to 1860 the amount of such change also matches what happened to the proportion of the population that lived in centers of 8,000 or more residents. The middle panel of Figure 6.3b demonstrates this by showing the *possible* G' trends, which match those found in the left panel (Tab. 6.2). Here, the growth of manufacturing and the draw of cities of significant size went hand in hand. Irish immigration to the United States, which in this period was the predominant overseas source of fresh population in eastern Massachusetts, crested in G' fashion at 1866 compared with 1867 for the possible G' of manufacturing employment and 1871 for the more definite trend of that shape in the proportion of the population living in cities of 8,000 or more (Harris 2003, 25; Tab. 6.2). The total population of Massachusetts, on the other hand, from 1810 through 1850 expanded in accelerating E manner toward a zero year around 1853, almost exactly like the proportion working in manufacture from 1820 through 1855. This was an exceptional pattern of overall demographic increase that in the full history of all 50 U.S. states and their colonial antecedents was shared for certain only by industrially pioneering Rhode Island--between 1790 and 1830, with virtually identical t_0 at 1854 (Harris 2001, 42, 52-53).

While population growth and urbanization in E shape may have been rare in American demographic history, however, they have been found repeatedly in Europe--especially, though not exclusively, in northwestern Europe (Harris 2003, 286). In England, to cite the best documented example, and the one which is most relevant to development across the first half of the 19th century in the United States, several key social and economic trends moved that way:[29]

	Massachusetts	England
Population	1790-1850 E 1853	1726-1806 E 1822
Ind. Prod. per. cap.		1730-1810 E 1825
% in Manufacture	1820-1855 E 1854	1700,1760 E 1800?
" " "		1760,1800 E 1840
Ind. Production		1730-1800 E 1800
" "		1810-1830 E 1835
% in Agriculture	1820-1855 C 1845	1700-1800 C 1820
% Urban (8-10 k)	1790-1820 G' 1825	1700-1850 E 1854
	1830-1860 G' 1871	

Total population in England expanded via E from 1726 through 1806, toward a target date of 1822 for the curve (Harris 2001, 150-51). In Massachusetts (along with neighboring Rhode Island), from about 1790 through 1850 demographic expansion took E form with t_0 at 1853, or about three decades later than in England (Harris 2001, 42). The C-type shift out of agriculture into industrial employment was comparably lagged in timing but similar in shape and relationship to the path of population increase. In Massachusetts, the percentage of labor in manufacturing during the first half of the 19th century rose in E fashion closely in company with population growth. In England, potential E-form increase between 1760 and 1800 in the employment of males somewhat lagged the contemporary E for population (t_0 around 1840 as opposed to 1822); but it may have been the second trend of this shape. Industrial production per capita, however, rose between 1730 and 1810 in E fashion that closely tracked population growth, while in aggregate it followed successive E paths resembling those possible for the share of men in manufacturing. The English movements in population and industrial production per capita lagged slightly behind an E trend in economic innovation as measured by patents, whose increase shifted to take accelerating E shape from the 1780s through the 1840s with t_0 at 1811 (Ch. 10).

The proportion of the English people who lived in cities swelled in E fashion from 1700 through 1850 with zero year in the 1850s, rather later than total population increase and industrial production per capita. This, on the surface, was unlike urbanization in Massachusetts, which advanced in successive G or G' surges. Yet the upward bend at the joining of G trends for towns of 2.5 thousand or more between about 1810 and 1840 (Fig. 6.3b) does resemble the E for manufacturing employment for that period. The G' patterns for cities of 8,000 or more, on the other hand, appear to reflect successive chronologically focused movements of native-born women to early water-powered textile locations (of less significance in the West), then the matching of movable steam power with immigration to existing cities.

For English women, occupational change and urbanization across the later 18th century increased nuptuality and, through it, overall fertility in similar E form as more married young and total marital fertility increased slightly (Figs. 1.4, 1.5, 1.6). In Massachusetts, in marked contrast, overall fertility as estimated by the white refined fertility ratio *declined* via C opposite to E-shape increase in industrial employment from the late 1700s into the middle 1800s (Tab. 6.2). Here, population pressure on resources for farming that were often of marginal quality made it more difficult to establish families and pushed males to seek fortunes westward where new territory was being developed, raising female celibacy in the places they left behind. At the same time, it became advantageous for young women to seek employment away from the farm, to accumulate resources for supporting marriage and perhaps to enlarge the pool of potential spouses. This life-cycle factory work, however, is likely to have raised the female age of marriage and made not marrying more attractive for women. Underlying these quite opposite impacts of economic change upon marriage and fertility in New and Old England was how young Massachusetts men extensively still found greater opportunity through emigrating to new, more promising agricultural territory while in England male wages in urban areas (though falling in real value and encouraging emigration) gained relative to agricultural earnings in E fashion, drawing young men instead to cities, where marriage was freer from traditional rural restraints.

On the European continent, meanwhile, in East Flanders, between 1750 and 1850 real wages for both day laborers and weavers declined in E fashion opposite to an E-shape increase for the population that resembled demographic expansion in Massachusetts at the time, and echoed earlier English relationships up to the beginning of the 1800s. The simultaneous deterioration of the wage advantage for home weavers there relative to common day laborers, in C form with t_0 in the early 1840s, meanwhile, suggests a trend toward industrialization parallel with urbanization that was evident in England rather earlier and possible in contemporary Massachusetts.

New England textile technology was at first simply smuggled from England toward the end of the 18th century to capitalize upon opportunities offered in the North American side of a growing international market for manufactured goods. In England, in contrast, agricultural improvements had fostered urbanization through population increase which generated gains in nuptuality as young people were freed up from traditional rural constraints on marriage. Over the 18th century innovation in production evolved to exploit this extra population profitably. In southern New England, imported, originally ready-made technology found workers first among young women who saw advantage in the relatively nearby factory work of river towns as a stage in the life-cycle that would enhance marriage in increasingly old, crowded, and land-poor farm communities, then among stranded immigrants in places to which coal could be readily delivered for the new, movable steam-driven machinery that replaced water power at fixed locations. Urbanization there largely reflected these successive surges of investment and recruiting. In Flanders, competition from the new international technology devastated the extensive home weaving industry (as it did in England) and along with agricultural change pushed people out of the countryside into cities as cottage earnings fell relative to those of urban workers and even day laborers. Delayed E-shape urbanization, population increase, and downward pressure on wages (for urban workers as well as rural ones) relative to England resulted as the international diffusion of industrial development took hold somewhat later, as in New England (Ch. 10).

In all, the features that made the demographic dynamics of early industrialization in North America different from the European experience were simultaneous opportunities to be had from an expanding agricultural frontier and a supply of foreign immigrants to help man the factories.

TO WHAT EXTENT DO THESE TRENDS OF FERTILITY IN GENERAL REFLECT CHANGE IN REPRODUCTION WITHIN MARRIAGE?

A repeated theme in the historical debate about North America concerns the extent to which fertility *within marriage* accounted for much of the observed overall declines in reproduction, particularly before the middle of the 19th century. Conclusions range from no meaningful decline before the Civil War (Hacker 2003, 614, Wahl 1986) to comparison with the extent of change in France (Smith 1987).

It has been established that before quite recent times it was *not* marital fertility that drove change in overall reproduction for England. To the contrary, I_g remained quite flat (Figs. 1.4, 4.1; Tab. 5.1). Instead, for example, it was E-shape gain in *nuptuality* from the 1750s through the 1810s with zero year at 1860 that mostly generated (along with successive surges in extramarital fertility) the E-form increase of overall fertility during the period. Net population growth was strengthened even further--to have a zero year for its E trend earlier, at 1822--by decline in C fashion of the rate of infant mortality--first from 1710 through 1750 and then from there to 1810 (Tab. 5.1).

In somewhat-later-industrializing East Flanders, with intensive home industry relative to England as a whole, nuptuality and the crude marriage rate in contrast declined via C even as population and urbanization increased in E fashion (paths closely matched by the E rise in percentage who never married)--it would seem because of the accelerating collapse of rural textiles into the early 1800s (Devos 1999, 106; Vandenbroeke 1984, 925-33). Accelerating demographic increase during the 18th century was generated instead by widespread, mostly E-shape, gain in fertility--judging by local Flemish ratios of births to marriages, a pattern found contemporaneously in England for Nottingham and 12 parishes of Worcestershire (Harris 2003, 206-7). In contrast, after about 1750 overall fertility in France, I_f, was indeed predominantly decreased by parallel C movement in I_g, a reduction of birth rates within marriage (Tab. 5.1).[30]

Unfortunately, not as much is known about demographic measures as specific as marital fertility and nuptuality in the United States before the middle of the 19th century. However, I_g for the majority white population, though running at a higher level, declined just from 1841 through 1863 about as much as it did in contemporary France during the whole first half of the 19th century--approximately 26 percent compared with 29 percent (Fig. 6.4; Hacker 2003, 615). The C path that it followed (with target year around 1886) closely resembled, furthermore, trends of that shape for the rate of total fertility and the white refined fertility ratio (Tab. 6.1), which can be affected by nuptuality and mortality, which indicates that this overall reduction occurred mostly *within* marriage contrary to what Hacker concludes for decrease before the Civil War. Subsequently, from the 1860s though the 1870s, I_g leveled out like the new C trend for total fertility across the second half of the 19th century, movement also characteristic of marital fertility in France (Fig. 4.1a; Hacker 2003, 615).

Total period fertility in two national genealogical samples, meanwhile, declined in C fashion from the late 1700s into the middle 1800s largely parallel with Hacker's findings for I_g and TFR and comparable patterns in France (Fig. 6.4, Tab. 6.3; Wahl 1986, 396). Though total *marital* fertility also decreased noticeably in C shape in Wahl's 'B' sample and in the data of both samples taken as a whole, in the 'A' sample there is little evidence of such change (Fig. 6.4). Wahl attributes the difference to peculiarities of the 'B' sample for women born between

1800 and 1812 and of average age to marry in the vicinity of 1829, and concludes that "intramarital fertility regulation did not become important in determining the number of children ever born to a family until the later half of the nineteenth century" (1986, 397).

Such an interpretation disregards the way that decline in this 'B' collection had already pared 15 percent off TMFR between women of age to marry around 1748 and those likely to be wed about 1798 (ibid., 399). The problem seems to lie in the compositions of the two differently derived samples. Collectively, meanwhile, Wahl's total evidence indicates C-type decline in total marital fertility between those wed about 1748 and 1829 with zero year around 1864. This is in fact rather more decrease than calculated by Hacker and comparable to the contraction of I_g in France during the period. Indeed, the U.S. reduction between 1748 and 1829 amounted to 27 percent rather than the 19 percent for France from 1755 through 1830 (Figs. 6.1, 5.1b; Tab. 6.3).

In a collection of just New England genealogies, on the other hand, for females wed between 1737 and 1850 decline in marital fertility similarly took C shape targeting about 1882: in all, a 28 percent reduction--most after 1800 (Main 2006, 41). Taken together, meanwhile, TMFR in genealogies from New England and the Mid-Atlantic in Wahl's study followed a comparable course for women of marriage age between 1748 and 1842 (1986, 406). These changes also paralleled the tracks of I_g in the southeast Paris basin between 1700 and 1790 and in southwestern France between 1780 and 1820 (Fig. 5.1a, Tab. 6.3).

New England, as broadly covered by Main, and this region along with the Mid-Atlantic in Wahl's collection included both older, original mid-17th-century European settlements along the coast and new interior areas occupied as late as after the Revolution. In a sample of Mid-Atlantic Quakers (from Long Island to Philadelphia) the weight of early settlements is, on the other hand, presumably heavier than in the broader eastern regions of the other two studies. In this Quaker group, marital fertility for women 20 through 44 fell between 1738 and 1793 in C form toward a t_0 about 1825--or closely parallel to the decline of I_g between 1770 and 1810 in Normandy, the region of France with the earliest reduction in marital fertility, though it should be remembered that one still earlier C-shape contraction had already taken place there between 1730 and 1770 (Fig. 5.1a). While that initial Norman trend, with zero year about 1800, resembles in proportional change current reductions of that shape for completed family size in Watertown and perhaps the ratio of births to marriages in Andover among towns of eastern Massachusetts (Tab. 6.1, Fig. 6.1), there is no evidence as to how much of those early American reductions took place within marriage.

In Wahl's data, among females of age to marry between 1829 and 1853 who lived in the Midwest the C path of falling TMFR paralleled changes during those years in New England and the Mid-Atlantic before assuming a new C track through the second half of the 19th century, which resembled the current trend of I_g in France (Tab. 6.3). Total marital fertility rates for genealogies from the West, in contrast, surged--roughly in G' shape--to a crest for those of age to marry in the 1860s. This movement gave data from the Midwest and the West together clearer, if less elevated, G' form between marriages of the 1850s and the 1890s, peaking about 1860, also imprinting this pattern upon the total evidence (the solid squares in Fig. 6.4) as proportionally more of the total data came from the Midwest and the West (Wahl 1986, 406).[31] The West and much of the Midwest were newly settled during the years around the Civil War. The G' surge in marital fertility there at this time is analogous to the several G' movements for completed family size or the ratio of births to marriages in early settlements of New England and Maryland (Fig. 6.1, Tab. 6.1).

In rural Ontario, meanwhile, 25 percent decrease in I_g comparably appeared between 1861 and 1891--rather later. A C trend that would fit the only two calculations of I_g offered heads to a t_0 around 1916 at a level just slightly lower than the U.S. path thirty years before. A C trajectory for all of Canada would be considerably flattened (made to bend only later) by the province of Quebec, where decrease amounted to only 7 percent. This effect is likely to be counteracted somewhat by the fact that provincial totals that include cities are not given for 1891. As of 1861 Canadian cities had lower marital fertility than rural areas, and their proportion of the total population increased significantly between 1861 and 1891 (McInnes 2000, 394, 407).[32]

In all, through most of the 19th century predominantly rural, if territorially expanding, populations in English-speaking North America experienced reduced fertility within marriage much as has been seen among the still largely agricultural French people to the 1850s, though starting from appreciably higher levels early in the century than already found in France. “Early” decline in *marital* fertility in North America during the later 18th century and first decades of the 19th was a reality, and generally spread across the continent (save in Quebec). The way that in most studies it has largely paralleled the proportional decrease found in more general of reproduction such as overall fertility, TFR, completed family size, and child/woman ratios, furthermore, suggests a limited margin for any *net* effect of change in factors external to the union such as celibacy, age at marriage, illegitimacy, or mortality before the completion of fertility, though these clearly had some impact--if less than has been thought--and must in turn be examined directly as best possible. The exceptions to this generalization are found just for the ‘A’ or random sample of Wahl, among families of the West in her ‘B’ sample, and in Quebec:

France	TFR	1807-1837	C 1875 = 1.88	-16%[33]
	I_g	1800-1852	C 1881 = .289	-29%
Hacker	TFR	1837-1863	C 1886 = 3.10	-30%
	I_g	1841-1865	C 1887 = .384	-26%
Wells	Completed Family	1738-1793	C 1820 = 2.80	-32%
	TMFR	1738-1793	C 1825 = 3.43	-27%
Main	Completed Family	1762-1850	C 1870 = 3.60	-40%
	TMFR	1737-1850	C 1884 = 3.68	-26%
All Wahl	Period TFR	1748-1858	C 1874 = 2.60	-38%[34]
	TMFR	1748-1829	C 1864 = 3.42	-29%
Wahl 'A'	Period TFR	1798-1858	C 1881 = 2.90	-31%
	TMFR	1798-1858	flat	-10%
Wahl 'B'	Period TFR	1798-1838	C 1870 = 2.05	-24%
	TMFR	1748-1829	C 1848 = 3.53	-41%[35]
N.E.-M.A.	Children Ever Born	1748-1842	C 1862 = 2.70	-38%
	TMFR	1748-1842	C 1890 = 3.20	-18%
Midwest	Children Ever Born	1829-1853	C 1885 = 2.30	-20%
	TMFR	1829-1863	C 1868 = 3.50	-16%

West	Children Ever Born	1866-1910 C 1913 = 3.80	-49%[36]
	TMFR	1853-1910 ?G' 1865 =9.05	-30%
Rural Ontario	I_f	1861,1891 ?C 1906 = .210	-33%
	I_g	1861,1891 ?C 1915 = .347	-25%

In all, *marital* fertility within the populations that became the United States of America, though beginning at a much higher level (as Ben Franklin noted in the 18th century), decreased proportionally much as it did in France--repeatedly in C fashion. As French reduction spread from Normandy (significantly for subsequent interpretations, the first area studied by modern historical demographers) to other regions, so did it diffuse in America from older settlements to later ones. The national sums for these regional shifts, however, appear to have declined in parallel fashion for France and the United States during the first half of the 19th century, show the data of Hacker and Wahl, while parallel countrywide reductions still earlier, between about 1750 and 1825, are indicated by the aggregated evidence of Wahl. A distinctive feature of new settlements in America, nonetheless, was the way that initial G' surges of fertility occurred until typical early stages of sex imbalance and plentiful land had passed, a pattern that also seemingly emerged as workers shifted to new factory locations during mid-19th-century industrialization in several European countries (Tab. 4.1).

Regional comparisons and contrasts--whether in terms of available farmland, economic development, or cultural differences--have repeatedly been advanced to structure arguments about the early history of fertility in America (for instance, Wahl 1986, 405; D. S. Smith 1987, 77-83; Haines 2000, 323-28). Since the white refined fertility ratio largely tends to parallel other more precise measures of reproduction, state-by-state patterns in it can be employed to expand regional interpretation of fertility decline still further. Table 6.4 summarizes trends found in white refined fertility ratios for individual sates and groups of them (Yasuba 1962, 61-62). A few of these curves are fitted for illustration in Figure 6.5 (Fig. 6.3a for Massachusetts). The rest are approximated by template.

Everywhere, overall fertility declined in C form. Between 1800 and 1860 sometimes this happened more than once. Some early-settled areas experienced comparable movements *before* 1800 as well (Tab. 6.1 for several parts of Massachusetts in particular, but also Rhode Island, New York, New Jersey, and Maryland). Part A of Table 6.4 lists individual states geographically. Part B averages trends for regional clusters of them, first westward across the North--including data on the total *marital* fertility rate for Utah (Bean et al. 1990, 111)--and then southward and westward across the South.

The earliest core or 'hearth' areas of European settlement like southern New England and the Upper South (if broken down by county this would include the tidewater portion of Virginia along with Maryland and Delaware) as of 1800 already had markedly lower fertility ratios than newer zones of settlement. Native women, meanwhile, had lesser levels for their typical trends of reduction than the immigrants who responded to new life chances that were appearing in 19th-century Massachusetts (Uhlenberg 1969, 413); and, as one would expect from differences between the northern and southern parts of this region, those who moved *within* New England had more children than those who remained in their communities of origin (Adams and Kasakoff 1990). Nationwide, genealogical records comparably indicate higher total marital fertility for immigrant women aged 20 through 44 in virtually all cohorts reaching typical age of first marriage between 1798 and 1900 (Wahl 1986, 412).

Likewise, the first calculated C patterns of contraction into the early 1800s for these older regions tend to have comparatively early zero years, joined by New York, New Jersey, and Pennsylvania, within which there was a kernel of early settlement as well, but also more substantial subsequent inland expansion. Early declines from high initial levels in Vermont and Maine, Ohio, and perhaps Kentucky largely reflect what was going on demographically in the pre-revolutionary zones of settlement from which these areas were briskly populated after the war. Within Ohio, regional white refined fertility ratios (Leet 1972, 50) display the kinds of initial G' surges found with the beginnings of settlement elsewhere (Fig. 6.2, Tab. 6.1). Such movement is most clear, and the peaks come latest (about 1828), for the more remote northwest part of the state. For the central eastern region (between Columbus and Wheeling) and for the southeast and southwest regions, which bordered the great inland artery of the Ohio River, data from 1810 through 1830 or 1840 infer a G' crest in the very first years of the 1800s instead, and C-shape decline then runs through 1860 or later. In the northeastern (Cleveland, etc,) and central western (Dayton to Columbus) portions of the state, possible G' trends would peak in between--more like 1812. The fertility ratio for whites in Ohio as a whole, meanwhile, might take G' shape from 1800 through 1830 with top around 1800 rather than the first C trend given in Table 6.4. During the first 20 to 25 years of Mormon settlement in Utah through the middle of the 19th century, on the other hand, marital fertility increased in G form, as it did for several local populations and social groups of New England during the 18th century (Tab. 6.1).

Second C declines into the middle of the 19th century regionalize rather differently. Most older states, linked to each other and to newer settlements first by water transport then by railroads, now shared further reduction in their white refined fertility ratios in this shape with t_0's in the vicinity of 1880, a pattern paralleled by *first* recorded C-type atrophy in Indiana, Illinois, and Michigan in the North and in the Carolinas, Georgia, Louisiana, Tennessee, Missouri, Arkansas, Mississippi, Alabama, and Florida in the South. That Iowa and Utah, farthest out on the pre-Civil-War frontier, lagged in fertility reduction seems easy to comprehend. Why Delaware, Maryland, and Virginia in the Upper South, albeit at low fertility levels already, witnessed delayed further decline may reflect how naturally accumulating supplies of nationally much-desired slaves and the southward spread of American industry bolstered opportunities for white families in these regions.

Also quite general, as shown in the fourth column of both parts of Table 6.4, was the way that during the first half of the 19th century white women of fertile age in all states increased in G form as a percentage of all white population (including men, children, and females 45 and older). A level of 10.0 percent at the year zero indicates that the G trend is heading toward a maximum of 27.2 percent; 7.5, the bottom of the range, implies an asymptote of 20.4 percent.[37] Notably, there was very little variation in the timing of these G-type increases across the nation, appreciably less spread than among contemporary C contractions in white refined fertility ratio (the third column). Normalization of the sex ratio seems to have occurred across the whole national population fairly much at once, unlike reduction in fertility.

The C-shape fertility declines summarized in Table 6.4, finally, largely determined how population growth repeatedly decelerated in state after state as settlement matured. The last two columns of part A of the table characterize the kinds of population increases that Volume I (Harris 2001, 42, 52-53) identified in these states: I, before the revolution, and II, just following it. Without letters, the numbers denote a succession of timings for the most common form of expansion, deceleration in G shape. For instance, “1’s” for Massachusetts and Connecticut in column I summarize how for much or most of the 18th century residents there multiplied via G trends with base years around 1720, while “2’s” indicate that in New Hampshire and Rhode Island the G movements of this period had base years two decades later or more. (New Jersey had first one, then the other, signifies “1,2”.) After the Revolution (col. II), G trends in Maryland and Virginia comparably had earlier t_0’s than those found for the Carolinas, while the G-shaped growth of the population of Georgia was timed later still (a “3” rather than a “1” or a “2”).

The spans of the trends and their actual zero years are given in Volume I (Harris 2001, 42, 52-53). As detailed there, during much of the 18th century the population of the large area represented by Virginia expanded in non-decelerating F fashion (like the colonies as a whole), while for part of the 19th century Pennsylvania and New Jersey experienced demographic increase in the slowly slowing H form, half way between G and F. From the revolution to 1850 in Massachusetts and Rhode Island exceptional E-type accelerating population growth occurred. In part B of Table 6.4, the slashes separate differing individual categorizations of curves for states that are grouped.

Basically, settlement areas with the earliest decelerating G-shape growth trends display the earliest fertility decline in C form. This association is most clear from part B of the table. Fertility change as populations increased via F or H shapes of trend seem, like the previously discussed E cases of Massachusetts and Rhode Island, to be associated with economic development that was shaped by more than just the spread of farm settlements.

Many studies--some cited here, some not--have sought to explain the decline of fertility in 19th-century America (overviews appear in Wahl 1986, 405-19, and Haines 2000, 323-28). In many cases, population density has been invoked as an important, perhaps the most important, determinant of reduction in what was still a mostly rural society--through mechanisms of land availability, the price of acreage, the percentage of land that was improved, farm values, farm labor, and agricultural mechanization; and, more generally, urbanization, industrialization, interstate migration, immigration, region of settlers' origin, education, religion, and political behavior. Easterlin, Alter, and Condran (1978, 25), in particular, took an important step by analyzing changes in terms of the maturity of rural settlement, judged from the proportion of ever-improved agricultural land that was not improved as of 1860. The findings of the present study indicate that, while this was a useful beginning, a more precise and continuous matching of regional changes in variables through time is needed, one that is sensitive to the recurrent tendency of demographic factors to alter in G-related forms, and to imprint change in these shapes upon economic developments as well.

Insights from regional variation, available since Yasuba's path-breaking study of white fertility ratios half a century ago (others cited in Wahl 1986, 405), clarify how this dilemma should be solved. Especially before 1860, so much depends upon what particular population within the United States provides the sometimes seemingly contradictory evidence.

MECHANISMS OF HISTORICAL FERTILITY CHANGE IN AMERICA:
I. FACTORS OFTEN BEYOND THE CONTROL OF REPRODUCING COUPLES

Though arguments sometimes seem to assume so, it is not useful to make too clear-cut a distinction between personal choices about how many children to have and the effects of external forces upon reproduction. Even the number of live births can be affected by decisions, for one reason or another, to let newborns die as "still births." Women can marry sooner or later, or not at, all through choice as well as in response to the supply of men or resources available for establishing households or for living single, the material standards and social norms for both of which can themselves significantly change. The age at which women stop bearing children can be determined by the death or illness of one spouse or by personal tension that terminates coitus, not just decisions to have no more children (on which couples may disagree). The spacing of births can be shaped by health, separation, or change in duration of nursing (which can reflect individual circumstances as well as cultural norms).

In all, this kind of division is somewhat arbitrary and mainly for convenience of presentation. The main point is that all of these factors affecting reproduction, within and without marriage, change through time in G-based patterns.

For one reason or another, some women never marry. Not much is known about **celibacy** rates in British North America before the 1800s. Main (2006, 43, note 9) estimates, however, that about 4 percent of New England females born before the Revolution reached 45 without marrying, but 20 percent of those born after 1835, or women of average age to marry roughly before 1800 and after 1860. In a *national* sample of genealogies the proportion, starting at 3 percent rises similarly--in a G' surge between the 1750s and the 1870s that crests about 1835 at 22 percent before receding somewhat (Fig. 6.6; Wahl 1986, 402). This compares with more gradual increase from about 4 percent for women born around 1740 in England to 11 percent among those born about 1820 (Fig. 1.5) and 6 to 11 percent for France at comparable points in time (Fig. 5.1b).

The more similar strong surge in celibacy occurred in England among women of age to marry between the later years of the 1500s and the 1620s--from about 5 to 25 percent within approximately 40 years (Fig. 1.5). This is when the already substantial net emigration from the country shifted from religious refugees, who often moved as families, along with soldiers or seafaring personnel to be composed mostly of young men seeking opportunity first in Ireland and then across the Atlantic. Many of these had already departed rural England for London and other centers, leaving potential brides behind, before choosing to go abroad as growing pools of urban labor rendered prospects at home less available and less healthy (Harris 2003, 185, 187).

Migration two centuries earlier in England, in other words, generated a surge in female celibacy comparable to what seems to have occurred in the older settlements of the United States after the Revolution as sons of stressed farmers in the early settlements sought better chances first in the interior regions of New England, New York, Pennsylvania, and Virginia, then over the Appalachians into Kentucky, Ohio, and beyond. Immigration into the Old Northwest (the eventual states of Ohio, Indiana, Michigan, Illinois, and Wisconsin), for example, surged in G' form between 1805 and 1855 or later to crest in the vicinity of 1847 (Harris 2003, 41-42; from Vedder and Gallaway 1975, 161 and 1987, 306).

In the early-17th-century English case, the rise in female celibacy set off decline in nuptuality, which brought down total fertility even as reproduction within marriage stayed constant (Fig. 1.4). By the post-revolutionary years in New England, in contrast, Main's data indicate that a 28 percent *reduction* in total marital fertility accompanied the rise in celibacy. Older agricultural settlements responded to relentless population pressure by *both* out-migration *and* decrease of reproduction within marriage. Growing celibacy, however, did contribute significantly to the way that as far as 1830 the refined fertility ratio (for all white females) in the New England states fell more steeply via C than did total marital fertility according to Main's genealogies, with zero years around 1850 rather than 1880. Between about 1830 and the Civil War, however, the trends became very parallel, suggesting that the impact of *change* in female celibacy upon fertility through nuptuality was no longer a substantial factor in the overall decline of New England reproduction (Tabs. 6.1, 6.3).[38]

In modern times, too, rates of female celibacy have altered in G-related shapes. In the United States, as in England and Wales, the proportion of women of age to marry who never did while still fertile fell in C fashion from the time of World War I to or through the 1950s (Fig. 6.6). Then both national percentages rose in G fashion into the 1990s.[39] The patterns for England and Wales ran about twice as high, and both up and down movements lagged a little behind the U.S ones (Schoen and Canudas-Romo 2005, 141). In Belgium, the proportion of females who survived to 15 who never married fell among those of typical age to wed between 1913 and 1953 through a zero year in the mid-1930s, just slightly earlier than the trends for the United States and England and Wales in Figure 6.6, while--judging by those never married by age 50--celibacy among females reaching marriage age between 1833 and 1943 contracted in slightly delayed but largely parallel C form (with t_0 about 1960; Devos 1999, 128, 130). Celibacy, however, was appreciably more common in northwestern Europe than in North America, falling from 16.5 to 4.5 before rising back to 23.2 percent in England (declining from 18.5 or more to 5.6 percent in Belgium), rather than levels at comparable stages of 5.2, 2.4, and 8.8 percent in the United States.

In highly industrialized Massachusetts, on the other hand, the percentage was about 23 in the years around 1913 and 11 in the vicinity of 1943 (Fig. 6.6, bottom; Uhlenberg 1969, 420). During the 19th century, the proportion there ran around 15 percent as of the 1850s and around 17 percent for the 1870s, or rather lower than the 20 percent for women in Main’s New England genealogical sample of age to marry from the Civil War forward. More distinctively, from World War I to World War II, as the Massachusetts rate fell from 23 to 11 percent the national proportion shrank from 5.0 to 2.4 percent. The Massachusetts level, in other words, was much closer to the one for England and Wales, which dropped from 15.2 to 7.1 percent at these times--and that for Belgium (about 18 to 6 percent). Did degree of industrialization and urbanization, more shared with England and Wales and Belgium by Massachusetts than by the United States as a whole, make the difference? Just how did those conditions affect celibacy?

Besides Massachusetts, during the later 19th century regional female celibacy within the United States can be followed among the Mormons of Utah and other regions of the West to which they diffused from their trek to the Great Basin in the 1840s (Bean et al. 1990, 82; 36, 40, 42). Females known to live to 20 saw celibacy increase from about 1 to 2 percent of those of age to marry between the 1820s and World War I (Fig. 6.6, bottom). Eliminating only those known to die before 20 (Fig. 6.6, top), the celibate percentage (including from 3 to 7 percent with unknown date of death) rose in G’ fashion from about 4 percent among those of age around 1830 (before the migration to the Great Basin) to over 8 percent from 1855 through 1875 as Mormon settlement expanded from its core in central Utah to Nevada, Arizona, Idaho, and Wyoming. This proportion shrank back to about 5 percent, but by rising then falling again in G’ form that crested just after 1890, much like what may be a G’ trend for Massachusetts women from 1873 through 1943, but at somewhat less than half their level (Fig. 6.6, bottom). Among just those known to reach 20 and remain celibate, there are signs of the same kind of movements; but while the second peak is contemporaneous, the first comes as early as among those of age to marry in the 1840s (rather than the 1860s), and a 1/G’ sag between crests is clearer in the data than two successive G’ surges.

The proportion of Mormon females born in Great Britain or Western Europe seems to have been a significant factor for the first G’ surge in celibacy. This share ran as high as 73 percent among those of age to marry around 1850 before falling away across the rest of the 19th century (Bean et al. 1990, 142). The Latter-Day Saints recruited heavily and successfully across the Atlantic following the industrial depression of the late 1830s and 1840s.

The prohibition of polygyny in 1890 might be thought to contribute to a surge in the generally low rate of Mormon celibacy into the first years of the 1900s; but was not a factor in Massachusetts, where comparable G' movement appears. The economic crises of the 1890s, which slowed further in-migration to Utah, seem more relevant for female celibacy in both populations (Bean et al. 1990, 46). The earlier surge in female Latter Day Saints who did not marry, to the middle of the 19th century, was apparently first made low by the high proportion of males among those who first settled Utah (a dynamic observed long before in both early New England and the Chesapeake), then rendered more normal by the mostly family-structured in-migration that followed (ibid.). The impact upon L.D.S. celibacy of sex-ratios for immigrants from Europe, a flow that ran high through the 1840s, 1850s, and 1860s, would be of interest (other recruiting sources may also have provided more women than men, ibid. 80-81). Did polygyny, which increased from about 6 percent among the marriages of females of typical age to wed around 1825 to 23 percent in the vicinity of 1858 before fading away by about 1890 (ibid., 94-95), spread at least partly as a response to female surpluses in a society that stressed family?

Mortality can shape overall fertility significantly. It can trim the number of women available to reproduce. It can disrupt marriages by the death of a partner, particularly the woman during her still fertile years. Until recently sterility was also beyond the control of couples.

Most Mormon females who never married did so because they **died before age 20**. This proportion for all girls born rose from about 1.1 percent to 17.3 percent among those of age to marry between about 1825 and 1895 in a G' path that then tapered off somewhat to the cohort of 1920 (Fig. 6.6; solid upward triangles). In New England genealogies, among daughters of age to marry from the later 17th century through the later 19th, the proportion failing to live to adulthood (much as for young men of their age) repeatedly fluctuated around 20 percent (Main 2006, 40). Heavier losses appeared among those marriageable in the vicinity of 1710 (for girls coming of age in a particularly violent period of border conflict), then 1760 (among those who were children during the diphtheria onslaught of the early 1740s and renewed frontier turmoil), and finally in the early 1870s or just preceding the high point of risk for Mormon girls (a crisis period of American epidemics of cholera and typhoid). In England, in contrast, the proportion for both sexes who died before age 15 ran as high as about 30 percent for most of the time between 1585 and 1833. Particularly after 1700, the trend also displays G' surges, but runs at about one and a half times the levels found among New Englanders and western U.S. Mormons (Fig. A.3b in App. A; Tab. 1.4). Clearly, the impact of female death before marriage has commonly, though not universally, made its imprint upon overall fertility in G' fashion for more than one population (including England during the Elizabethan era of urbanization).

The **loss of one partner** or the other during marriage likewise affects fertility. English mortality rates for young adults between 25 and 40 fell significantly from the middle 1600s to the early 1800s, but did so through three successively lower G' movements (Fig. 1.9, Tab. 1.5). Through the morbidity that led to death, these can be expected to have affected the number of births *within* unions as well as nuptuality. Mormon marriages between about 1840 and 1900 were disrupted by death before the wife reached 45 also in G' patterns that crested in the vicinity of the early 1860s for couples in which both spouses experienced only one marriage in their lifetimes, for first wives, and for the first union of women who married more than once. Such maxima arrive about 30 years before the peak in the proportion of females who died before reaching age 20, reflecting mortality earlier in the life cycle (Fig. 6.6). Deaths for adults that affected fertility, however, moved quite opposite to the 1/G' dip in celibacy among Mormon women from 1840 through 1905 (Fig. 6.5). Among polygynous couples, on the other hand, such an opposite 1/G' trend appears also in the disruption of marriage by death, bottoming also in the 1860s, while for wives who married widowers mortality before the woman reached 45 contracted in C fashion from 1840 through 1915 (Bean et al. 1990, 118-21).

In the United States as a whole, among those of age to wed from about 1939 through 1953 fewer ever-married women had **no children**. The trend took C form with zero year around 1927. It was followed by G-shape increase among those of marriage age between 1963 and 1973 (or later) with t_0 around 1996 (Ruggles et al. 2004; cited by Bailey 2006, 31). Both the C path down and the G trend back up are steeper than the trends for U.S. female celibacy during these years (Fig. 6.6); still, not marrying and not having children once married followed much the same patterns in this society. Since the proportion of couples who are naturally sterile has been quite uniformly estimated at about 3.5 percent for women age 20, 6 percent for those age 25, and 17 percent for those age 30 (Billari et al. 2007, 157), one might expect that in westernized parts of the modern world the parallel of not marrying and having no children once married has resulted chiefly from similar motivations about the benefits and the costs of family formation.[40] In Massachusetts, on the other hand, childlessness among ever-married women tended to surge in G' fashion for those of age to wed between the 1870s and the 1940s, peaking in the estimated marriage cohorts of the 1890s for those without children in their 40s and 30s at 21.6 and 26.1 percent respectively (Uhlenberg 1969, 240). This trend, however, closely resembles the G' paths proposed for celibacy both in Massachusetts and among western Mormons during the later 19th century and early 20th (Fig. 6.6).[41]

Marriage as a monopoly of sex has never been a perfect institution. Even if partners live, unions can effectively end. Meanwhile, some reproduction takes place outside prescribed boundaries.

Separation and continued cohabitation without coitus are impossible to quantify historically. In modern western societies, however, **divorce** has recently become a become a significant factor in reducing how many children are produced, though it must be remembered that, on average, women experience divorce quite late in the span of their fertile years. For almost half of them, divorce has no impact upon fertility--for others, very little. On the other hand, without legal divorce many other couples separate or continue to live together without coitus--because they still care for children or dare not split in spite of interpersonal stress because of poor alternatives to remaining in a marriage. Tension between the institution of marriage and sexuality has been timeless. Modern divorce has to some extent made past disruptions in relationships legitimate and easier to acknowledge. Its pattern yields at least some insight into what shape trends in marital strain that affect reproduction might take through time. Divorce rates have increased apparently independent of general trends in population growth, urbanization, nuptuality, and fertility, though they contribute to the latter two. The change, nonetheless, has taken also long-term G-related shapes. In the United States, for instance, resort to this legal procedure between 1860 and 1950 increased in approximate H fashion from just above 1 per 1,000 currently married couples to over 10 (Rosenfeld 2006, 35). In Belgium, among females of age to wed between 1918 and 1953 and between there and 1967 the proportion of marriages that ended in divorce rose twice via G--from 4.2 percent to 9.4 percent, then from there to 14 percent, alternatively perhaps all the way from 1918 through 1967 along an H path (Devos 1999, 130). From 1953 through 1998 a G' surge maximizing about 23 percent around 1984 is possible. While some similarity emerges between the patterns for the United States and Belgium, in Sweden divorce rates rose in E fashion from the 1850 to the 1920s, then again this ways between the 1920s and the 1940s (Fig. 5.2) from 2 per 1,000 to almost 50.

Increases in violating or abandoning other long-standing norms and customs of marriage further illustrate the way that populations absorb change. In one example of **non-traditional unions or households**, interracial bondings as a proportion of all marriages for whites in the United States have recently surged in G' fashion toward crests in the vicinity of 2020. This is evident for white men with Asian wives, white women with Asian husbands, white women with black husbands, and white men with black wives, reaching 9.2, 3.4, 5.4, and 2.0 percent as of 2000 (Rosenfeld 2006, 42).

Meanwhile, the proportion of young white men cohabiting with women, but not married to them, advanced in parallel G' form to 7.6 percent at 2000. Likewise, the shares of single young men and young women who head their own households have each swelled via G' from the 1950s through 2000 to maximize about 2002, with the fraction of males 20 through 39 who lived in nongroup quarters and neither were married nor lived with their parents surging in G' fashion toward a high in the vicinity of 2011 (ibid., 37).[42] And if the sharp increases in single parenthood among both whites and non-whites between 1960 and 1980 were temporary shocks rather than more durable shifts in level, they too may have taken G' shapes peaking in the last years of the 20th century (Ruggles 1994, 106). Among children of both natives and immigrants in the United States from 1970 through 2000 the proportion who had single parents did indeed climb in G' form, with estimated crests around 2006 and 2003 respectively (Van Hook et al. 2004, 659). Simultaneously, G' trends in single parenthood from 1960 through 2000 that peak around 2001 and 2003 are indicated for the lowest quartile and for the middle two quartiles of women by education (with projected maxima around 47 and 25 percent). For the remaining 25 percent of women with most education from 1970 through 1990 change *may* have followed G' form with about 9 percent near 1987 (McLanahan 2004, 612--also from PUMS). Have these surges now begun to recede?

Meanwhile the proportion of single households headed by women (whether or not they had children) among these and households headed by couples expanded among U.S. women of all races aged 30 through 39 in the Current Population Surveys between 1972 and 2002 in a G' trajectory aimed to crest at about 38 percent in 2006. Separately, for nonwhites a G' crest of some 64 percent is indicated near 1998; for whites (1977 to 2002) about 31 percent around 2005 (Musick and Mare 2004, 632). This is the kind of movement that appears for singleness among Massachusetts women 25 through 54 who came of age to wed between 1873 and 1943 (Uhlenberg 1969, 420).

Recently both eschewing or postponing marriage and willingly or unwillingly engaging in single parenthood have evolved in a context where more women work, of necessity or by choice. While for the second and third quartiles of females by level of education participation in the labor force outside the home increased during the later 20th century in H form, much like industrialization and urbanization in many countries (Harris 2003), between 1970 and 2000 the proportion of U.S. mothers in the upper quartile of educational experience who were employed for a significant fraction of their time climbed in G' shape toward a projected top of 66 percent around 2013 (McLanahan 2004, 613). Yet these women with the most education were least likely to be single parents, never reaching 10 percent during the period studied. Among the *least* educated women, the bottom quartile, between 1960 and 2000 the percentage of mothers who were employed rose the least, from 8 to 30 percent. For them, support from the extended family and welfare probably was most significant. From 1960 to 1980, however, the increase from 8 to 15 percent took G' form with estimated projected maximum around 16 percent in the vicinity of 1992. Then, new gain from 18 to 30 percent appeared between 1990 and 2000. The fundamental shift in welfare policy that took place in the 1990s probably drove some of this renewed expansion of employment among the least educated mothers. If it followed G' form, and continues, a crest of about 45 percent around 2027 would be projected.

In another key social change for American society, the extended family (the role of grandparents, aunts and uncles, half- or whole brothers and sisters in households, particularly those in which children are raised), following slight increase up to about World War I the proportion ended to taper off via a G' trend. For whites, between 1910 and 1980 the curve came down from a crest at 1916. For nonwhites, the G' maximum was appreciably later, at 1931. Later movements of G' shape also occurred, for native-born U.S. women and probably also immigrants (Van Hook et al. 2004, 659). It is estimated that the proportion of children of natives who lived in extended households (many of whom would seem to have been nonwhite) peaked at about 19 percent in the vicinity of 1984, and that segment of the children of immigrants at approximately 33 percent around 2000. This compares with 21 percent extended among all white U.S. households at 1916 and 27 percent at 1931 for nonwhite ones (Ruggles 1994, 1107). At each stage of social and economic change across the 20th century, the group undergoing the greater strain and novelty of environment at the time not surprisingly relied more upon extended family for support. In each case, however, the swing in that direction took G’ shape.

Accompanying movements for childlessness among nonwhite couples, stress on nonwhite families peaked in G’ fashion during the Depression. A similar period of tension drove up childlessness and inability to marry (or stay married) among the women of Massachusetts to a crest in the 1890s--in large part, it is hypothesized, immigrant women. Such women today, though they come from different places than the southern and eastern Europeans of the early 1900s, once again most count on their extended family for support, while less often forging ahead as single-parent heads of households than native females.

These variations in marriage, like celibacy, provide additional examples of how cultural or socioeconomic change of particular relevance to a certain age group, especially a young one, diffuses via G’ in a population. G’ surges have appeared for secularization in Europe among various generations during the 17th, 18th, and 19th centuries, patterns that in Flanders were associated with economic change (Figs. C.6, 5.12; Tab. 5.10). Chapters 1 and 3 of Volume II have likewise identified this pattern repeatedly in migrations, between countries and to cities within them. In that process young adults are motivated to abandon their roots and relocate.[43]

As noted for Europe in Chapter 5, **premarital pregnancy, illegitimacy**, and **extramarital fertility** also repeatedly display G’ surges (or 1/G’ dips). The first is another phenomenon principally relevant for young men and women, the others largely so. Figure 6.7 and Table 6.5 first display examples of American historical patterns for these anti-normative forms of reproduction.

Between about 1660 and 1810, the frequency of premarital pregnancy in several Massachusetts towns (and fornication rates for Essex County) tended to surge in G' form to crest in the vicinity of 1690 and 1775 (and in at least one community also around 1740). Main's collected New England genealogies, meanwhile, display possible G' trends peaking about 1696 and 1735 and fairly clear ones maximizing in the vicinity of 1775 and 1807 (2006, 45).[44] Evidence from other older colonies displays parallel movements.[45] An extension of the second G' curve for these places into the 19th century, moreover, comes down close to where rates from Hingham ("2") and Lexington ("1") resided in the middle of the 1800s. The maximum for this later G' movement reaches about 12 percent of marriages with births 6 months or less since the wedding in the 1770s, compared with about a 20 percent crest for once-Puritan Hingham and 16 percent for Watertown at the time of the American Revolution. The early Bergen level of 19 percent may seem very high relative to a contemporary 4 percent for some still strictly Puritan Massachusetts towns with ample land in the 1680s, but it is not out of line with what happened later on in Hingham and Watertown as communal social control weakened.

At the right end of Figure 6.7, about halfway between the top and the bottom, from 1860 through 1940 a series of numbers cluster around a G' curve with crest at 1903 ("Various U.S. Locales" in Tab. 6.5). These represent the proportion of births in certain U.S. communities that occurred within six months or so of marriage (Smith and Hindus 1975, 561-65).[46] For white women in the United States at large, meanwhile, survey data suggest G'-type movement in premarital pregnancy between 1905 and 1937, cresting at 1914 (D. S. Smith 1973a, 325).[47]

A second, higher G' surge for premarital pregnancy in the United States from 1942 through 1962 (or further), projects a maximum in the vicinity of 1979 (Fig. 6.7; Tab. 6.5, col. 8).[48] This date approximates where a G' curve fitted to 1960 and 1980 observations for the percentage of single-parent households among U.S. whites would also crest (Ruggles 1994, 107). Meanwhile, the proportion of women who bore children *before* marriage (Smith 1973a, 325) increased in G' fashion from 1942 through 1962 with zero year about 1976.

For various stretches between 1940 and 1967, furthermore, age-specific rates of illegitimacy in the United States display G' movements with tops for females 15 to 19 in the vicinity of 1976, 20 to 24 around 1989, 25 to 29 around 1990, and 30 to 34 around 1991 (ibid., 327).[49] Nonmarital completed fertility among women over 40 for whites, blacks, and hispanics swelled in G' form among those turning 25 from around 1950 through the early 1970s toward crests in the later 1970s (Wu 2008, 202). The nonmarital fertility rate for both white and black teenagers from the 1960s to the first years of the 21st century surged in G' manner toward peaks about 2015 and 1995 respectively. Similar patterns cresting around 2015 and 2007 appear for white and black females 20 through 39 (Gray et al. 2006, 241). Among white, black and all U.S. women reaching 23 in the years following World War II, the proportion having one or more nonmarital births by 20, 25, and 30 increased instead in G fashion anchored around the late 1940s, though the black *level* was five times that for whites. For hispanics, the same shape of change appeared from 1965 through 1990 with zero years in the 1970s. From the early 1970s through into the 1990s, all women collectively experienced new G increase for births outside marriage, doubling or tripling the level as the frequency for whites now for some reason surged in E form instead (ibid., 201).

These various perspectives on the U.S. 'sexual revolution' of the post-World -War-II era produce a coherent, mutually supportive picture of behavioral change among young adults. This understanding of the recent is expanded by the recognition of likely G' swings in past reproductive practices since the later 1600s. The phenomenon, furthermore, has been international. The middle and bottom portions of Table 6.5 review some comparable findings from later 16th-century England to 20th-century Australia, drawing upon national, regional, and local evidence on premarital pregnancy, extramarital fertility, and illegitimacy.

Premarital pregnancy in France (Smith and Hindus 1975, 566-67) between the 1680s and the first years of the 1800s moved notably parallel with patterns for British North America (Fig. 6.7). The proportion rose somewhat from peak to peak (around 1690 then 1775), like the rates for New England (and was comparable in level)--though quite unlike the long-term decline found in more mixed colonial data. But then a new G' surge appeared in France from the Napoleonic years into the second quarter of the 19th century that has no parallel across the Atlantic, probably because during the early 1800s opportunity from expansion in settlement eased marriage in the New World while accelerating population pressure from revolutionary-era reproduction combined with losses of men to tighten chances for family formation in France. Later, from 1937 through 1961, premarital pregnancy in France--which had more than halved since the 1820s during a period of spreading family limitation--rose back to about 20 percent in G' fashion, or roughly the level of 1815. Rates for illegitimacy in France, however, seem to have followed rather different paths than premarital pregnancy (Fig. 5.1b)--a difference whose causes might be profitably explored. Extramarital fertility in France, nonetheless, repeatedly rose and fell in G' movements (Fig. 4.4d) along with the other evidence of Table 6.7, as did illegitimacy in several French communities--and in some Swiss and German locales (Tab. 6.5; Figs. C.4, C.7; Imhof 1975, 1: 536-37).

Taking a broader trans-Atlantic view, in Spain, Finland, Denmark, France, Sweden, England and Wales, and Scotland G' surges of extramarital fertility reached their crests from 1890 through 1900, while Germany and various parts of the Austro-Hungarian Empire display maxima in the 1880s (Tab 4.5).[50] In Belgium, meanwhile, from the 1880s to World War I the proportion of illegitimate children who were legitimized surged in G' manner to peak around 1908 (Shorter 1973, 315), suggesting how a later movement of this shape continued still further a series of G' waves in secularization of marriage paired with G' bulges in premarital pregnancy and childbearing out of wedlock that for the region of Flanders can be traced back to the 1600s --and linked to changes in the Flemish economy (Tab. 5.10; Fig. 5.12).

In Norway, Sweden, and England, comparable G' movements appear between the middle or end of the 1700s and World War II. In England and Wales and in Australia the postwar G' surges closely resemble patterns for France and the United States. England also displays a strong

G’ trend very early, through the later 1500s and the first half of the 1600s (peaking with the nadir for real wages around the turn of the century). In between there and the 1750s, however, no movement of this shape appears (Fig. 1.4, Wilson and Woods 1991, 414-15; Fig. 1.7; Wrigley et al. 1997, 224, 421). Instead, extramarital fertility, illegitimacy, and premarital pregnancy within 6 months after nuptials assume H paths, although another calculation of illegitimacy for England (Imhoff 1975, 537) does yield intervening G’ surges that peaked about 1696 and 1746 as well as a comparable one in the vicinity of 1600. The reasons for a possible historical hiatus for G’ surges in non-normative reproduction would be of interest.

The findings presented in Figure 6.7 and Table 6.5 extend and specify more precisely important themes that were advanced fruitfully by Smith and Hindus. There was even more, and more diversely timed, interregional and international comparability in surges of procreation outside of marriage than they identified. Illegitimacy and extramarital fertility, moreover, tended to flow and ebb very much like premarital pregnancy. The shape of these changes between the later 1500s and the early 21st century, furthermore, has repeatedly been G’. These G’ patternings of common and distinct movements of premarital pregnancy, illegitimacy, and extramarital fertility helpfully structure inquiry as to how such trends occurred where they did and when they did.

What made the hegemony of marriage over sex and procreation weaken at these times, in these places, and in this particular form? Local circumstances alone may not suffice for formulating the best answers. What brought about the parallels from place to place? What roles did these G’ trends then play in the further development of communities or societies?

Like the analysis of Smith and Hindus, the study of several fertility-related changes in Flanders and of French and Belgian secularization and illegitimacy (Figs. 5.12, C.4, C.7, C.6; Tab. 5.10 have drawn upon both change in values, as in the era of the American and French Revolutions or in the international attitudinal shifts that followed World War II, *and* evolving socioeconomic circumstances--whether the latter took the form of pressures on land in maturing farming towns, the rise and fall of home industry, the arrival (and aging) of factory industrialization, or the urbanization and migration (especially of young adults) that were central in many of these developments.

In another insight, illiteracy in Hartford County, Conn., Essex County, Mass., New Hampshire, and Maine rose in G' fashion along with this shape of movement in column 2 of Tab. 6.5 for premarital pregnancy in parts of older colonies (Klingaman and Vedder 1987, 160). The comparatively high levels of the other three northeastern locales relative to Hartford County probably reflects the high proportion of seafaring men in communities stretching "down East" from just north of Boston to Falmouth (Portland). The first observations for Maine and New Hampshire, furthermore, probably begin high as they do--rather than rising significantly to a peak--because much of first settlement there, for instance in Gosport and Portsmouth and along the Maine coast, was for fishing and lumbering and lacked the weight of agricultural settlement led by ministers (who were often also teachers) in which Hartford and Essex Counties participated along with their early commercial activities. Did this combination of illiteracy and premarital pregnancy, even in unusually well-educated New England, reappear as other agricultural frontiers expanded, straining support for education and weakening other institutions and diluting other values?

In early New England, those exploiting a new opportunity like fresh agricultural land produced regional 'baby booms.' The new wave of settlement weakened institutions and social control but before long provided people for the next expansion of settlement as inheritance began to figure significantly in the local distribution of life chances and encourage further dispersion. Signs of such dynamics have previously been noted in the G' fertility surges of various Massachusetts towns of the 1600s and 1700s (Fig. 6.2; Tab. 6.1).[51] As in the 19th century industrialization and urbanization of much of Europe, G' surges of fertility were part of what generated bursts of combined, interacting demonomic change in the settlement of America.

During a later period, the underlying path of the fragmentary evidence for premarital pregnancy in several U.S. communities between 1860 and 1940 (Fig. 6.7) very closely resembles the G' surges in absence of marriage and in lack of children within marriage among Massachusetts women over 25 between 1873 and 1943, with peaks in the 1890s, as a further wave of young people was pushed out of stagnating rural communities and drawn along with foreigners to new industrial and commercial centers of opportunity (Fig. 6.6; Uhlenberg 1969, 420). It is also much like the G' path for proportion of extended households among all living arrangements for whites, which contracted from a maximum in the 1910s to the 1980s as immigration then waned (Ruggles 1994, 107).

Further perspective on conditions that tightened or loosened limitations on fertility comes from the Mormon population of the American West (Fig. 6.8). Echoing the rise then collapse for the proportion of settlers who were foreign born (Fig. 6.6), among all marriages the proportion of women who had migrated to Utah then had children there maximized in G' fashion among those of age to wed in the vicinity of 1870 before contracting via D as the population became predominantly native-born--which happened in free and slave immigrant groups very generally around the world (Harris 2003, 413, 427, 432, 440, 443 446, 464; 322-24, 332-34, 338, 345, 348). Paralleling this initial surge, the percentage of women who married young, the average age difference between husbands and wives (Skolnik et al. 1978, 14), the fraction of wives who died before reaching 45, and the practice of polygyny (Bean et al. 1990, 94-95)[52] all crested in comparable G' movements. As in the earlier New England findings of Adams and Kasakoff, accompanying G' increase in fertility is most evident among families that could establish and maintain stable farms or other enterprises in the heartland of Mormon settlement, central Utah, though it also appears among those who, rather than moving around within the region, left it completely for greener pastures elsewhere (central panel, Fig. 6.8). Among types of marriages, the most marked G' change appeared among second or later wives of men who did not practice polygyny but instead had lost or divorced earlier spouses (Bean et al. 1990, 115). Those who were not Latter-Day Saints or converts to the religion, meanwhile, likewise display the G' pattern more than others (right panel). In several ways this western U.S. population, too, illustrates the impact of new settlement upon fertility and the social framework that encompasses it.

In another example of the impact of religious experience upon fertility, Old Order Amish women born between 1870 and 1934 and estimated to have married on average between 1890 and 1954, females wed from the later 19th century through the Depression who themselves were Old Order Amish, or whose parents remained members though they themselves did not, reduced fertility generally in C manner, the former more slowly--with zero year around 1983 rather than 1956 (Ericksen et al. 1979, 272). Together, these two groups dominated the family sources studied, giving the trend for the whole data set C shape with t_0 in the vicinity of 1978 for women married roughly during the first third of the 20th century. Among those whose parents were *not* Old Order Amish and themselves either did not belong or had unknown religious affiliation, in contrast, for those married between 1890 and 1934 or 1944 the number of children ever born rose via G' to a crest around 1905 and then fell away in this manner until the point where fertility dropped markedly (about three-quarters) for women of all religious histories. Before this shared collapse, however, those whose parents were already not Old Order Amish and who themselves did not belong responded with a G' surge of fertility to changes taking place around them in the 1890s and 1910s in a way that those with more consistent ties to the denomination did not.

In New England during the 1800s, meanwhile, among those of age to marry from 1853 through 1893 it was *native* women whose fertility rose then fell in G' fashion while for females of foreign origin the number of children ever born came down in C shape (Uhlenberg 1969, 413). The approximate 1863 date for most children in that native G' pattern (by date of marriage) implies that New England-bred women experienced a surge in fertility contemporaneous with what has been observed in Table 4.1 and Figures 4.1a through 4.1f for I_g in Belgium, England

and Wales, Germany, Denmark, Bohemia, Sweden, Switzerland, Norway, the Netherlands, Austria, and Hungary (G’ movements across the later 19th century with maxima between 1863 and 1889 in marital fertility).

The midpoint of 1876 for this range of northwestern and central European peaks for current births lags somewhat behind the New England crest at 1863 and the topping out for the core settlements of Utah in the early 1870s. That seems natural since these U.S. patterns are calculated from estimated average date of marriage, unions whose births would be spread out over the next several years. It seems, in other words, that *settled* populations of the North Atlantic World experienced together the observed G’ bulges in fertility. Was the socioeconomic outlet to be found in cities crucial in absorbing demographic excess--regional urbanization feeding off bursts of geographical mobility that were generated by rural demographic dynamics that provided new workers for new ventures? Or, did changes within the cities, such as industrial innovation, provide the initiative by generating periodic windows of new opportunity for young adults to form families and reproduce more vigorously than usual, in the countryside as well as in urban settings?

The identification of common and often contemporaneous G’ patterns during social change should assist in sifting through the contributing elements to demonomic systems and their relationships to each other more fruitfully. Whatever the initiating impulse, the impact repeatedly has taken G’ shape.

MECHANISMS OF HISTORICAL FERTILITY CHANGE IN AMERICA: II. INDICATORS OF POSSIBLE CONSCIOUS FAMILY MANAGEMENT

The age at which women marry is in essence a transition topic between factors beyond individual control and personal choice. The age of females when they bear their last child and the resulting span of potentially fertile years during which women are ‘at risk’ of conception each probably more significantly involve conscious decisions, while the spacing of births even to a greater extent can reflect personal determination. The modern questioning of living indivduals, finally, has made it possible to delineate trends in actual efforts to limit births and the methods employed. Overall, age-specific marital fertility yields valuable insight into where in the life cycle net reductions are taking place, while historical researchers have developed summary indicators of family limitation before direct questioning became possible.

To begin with an overview, **age-specific fertility** reveals where in their life cycle married women produced more or fewer children. Its trends yield perspective on how, as well as when, fertility might be being curtailed or enhanced. Patterns for some American populations can insightfully be followed over time, and compared with each other and with similar movements observed in Europe (Tab. 6.6).

In America, relatively new settlement, as in early 18th-century Nantucket or mid-19th-century Mormon Utah--or reenergized settlement, as in Deerfield--first produced *increase* in fertility for all or most age groups (Tab. 6.6, part B. Logue 1983, 439; Byers 1982, 27; Bean et. al. 1990, 256-57; Temkin-Greener and Swedlund 1978, 33).[53] In New England G' was the pattern. For the Mormons of Utah, this appeared only among early female setters in their last years of potential fertility; otherwise, the shape was G, the trend for many local secondary increases of fertility in early colonies. In Deerfield, G' was a phenomenon for women 30 and over. Younger females, in contrast, display already by the third quarter of the 18th century the kind of C-shape decline that one sees in contemporary Nantucket, though rather sooner in base year (and therefore steeper) than movements in Sturbridge (Osterud and Fulton 1976, 487). In the national genealogies gleaned by Wahl (1986, 398-99), during the first half of the 19th century--an era of heavy westward settlement--the combined samples display possible G' patterns for all cohorts of women for several decades beginning with those of age to wed about 1830.

In Nantucket and Sturbridge and among Mid-Atlantic Quakers and Wahl's combined national samples of genealogies, moreover, between the middle of the 1700s and about 1830 fertility for older women declined more steeply via C (toward earlier target years for the curve) that it did for younger ones (col. II, Tab. 6.6). Through somewhat later-running spans of time, furthermore, comparable arrays of C-shape declines in age-specific fertility--for the most part becoming shallower from the oldest to the youngest cohorts of women--appear for elite Philadelphia families (Kantrow 1980, 24) and for the white women of the United States as a whole (Hacker 2003, 612). Similar ordering appears between about 1870 and 1920 for western Mormon women, and for Old Order Amish females in the early 1900s (Ericksen et al. 1979, 259) along with the Mormons again from about 1920 forward. Proportionally, older women somehow experienced stronger and earlier fertility reduction than younger ones, often a sign of some conscious family limitation in historical populations.

Part A of Table 6.6 recapitulates how this was also the case among the women of Geneva and among the elites of Milan and Florence during the last three quarters of the 17th century and in England during the first several decades of the 1600s (Tabs. 1.3, 5.7; Pinto and Sonnino 1997, 504). Such a mostly progressive order for C-shape decrease in successive age cohorts reappears during the 18th century: again in Geneva, in parishes of the eastern Paris Basin (and several other groups of French communities; Tab. 5.6), along the southern frontier of Hungary, and among all but the youngest women in some German villages. Still later, it is observed for all Swedish females (Fig. C.8) and for German villagers from their early 20s upward between the second quarter of the 19th century and the opening years of the 20th, and then in Sweden again from there through the Great Depression (Tab. 5.7; Figs. 5.8, C.8).

During the later 17th century, on the other hand, as recovery from the Dutch Revolt (which devastated much of the southern Netherlands) took place, fertility in Flanders and Brabant mostly increased in G form for all ages of wives very much together. The G pattern was not just a phenomenon of growing settlement, as in North America (following initial 'baby booms') but a way that reproduction in general responded to more lasting opportunity. In England (Fig. 1.6), also following civil war, across the later 1600s and early 1700s age-specific fertility likewise rose mostly in comparable G paths, for some reason more steeply among women in their 40s. For women 15 through 19 and 25 through 29, however, the increase of this period took E form instead. It expanded that way for these two age groups again for the remainder of the 18th century and the first years of the 19th. During that later period, upward thrusts in this E shape were strong enough to override C-type declines for other cohorts and give total fertility the same shape of accelerating increase. In Sweden, somewhat the same combination of trends (with E movements for females 15 through 24, C's for others) is evident into the early 1900s, while in preceding years E-type expansion of fertility appeared among those 20 through 34 as other cohorts experienced mixed C and G changes. During the middle of the 19th century, Flanders and Brabant also had E-shape fertility increase among young women but G' surges for those were further along in their reproductive careers.[54] It would be of interest to see whether in early and rapidly industrializing areas of the United States like southeastern New England, where population expanded in E form during the early 19th century (as in England and Flanders and Brabant somewhat previously), E-shape fertility increase also appeared, concentrated among young wives. The rather different relationships of E-type fertility increase to population growth, urbanization, and economic change among younger women from the later 1700s into the early 1800s in Sweden also merit probing.

Flanders and Brabant, finally, stand out for having *many* G' movements in age-specific fertility--especially among older women from the later 1700s to about 1880, though repeatedly among those 20 through 24 from the 1690s through the 1850s. It would seem worth exploring the relationships of these patterns, both for young women of typical age to marry and for older females, to repeated rhythms of this G' type in wages, rents, secularity, illegitimacy, and shifts in and out of agriculture that are identified for the region (Figs. 5.12; Tab. 5.10).

Table 6.6 also presents information on the *level* of fertility for the different age groups in various populations. After the '=' sign in each entry is given the height of the estimated C, G, G', or E curve at its zero year. For G' that point is the maximum: the number says how high the rate went, or is projected to have gone, in its surge. For G and C trends, on the other hand, an approximation of the asymptotic level toward which a trend headed upward (G) or from which it came down (C) can be obtained by multiplying by *e*, or 2.718. For example, among Geneva women 25 through 29 the value .190 at the zero year of 1788 implies decline from a hypothetical starting plateau of about .516 (as of the 1660s--where the data actually begin--the height of the curve had slipped to .498).

Just comparing the values for the zero years of curves as estimated in Table 6.6, however, gives a sense of the levels of similarly shaped fertility trends from age to age and place to place. For instance, in Nantucket the C trends from the second quarter of the 1700s into the early 1800s were at first glance fairly comparable to, perhaps somewhat lower than, those for women 20 through 44 in Geneva from about 1725 to 1805 (ranging from .005 to .150 vs. .032 to .190 by target year). In all, however, though fertility was falling age-by-age in each population via C over much of the 1700s and the early 1800s, the movements in Geneva were somewhat earlier in timing and therefore in any given year reaching a lower level. This, after all, was already Geneva's *second* C-type decline in age-specific fertility.

Identifying the G-related patterning, one can glean considerable insight out of comparisons from place to place within America, or between American and European developments. From population to population certain age groups display more difference than others. The broad and basic points, though, are: 1) how *general* adjustments in certain G-based shapes have been for all ages of women in the diverse populations examined since the 1600s; and 2) on the whole how *similar* both paths and levels of age-specific reduction in fertility were from the Old World to at least parts of the New. What might generate such age-ordered patterns repeatedly from one population to another and from era to era? Were reproductive practices across much of Europe and over the Atlantic for women of European stock so similar or did different dynamics produce convergent results?

A lead for older women in reducing fertility has been one characteristic of populations in which some conscious family limitation is known to have taken place. Historically methods have evolved from abstinence, coitus interruptus, abortion, and infanticide to contemporary physical and biochemical interventions; but it should be remembered that even in the least modern cultures, while unreliable in individual cases, the most fundamental practices can have significant collective effects for a population. Coale, for example, argued that most of the European fertility transition took place without benefit of modern techniques for preventing births (1986,).

The **age of women at first marriage**, which is partly determined by social control, but is increasingly an initiative of young women historically, does much to determine the amount of reproduction that takes place. Even in inheritance-dominated restrictive marital systems, couples can manipulate nuptials through premarital pregnancy (D. S. Smith). As noted previously, however, *proportional* change in this measure over time is slight.[55] In the literature, graphed comparisons of trends in age of marriage with those in fertility typically employ greatly different scales. Yet female age at first marriage has had significant impact upon fertility, particularly in pre-modern populations. **Age at last birth** likewise changes in limited proportional terms.[56]

The resulting known, or biologically estimated maximum, **duration** of the period over which women reproduced between marriage and cessation, however, moves more measurable in proportional terms. Figure 6.9a presents some information on changes from three communities of early Massachusetts. The roughly 25 percent shortening for years of reproduction in C form targeting about 1840 that appears from the middle 1700s into the first years of the 1800s in all three (closer to 50 percent by 1830 in Sturbridge) and the preceding tendency in Nantucket and Deerfield for the span to rise via G' both closely resemble overall fertility trends summarized in

Table 6.1. The underlying changes contributing to these patterns of Figure 6.9a (somewhat more than half via G-type increase in age at marriage, but a significant portion through C-shape contraction in age at last birth) indicate how combined delay in first marriage and decrease in reproduction during later potentially fertile years curbed fertility in rural New England significantly long before the era of modern contraception. In Main's more comprehensive New England genealogies (2006, 44), the span between average age of first marriage and last birth shrank a comparable amount between about 1660 and 1840, the large majority due to earlier termination, though toward a rather later zero year in the 1860s. For Wahl's 'B' sample, meanwhile, C trends in span between first and last births in New England, the Mid-Atlantic, probably the South, and the Midwest contracted similarly but toward t_0's more like 1880. Among women of age to marry between the first half of the 18th century and the 1830s, about two-thirds of the reduction came from an earlier ending to reproduction rather than later marriage, more than what lay behind the net changes for the three New England communities of Fig. 6.9a. The Midwest and the West display subsequent parallel C-shape trends thereafter (Fig. 6.9b; Wahl 1986, 408).

In the Philadelphia elite families studied by Kantrow (1980, 28) the specific age of women at marriage is not given; but average age at last birth by itself again came down in C fashion--about 4.5 years from unions around 1737 to those around 1850, with t_0 in the vicinity of 1905. For those wed under 21, the change was greatest (5.2 years with target year around 1896 vs. 3.4 years and t_0 only around 1922 for those married at 21 or more). As a whole, age at last birth in these particular families decreased in C movement that paralleled decline of that measure in this form for Nantucket, Deerfield, and Sturbridge, on the one hand, and for the New England and Mid-Atlantic genealogies examined by Wahl (1986, 408), on the other, when the latter are adjusted from birth cohort to estimated marriage cohort.

A year of delay before marriage of course had more effect on total fertility than a year less of reproduction toward the end of possible fertility because of the age-specific distribution of births among mothers. Age-specific fertility rates over time, however, declined significantly for females approaching the end of their potential reproductive span relative to those near its beginning. The fertility rate for women 35 through 39, for example, fell from 57 percent of that for women 20 through 24 around 1848 to 47 percent around 1878 among white women in the United States and from 70 to 61 percent among Mid-Atlantic Quaker women from those of age to marry about 1738 to those wed around 1793 as reproduction generally declined in these populations, or 18 and 13 percent respectively (Hacker 2003, 614; Wells 1971, 76).[57]

Along with the age-specific fertility evidence of Table 6.6, direct or estimated findings on the ending of reproduction among more mature but still fertile women suggest that, much like the similarity of age-specific English change with that in Geneva and among northern Italian elites one hundred years before,[58] married women in the coastal regions of the United States were limiting their reproduction during the later 18th century and the first years of the 19th at least by some ‘stopping’ of their potential reproduction during their older fertile years as their number of children accumulated--like contemporary women in Geneva, in many French locales, in Sweden, in Transdanubia, and among English wives 30 and older.

Another familiar lens for historical insight into how much women play a part in managing their fertility, one that is sometimes available for periods well before the modern contraceptive era of the 20th century, comes from the **spacing of children**--particularly as the number of previous births advances. Figure 6.10a trends the average number of months between births at various levels of parity in Nantucket for women married from 1700 through 1830 (actually 1680 to 1839, Byers 1982, 33; compare Logue 1983, 448). It depicts spacing as having increased mostly in G fashion from 1700 to the third quarter of the 18th century and then to have expanded rather further in E form to 1830. In all, the gap from penultimate to last birth increased 86 percent between 1700 and 1830 (from 25.0 to 46.6 months), the 4th to 5th interval by 38 percent (66 percent as of 1810, before receding), the 3rd to 4th spacing only 6 percent in all (but

24 percent before dropping back after 1790), the 2nd to 3rd lag by 14 percent, and the delay from 1st birth to 2nd by 106 percent (the bulk being achieved during the opening G trend to the middle of the 1700s). The reason for this most substantial proportional change at the very beginning of the birth sequence in Nantucket is indicated by Logue.[59]

The kinds of E trends observed in increased spacing between births in Nantucket during the later 1700s and early 1800s also appear in Kantrow's Philadelphia elite families (1980, 28), though with a noticeably lower average number of months at each interval. Except at the very end of the reproductive phase of the female life cycle, these movements in the Middle Atlantic lag behind those of the New England whaling community as follows:

	Nantucket (Fig. 6.9a):	Philadelphia (estimated):
Penult. to Last	1750-1830 E 1883 = 103	1737-1850 E 1878 = 72
4th to 5th	1750-1810 E 1856 = 83	?
3rd to 4th	1750-1810 E 1845 = 81	1737-1850 E 1903 = 66
2nd to 3rd	1700-1790 E 1882 = 89	1737-1850 E 1902 = 63
1st to 2nd	1770-1830 E 1864 = 84	1737-1850 E 1906 = 56
Marry to 1st	?	1737-1850 E 1924 = 36

Such lagging is what age specific fertility has been seen to do between these two local populations in part B of Figure 6.6. There, however, fertility levels were *higher* as well as later in Philadelphia, a finding that conforms with the fewer months between births indicated here for those elite mid-Atlantic families. Among Mid-Atlantic Quakers, on the other hand, for all wives in completed families and for those married under 25 between 1738 and 1793 the gap between penultimate and last birth on average rose in E form even earlier than in Nantucket, with t_0 in the vicinity of 1830, though for those married 25 and older such a path targeted more like 1880 (Wells 1972, 80)--as in Nantucket and among the mixed-religious elite of Philadelphia.

Figure 6.10b trends evidence on the spacing of births in Utah, a population consisting largely of Mormons (Anderton and Bean 1985, 174). Date of first wedding is estimated as about 23 years from a woman's date of birth.[60] For women who married during much of the later 19th century spacing first expanded in E fashion to all parities from 2 through 9.[61] From parities 2 through 6 each successive E curve becomes a little steeper (has a somewhat earlier zero year). The initial E trends for parities 7 through 9 then flatten back to having t_0's between 1904 and 1910.[62] These increases in E form at all parities among women of age to marry between 1863 and 1898 played an important role in reducing completed family size among Utah women in reciprocal C shape between 1864 and 1915 with t_0 at 1922 (Tab. 6.1).

For parities 7 through 9, a second set of E trends emerges for Utah women of typical age to marry in the very late 1800s and early 1900s (Fig. 6.9b). Earlier in the birth order, in contrast, during this ensuing period G-type increase was the norm--a trajectory that levels out with time. Still, these G-shape gains in interval for parities 2 through 6 expanded spacing proportionally as much or further as the E trends for parities 7 through 9. Extensions of spacing in G form also occurred in Nantucket during the 18th century (Fig.6.9a).[63]

In a rather different perspective on further reproduction once a certain number of births had taken place, in Wahl's 'B' sample the probability of having another child decreased for women wed between 1798 and 1860 via C trends targeting about 1875 for those with one child, and the 1890s with those who had two or three prior births. Then, from 1860 forward, further reduction in this likelihood took D shape based about 1820. C is the opposite of the E that is found so commonly in spacing, while D is the counterpart of G. In the 'A' sample, in contrast, reductions in these probabilities after the middle of the 19th century took C shape toward zero years as late as the 1960s for all three parities, and generally no decline appears after two or three births until 1860, though seemingly by 1835 for women with just one child (1986, 404).

By what **methods** might women in North America have started to control their fertility in the 18th and early 19th centuries? For one thing, at least partially effective techniques for inducing abortion were widely known. For example, a transatlantic pharmaceutical network operated out of the Franckesche Stiftungen in Halle, Saxony. Its offerings by the early 1700s included an array of gynecological concoctions that were deemed to prevent conception or induce abortion (Renate Wilson 2000, 171-81). Even though Pietism followed "the Christian consensus against aborting a live or quick fetus," the wives of pastors played a central role in the distribution system for these "female" pharmaceuticals (along with other, what one would today call quality-controlled and "branded," medicines out of Halle). The question are how many consumers of what types chose to use them, how often, and how successfully. Since in the colonies these preparations are known to have cost more than their less reliable English counterparts, it is clear that the diffusion of pharmaceuticals with at least some limited power to curb the number of children that one bore was not beyond the reach of other colonists as well as German settlers in the Mid-Atlantic region who patronized the Halle network.

Later, Sanderson (1979, Tab. 5) estimated that for U.S. females as a whole who were born between 1838 and 1873 (estimated here to have married on average between 1861 and 1896), induced abortion--by the practice itself and by its consequences upon the subsequent fertility and health of women--accounted for somewhere under half of all aversion of births. For upper-middle-class females between 1892 and 1920 abortion was less frequent still, as effective means of contraception spread--though the practices of less fortunate women are unclear in what was an era of aggressive debate about abortion (David and Sanderson 1986, 329-35). Along with abortion, until fairly much the beginning of the 20th century control of conception instead is considered to have been enacted among ordinary people through other simple but partially effective methods known for ages, such as coitus interruptus and abstention, or through illness, absence, or spousal tension and alienation even though the couple continued to live together. For instance, no special “modern” knowledge or equipment was needed to get the substantial and widespread European fertility transition of the 1800s and early 1900s under way (Coale 1986,).

Figure 6.11 displays some probable trends in specific sexual behaviors that contributed to fertility change among upper-middle-class married women in the United States during the first half of the 20th century. The left panel begins by showing at its top how frequency of coitus for married women 25 through 59, on average, rose in G shape between the 1890s and the 1930s from 3.8 to 5.5 times per month, or by just short of 50 percent (David and Sanderson 1986, 336-37), as controlling fertility became more common and more reliable. This was followed by a spike during World War II that reached above 7.0. Women from 35 through 44 increased their average frequency of coitus even more over the four decades between the 1890s and the 1930s--also via G, to 1.9 times the low starting level of 2.7 or 5.0. Women 45 through 59, for whom coitus posed the least threat of unwanted births, just between the 1890s and 1916 expanded coital frequency by a multiple of 1.7, from 3.4 to 5.9--in what would be an even steeper G trend. Then, however, the rate fell back to 3.9 at 1935, presumably with the tensions of the Depression, before jumping up to what may have been a parallel but appreciably higher path of C-shape decline from 1940 forward as World War II arrived and passed. Among young married women from 25 through 34, in contrast to their elders, coitus became somewhat *less* frequent between the periods of 1890-97 and 1913-20. Was this simply a consequence of World War I or the curtailment of immigration (immigrants tended to welcome more children than natives)? Or did such decline represent the tail end of a long-term trend to reduce fertility during a period when convenient and effective contraception was still limited even though the advantages in quality of life from having fewer births were beginning to be appreciated? Then through the ‘flapper’ era of female liberation, the Depression, and World War II, the frequency of coitus in this group of younger married women surged in what seems to have been G’ shape, cresting at about 8.2 times monthly in the early 1950s compared with the 3.5 level around 1916. Here appears one foundation of the 1938-to-1958 G’ baby boom in the United States (Fig. 6.1).

How upper-middle-class white women in the United States did or did not manage their fertility during the first half of the 20th century is illustrated from the same studies in the right panel of Figure 6.11 (David and Sanderson 1986, 324-25). Between 1894 and 1935 the proportion who did nothing fell from 10.0 to 1.5 percent in C form with zero year at 1902. If one adds in those who merely abstained from coitus, the share starts at 20.0 percent in the 1890s but drops also to 1.5 percent by the middle of the Depression via a somewhat earlier and steeper C path. Among those who practiced some form of limitation, meanwhile, reliance upon safe periods/rhythm methods or douching, on the one hand, and withdrawal, on the other, both also probably atrophied in accelerating C manner. The first approach shrank from 66 percent of all preventative measures around 1895 to 26 percent in the middle of the 1930s. Withdrawal, meanwhile, decreased from 17 to 12 percent between 1894 and 1916 (if via C, with zero year at 1934 compared with 1925), but then expanded back to 25 percent by the 1940s in G manner. Would closer examination of the data reveal that this reversal, and the contemporary increase in abstention, reflected an increase of Catholics within the upper-middle-class population thanks to successful, absorption of many immigrants from the massive turn-of-the century wave into American life?

Mechanical measures like condoms, pessaries, and diaphragms, meanwhile, between 1894 and 1935 surged in G’ manner to provide 40 percent of all contraception at 1935 from 12 percent forty years before. Then, however, this proportion contracted somewhat into the 1940s as the use of chemical techniques such as suppositories, jellies, and foams or other methods in turn also expanded in G’ shape--only noticeably later--toward a projected crest in the 1960s, taking this proportion of all contraception from 6 percent around 1916 to 19 percent around 1944. *Together*, however, mechanical and chemical techniques expanded via G from 17 to 55 percent of all prevention between 1894 and 1935.

Such G’ shape in the spread of specific contraceptive procedures in the United States during the first half of the 20th century provides another example of how spurts of innovation or opportunity impact populations in the shorter term while collectively generating more gradual G-related accumulative trends of change, as in the role of marriage and baby 'booms' for population increase, in the aggregation of migrations (Harris 2003), or perhaps how general secularization builds from certain specific breaches of church law (Fig. C.5 vs. Figs. C.4 and C.6). In all, techniques for managing reproduction spread or contracted in G-based forms like other dimensions of demographic change.

The **summarizing index**, ***m***, for parity-related family limitation (Coale 1986, 12), likewise increased in the population of the United States in G fashion (Fig. 6.12). This particular measure, however, seems to be available only for the country as a whole (with the exception of late-settling western Mormons) and not (excepting the one community of Nantucket) for the regional sub-populations that first display--before the middle of the 19th century--reductions in marital fertility, age-specific fertility, and span of reproduction, or increases in the spacing between births.

For U.S. whites as a whole (Sanderson 1979, 341) *M*, the comparison of actual fertility to natural fertility, meanwhile came down along a succession of two C paths, as it did sooner and more steeply for the women of Nantucket (as much as 40 percent between 1712 and 1837). Though the transition from the first of these curves to the second also took place in the 1850s, the amount of change was much flatter than what has appeared in the comparable C patterns of total fertility and fertility ratios (Fig. 6.12 vs. Fig. 6.1). Likewise, *M* for the Mormons from the 1860s into the 1920s declined slowly in C form toward a zero year as late as 1990 (Bean et al. 1990, 134), compared with 1972 for all U.S. whites. As for the nation, this made *M* decrease appreciably more flatly than the white total marital fertility rate which had its t_0 at 1959. Overall, in America as well as in Europe fertility control (*m*) repeatedly increased in G form, whenever it happened to arrive and at whatever level, while actual fertility as a proportion of natural fertility (*M*) declined in C shape like the birth rate, children ever born, total fertility, age-specific fertility, and other measures that have been examined.

Though increase in *m* among U.S. whites, as in Europe (Tab. 6.7), typically followed G paths since the early 19th century, it broke through the 0.2 level--considered to be where parity-related family limitation becomes a significant factor--only about 1840 (Sanderson 1979, 341) or 1860 (Hacker 2003, 614) or 1885 (Wahl 1986, 403, by date of marriage) and for the Mormons around 1900 (Bean et al. 1990, 134). In contrast, this level was probably reached by the early 1600s among the elites of northern Italy, France, and Switzerland, the 1770s by some villagers of Transdanubia, and the 1790s by others (Tab. 6.7). The G trends for the Protestant and Catholic German communities studied by Knodel surpassed 0.2 between the last quarter of the 18th century and the third quarter of the 19th, some of their Jewish compatriots roughly in the 1850s--or along with U.S. women as a whole (Figs., 5.4, 5.9, 5.10).

The asymptotes implied by the G trends for the U.S. come well below the high level that is observed among elites of Europe a century before, by whom western fertility control was pioneered. A t_0 of .235 at 1849 (Sanderson) or of .239 about 1870 (Hacker), however, suggests an eventual maximum of approximately .650 for these two U.S. G-shaped patterns of family limitation. At their zero years these trends, moreover, are not much below the average of .262 for eight German village populations during the middle and later 19th century while the timing of t_0 falls along with or slightly later than the base years for those European G movements. Contrasts between and within the German and the Hungarian evidence and the difference between the Belgian and other elites (Tab. 6.7; Figs. 5.9, 5.10) underscore how there was within the Old World, too, considerable local variation in both the timing and the extent of movement toward managing fertility.

Recently it has been argued that *m* fails to detect parity-dependent control of fertility during the early stages of transition (Hacker 2003, 616-17). In Nantucket (Logue 1983, 445), the one measured sub-population from the coastal regions where fertility declined first in North America for example, *m* stays flat and hovers around zero from the late 1600s through 1850 (not graphed in Fig. 6.12 or included in Tab. 6.7). Yet between about 1730 and 1830 the age-specific fertility for older wives characteristically led the C trends for younger women downward, very much as in Geneva between about 1725 and 1800 or parts of France and Hungarian Transdanubia, where *m* is calculated to have increased substantially. Significant curtailment of how late in life Nantucket women bore their last child is also evident during the period in question (Fig. 6.9a). So is increased spacing between births, especially during the middle of the 18th century (Fig. 6.10a).

So while locally ‘stopping’ and ‘spacing’ both occurred, older women characteristically led fertility decline, *M* decreased by 40 percent, and the New England region more broadly experienced decrease in marital fertility (Tab. 6.3) with Nantucket as a local leader in decreasing size of completed family (Tab. 6.1), just how can *m* there show so little change?

Sanderson also estimated patterns of fertility control for all U.S. white women in terms of the percentage of females who effectively reduced their reproduction (1979, 350). He presented these calculations in terms of upper and lower bounds. The trends once more take G form (Fig. 6.12). The succession between G movements occurs about 1876 when 23 years are added to birth cohorts to estimate average marriage cohorts, which are employed in other measures of Figure 6.12 and Table 6.7. By the marriages of the middle 1890s, Sanderson calculated that from 64 to 81 percent of white women in the United States reduced their fertility. At the time of the Civil War, the proportion stood somewhere between 38 and 71 percent. Sanderson hypothesized (ibid., 352) that, as of the unions of the later 1850s (implying marriage cohort here from birth cohort), about 49 percent of U.S. white women may have been curbing fertility. This trend rises from about 9 percent around 1808 through approximately 25 percent around 1830.[64]

In all, there is room in these national patterns for substantial proportions of couples in older settlements to be consciously reducing their fertility by the early 19th century while later populations, such as the Mormons of the West, took up such practices only during the early 1900s.[65] Were *all* Americans adopting family limitation as soon and as enthusiastically as the pioneering population of France? Clearly not. Were couples of *some* sub-populations, particularly in the Northeast, behaving comparably in their control of reproduction? Data on local and regional total and age-specific marital fertility, stopping, spacing, and even nation-wide estimates of family limitation strongly suggest yes.

Most important for the present discussion, all these changes took G-related forms--along with celibacy, death before reproductive maturity, age at marriage (though very flat in proportional change), age at birth of last child, death of a spouse while the woman was still fertile, childlessness, divorce, premarital pregnancy, illegitimacy, and resulting rates of fertility (age-specific and total) or completed family size. Historical demographic trends in the New World were as much shaped in G-related forms as those in England or continental Europe.

NOTES

1. Children ever born to second- and third-generation U.S. women of Mexican stock who were of age to marry from the 1920s through the 1950s and the 1860s through the 1937, respectively, declined in comparable C fashion toward zero years about 1940, though for mothers in Mexico and first-generation immigrant women C paths through the 1980s targeted about 2000, and began only around 1950 and 1910 (Parrado and Morgan 2008, 659).

2. Figures 4.1a through 4.1f have demonstrated, meanwhile, how common such C trends in overall fertility (I_f) were in all the recorded countries of Europe during the first half of the 20th century.

3. Among immigrant mothers born in Mexico or first-generation U.S. residents, however, for those of age to marry (23) right through to 1985 the number of children ever born continued to fall via C toward about 1995 (Parrado and Morgan 2008, 659). The bulge came from the fact that females of such recent Mexican stock on average had up to twice the number of children as white women with three or more generations of native roots, and the numbers of `Mexican immigrants within the population surged (Harris 2003, 34).

4. The tendency of total fertility rates for European populations--as in Canada, Australia, and New Zealand (Fig. 6.1)--to bottom out about 2000 and begin to rise is discussed extensively by Goldstein et al. (2009) and is addressed along with trends from other continents in Ch. 7 and (via projections) Ch. 9. In the United States, the upturn occurred in the middle 1970s.

5. After delayed G growth from 1963 through 1978, a comparable 1/G' sag occurred in Italy though not Hungary.

6. Exceptional is the delayed G trend during the 1960s and 1970s in Hungary.

7. And in Bulgaria, more immediately after the war.

8. Some exceptions will be discussed.

9. Decadal calculations of total fertility employed by Haines (2001, 308), on the other hand, follow what seems to be one C trend from 1850 to 1880 with t_0 in the vicinity of 1913, then another from 1890

through 1940 with target year at about 1952.

10. Haines, comparably, shows C-shape decrease from 1800 through 1850 with zero year in the neighborhood of 1882. Data on period total fertility rates that Jenny Bourne Wahl (1986, 396) developed from genealogies also follow a C-shape trajectory over the first half of the 19th century--and earlier. In her ‘A’ sample, the pattern from 1755 through 1865 is estimated to take C form with t_0 in the vicinity of 1889 compared with the 1886 of Hacker’s calculations and the 1888 of Coale and Zelnik. In her ‘B’ sample from just 9 families, from 1805 through 1855 the rates follow a C path with target year around 1879. Contemporary findings of Louise Kantrow (1980, 24) for several elite Philadelphia-based families similarly display TFR decline of C type with zero year around 1880.

11. The next phase of C-shape atrophy according to Yasuba, from 1850 through 1890, mostly parallels the 1862-to-1902 curve for TFR generated by the data of Coale and Zelnik (t_0’s at 1921 and 1929). The trend for the combined genealogical data decreases from 1815 through 1845 in C fashion targeting about 1906. Then a third, delayed C contraction for the period 1890 through 1930 has its zero year only at 1959 (the Wahl data for some reason display a hump in the 1850s and 1860s before falling back for the 1870s). The 0-4/20-44 rate in Yasuba’s census-based evidence demonstrates how the transition to a new C curve of fertility reduction between 1850 and 1860, which is only hinted by the refined ratio for children under 10 and females 16 through 44, is probably a genuine phenomenon. Haines uses the ratio of children under 5 to white women 15 through 44. His calculation for total white fertility also declines in two successive C paths, from 1850 through 1890 then from 1890 through 1940, closely parallel with Yasuba’s ratio for children under 5 to women between 20 and 45 (2001, 308).

In the two separate nationwide genealogical samples of Wahl (1986, 396), the ratio of children under 5 to once- or never-married women aged 15 through 44 for the ‘B’ sample came down from 1815 through 1855 via C with zero year at 1853, having previously declined--also in C form, it seems--between 1755 and 1815 (with t_0 estimated around 1832). For some reason the ratio in the ‘A’ sample *rose* in accelerating E fashion, opposite to C, between 1805 and 1875 (with target year in the vicinity of 1898). Questions arise about just what populations these samples represent.

The evidence of Steckel, meanwhile, shows a ratio of children under 10 to *slave* women 15 through 49 for the United States that from 1820 through 1850 declines in C form toward a zero year in the vicinity of 1876 (very much like Yasuba's white refined fertility ratio with its t_0 at 1879), though in the Southeast and the Southwest C trends for the pre-Civil War period are later and flatter while gradual emancipation in the North affects the total (2001, 442). For free blacks (ibid., 457), the national trend for 1820 through 1850 takes C shape with zero year about 1900. As slaves were moved in great numbers to new land that would grow cotton, in both the Southeast and the Southwest between 1820 and 1850 the pattern has G' shape (with crests around 1839 and 1828)--as in new settlement of New England during the 17th and 18th centuries, judging by children ever born (Tab. 6.1). The proportion of women in slave populations surged this G' way in the Chesapeake and the older settlements of the British West Indies during the later 1600s and in South Carolina during the early 1700s; but the implied pattern as new slave populations likewise naturalized is not clear for children (Harris 2003, 349, 352).

12. Australia and New Zealand about 1870. Fig. 5.1b (from Wrigley 1985b); Fig. 1.4 (from Wilson and Woods 1991); Figs. 4.1a through 4.1e (from Coale and Treadway 1986); Hacker 2003, 615; Caldwell 1999, 482).

13. As of the 1860s, nuptuality (I_m) in France (.53) was only slightly higher than in England and Wales (.51).

14. It should be remembered how wide was the range of differences in marital fertility between regions *within* nations. In Germany, for example, at 1871 a national index at .76 for I_g melds levels of .92 or more in Niederbayern, Schwaben, and Donaukreis, with measures under .70 in Thuringen, Anhalt, Oldenburg, Braunschweig, Lothringen (Lorraine), and several cities (Coale and Treadway 1986, 108-14).

15. A third C movement is possible from the 1850s through the 1880s, but is not fitted.

16. In the graphing of Fig. 6.2, 1678 approximates a midpoint for evidence preceding 1691.

17. For men 34 and women 31, the generational averages, or recording subjects a few years older than the age at marriage for Hingham families. Completed family sizes by date of the first child for five towns of Middlesex County (including Watertown), three of Suffolk and Plymouth (including Hingham), and

four in Hampshire and Worcester, both as three regional clusters and collectively, on average display 17th-century G' surges cresting in the 1650s (Anderson and Thomas 1973, 666). In the Middlesex group, at least, this was seemingly followed by increase in G form (base year about 1640, like Watertown in Tab. 6.1) across the last three decades of the 1600s.

18. Why the Hingham trend for 1728 through 1790 declines even later needs to be explored.

19. Still later and weaker decline in reproduction appears among the Old Order Amish (Knodel 1983, 88, citing Ericksen et al. 1979; estimated by template, but not shown in Tab. 6.1). For these women born between 1885 and 1914 and of typical age to marry roughly 1905 to 1934, total marital fertility fell in C shape with t_0 in the vicinity of 1973 (1993 by approximate date of marriage).

20. Which sprung up between Andover and Danvers.

21. When one add a few years to the latter's possible peak around 1653 by date of marriage for maximum births to occur.

22. Principally people from Lynn and Newbury (Greven 1970, 21; 1964, Ch. 1).

23. Data for Maryland at 1755 and 1800 (Yasuba 1961, 71) would conform to a C trend with zero year around 1850, a rather later decline than for the composite northern colonial evidence graphed in Fig. 6.1, but not unlike the first Middlebury trend and the second C for Ipswich and Boxford.

24. In several communities of the Belgian province of East Flanders the ratio of births to marriages rose in E fashion very much as in certain locales of the English Midlands (Harris 2003, 206-7). Did agricultural improvements shared by Flanders and England, but not by France, Sweden, and the British American colonies, facilitate marriage, foster urbanization, and provide labor for other economic uses?

25. Settlement the other way during the 18th century from the same German sources (and also Irish ones)--westward across the Atlantic into Pennsylvania and its environs--clearly opened with families, implying the kind of baby bulges observed in early New England for the interior (Wokeck) following the concentrated flow of British Quakers that probably produced a 'boom' in the Delaware valley during the years before Well's Friends and Kantrow's Philadelphia elite families start to display C-shape decline.

26. Peaking rather sooner on Barbados (about 1680). These early movements are all graphed, but fitted

to G’ only for Jamaica (Harris 2003, 331 vs. 333-34). For the British West Indies as a whole, however--and for the French West Indies--the proportion of the population that was not white surged in G’ fashion to crest about 1690 before taking up long-term G growth (324).

27. To pattern change from 1765 through 1860, the level of each area at 1800 is employed to adjust the height of the crude fertility ratio from 1765 to 1800 to the level of the refined fertility ratio of 1800 to 1860.

28. Yet successive reproductive bulges in G’ form are more evident in these data among persisters than among migrants. The evidence of Uhlenberg (1969, 413), furthermore, indicates that while among women of foreign origin between marriages of approximately 1853 and those around 1913 (from female birth cohorts around 1830 to those round 1890) children ever born per woman declined in C form with t_0 in the late 1930s, in marriages roughly from 1853 through 1893 native females produced a surge of births in G’ shape that peaked around 1863. Within settlements of the New World as well as coming into them from Europe, migration raised the level of fertility; but shorter-term surges of population pressure that contributed to new pulses of advance in the frontier of settlement were produced by families who themselves did not move but benefited from such new opportunities for their descendants.

29. Elaborated and connected in Ch. 10.

30. Figs. 1.4, 5.1b, 5.3, 5.12, C.4, C.7.

31. Wahl’s ‘B’ sample, the one for which regional evidence is given, covers all the data in nine published family histories: 16,820 individuals in 5,632 nuclear families (Wahl 1986, 393-94). Going from generation to generation, one can expect a shift in representation from East to West as new family members continually migrated out of increasingly congested older settlements. Up through women of age to marry around 1829 some 465 of 534 families covered dwelt in New England or the Mid-Atlantic. From 1842 through 1866, 206 of 338 did so; and just 159 of 458 following the Civil War (all for some reason in the Mid-Atlantic between 1873 and 1885 (Wahl 1986, 406).

The ‘A’ collection, on the other hand, randomly sampled nuclear families included in about 1,400 family histories: 15,748 individuals in 4,467 families. Of 948 nuclear families examined in all, 686 contained wives of age to marry after 1848 compared with 257 of 941 for the ‘B’ sample (ibid., 394). This distinctly different temporal distribution, presumably also shifting westward, can be expected to have kept the level of marital fertility in this ‘A’ sample high before its C-type decline following the Civil War.

32. Among Ottowa, Kingston, Toronto, Hamilton, and London in Ontario, I_g shrank 18 percent on average. This compares with 19 percent for the national commercial capitol of Montreal in Quebec, but only 6 and 2 percent for Quebec City and Trois Rivières. Overall fertility, meanwhile, decreased about 32 percent for the five cities of Ontario, 29 percent for Montreal, but only 9 and 5 percent for the other two centers of Quebec. There, rural people mainly of French descent--carried their demographic behavior to town with them. Of interest for understanding how fertility declined, in rural Ontario nuptuality contracted only 10 percent compared with 33 percent for overall fertility and 25 percent for fertility within marriage. In rural Quebec, it actually increased about 3 percent as marital fertility shrank rater more than overall fertility--neither very much in 30 years (McInnes 407).

33. From 1797 through 1853 = -29% thanks to more than one C decline.

34. From 1748 through 1838 = -28%.

35. From 1798 through 1829 = -30%.

36. From 1853 through 1910 = 40%.

37. Trends are estimated, not fitted.

38. In a weighted average of Wahl’s ‘A’ and ‘B’ samples, too, up to the 1830s the child/woman ratio fell more strongly in C fashion than total fertility within marriage, though both declined in that shape, indicating a combination of inputs to decreasing overall fertility.

39. For just U.S. women in their 30s, the proportion who were unmarried increased between 1972 and 2002 toward a crest of about 38 percent in the vicinity of 2006. Proportions among white and black females rose in largely parallel fashion, though at a level about twice as high for African-Americans and peaking a few years sooner, near the end of the 1990s (Musick and Mare 2004, 632). Meanwhile, the proportion of children of native-born Americans who lived with single parents (and probably the children

of immigrants as well) grew in G fashion from 1970 through 2000 with zero years in the 1970s (Hook et al. 2004, 659), or much like the G path for celibacy in the U.S.A. (Fig. 6.5). The overall surges for single motherhood mostly reflect the circumstances of women with low or middle levels of education (McLanahan 2004, 612).

40. On the other hand, permanent childlessness in several German villages between 1787 and 1812 can be said to have surged in G’ form from about 10 to 14 percent and back, cresting about 1810 (Fig. C.9)--possibly a consequence of the Napoleonic wars, perhaps a result of the tuberculosis that scourged early 19th-century Europe.

41. The proportion of nonwhite couples without children in their household, probably driven by the encounter of the great northward migration of the early 20th century with the Depression, rose then fell later comparably in G’ manner between 1910 and 1960 with crest in the vicinity of 1935 before tapering off through 1980 in C fashion. In contrast, for white households a G trend from 1910 to 1960 was followed by E-type increase opposite to nonwhite decline via C between about 1940 and 1980, both targeting zero year in the first years of the 2000s (Ruggles 1994, 107). This measure mixes those never having children with couples currently without them.

42. The share of young women living with their parents, meanwhile, declined from 1910 through 1980 in C fashion with t_0 around 1992, before perhaps starting to shrink again through 2000 in new, later C manner. For young men, two successive C-shape contractions in this proportion to 1980 seem to have occurred before and after 1960, starting only about 1940 following increase in G form between 1910 and 1940 (ibid.).

43. Similar patterns in the slave trade (Harris 2003, Ch. 2) reflect the attraction of new European or Arab merchants and new enslavers in Africa and transatlantic planters opening up new settlements or beginning to acquire heirs to a business that specialized in young adult labor.

44. G is the best fit for 1657 through 1705 and 1705 through 1745. The G’ pattern for 1815 to 1855 is lower than its predecessor and runs all down hill.

45. Smith and Hindus 1975, 554, 561-63: T = Topsfield, 1738-1740; D = Dedham 1760-1770. B =

Bergen, N.J., Dutch Reformed, 1690, 1710; M = Middlesex Co., Va., around 1728; V = average of Christchurch Parish, Middlesex Co., Va., around 1728 (M) and Kingston Parish, Gloucester Co., around 1755 (G); N = Hollis, N.H. (the first very low observation there, for 1741-1760, is not included in the G' fitting); P = New Palz, N.Y., Dutch Reformed, around 1806; Osterud and Fulton 1976, 487.

46. 1 = Lexington, Mass., 2 = Hingham, Mass., 3 = Washentaw County, Mich., 4 = Utah County, Utah, 5 = Tippecanoe County Indiana, 6 = Defiance County, Ohio.

47. The symbols pointing down are for a 1959 study; those pointing up represent results from an investigation of 1965. The 9-month premarital criterion is chosen because, overall, according to it the two series follow each other closest for overlapping years.

48. So does a G' trend for births within 6 months of marriage for 1947 through 1962.

49. The proportion of all U.S. births that were illegitimate, meanwhile, rose from 1920 through 1950 via G with t_0 near 1891 and then in G form again from 1960 through 1992 (Himmelfarb 1995, 16).

50. For England and Wales and for Scotland (Fig. 4.4a) there is no segment of the G' curve moving upward with this timing, but a resetting of decline downward into new G' form.

51. According to Adams and Kasakoff (1990, Graph 2), while the number of children born to New England farmers who are estimated from date of birth to have married between about 1700 and the Civil War generally declined over the long term, those who persisted within a few miles of their place of origin display successive bulges of G' shape in the number of children they produced. These surges contributed to a process of rolling diffusion of settlement that can be traced, for instance, through a pulsing addition of new New England towns and churches, from the 1630s into the middle of the 1800s (Harris 1969, 236, 240). Men who themselves moved and initiated new farms did not supply such 'booms' in births (at what stage could they afford to marry?), but their children who settled nearby.

52. Though less than a third of L.D.S women experienced polygyny at its maximum among those of age to marry in the 1860s.

53. And, completed family size implies, also in Hingham, Watertown, Sturbridge, several other towns of Massachusetts (Anderson and Thomas 1973, 666), and St. Mary's County, Maryland, while birth-to-

marriage ratios indicate the same in Salem-Danvers, Andover-Middleton, and Ipswich-Boxford (Tab. 6.1).

54. Among the Old Order Amish in America during the first half of the 20th century (Ericksen et al. 1979, 259), in contrast, as influences of a modern environment began to expand opportunities beyond just traditional circumstances, G-form rather than E-type fertility increase appeared for the *youngest* women (Tab. 6.6, col. V).

55. All the way between 1610 and 1837, the range between the youngest and the oldest average for first-marriage brides in England was only 3.2 years, just 12 percent less during the minimum of the 1830s compared with the maximum in the 1710s--with 1.4 years of that difference occurring only from the 1760s forward (Wrigley et al. 1997, 134).

Yet G-shape trends of increase in age of first marriage for females appear in Sturbridge, Deerfield, and Nantucket from the middle of the 1700s into the early or middle 1800s (Osterud and Fulton 1976, 489, 485; Temkin-Greener and Swedlund 1978, 35; Logue 1983, 486).

56. But in the same three New England communities contracted via C.

57. Among Wahl's genealogies the ratio fell about 15 percent between women wed around 1698 and those married about 1798. Then it rose most of the way back during the era of heavy settlement to the Midwest and West (1986, 398-99).

58. While colonial fertility was mostly bulging in G' fashion with new settlement (Tab. 6.1).

59. Logue's analysis for Nantucket for some reason shows less--and less systematic--increase in net spacing between 1700 and 1837: only 29 percent for 1st to 2nd, and 11 percent for intervals above 4th (not just from 4th to 5th), excluding evidence of the penultimate gap (447-48). The variability for each of her birth intervals (given as the standard deviation), however, rises significantly with time: 95 percent for the gap from 2nd to 3rd birth, and on average 37 percent for the other three spans. Is increasing variability a sign of spreading initiative in determining family size? Meanwhile, though, her attribution of extended spacing and lowered fertility to lengthening voyages for Nantucket's famous whaling vessels appears vulnerable (435, 447). For instance, average duration of voyage rose 71 percent (from 23 to 39 months)

between the period 1800-1829 and that of 1830-1849 (midpoints at 1815 and 1840) while higher birth intervals for women who were clearly married to mariners between unions of 1800 to 1824 and those of 1825 through 1849 actually *shortened* 21 percent for the 4th to 5th and higher intervals and 28 percent for the spacing from 3rd to 4th child. There was just an 8 percent gain from 2nd to 3rd birth and an only slightly larger upward extension of 18 percent from the 1st to the 2nd child. This is hardly evidence for a determinative role of voyage length in the stretching out of birth intervals, especially when perhaps half of Nantucket men were going to sea. Some 37 percent identified as mariners as of 1850 plus an unmeasured fraction of others among those called carpenters, coopers, cooks, and blacksmiths (Logue 1983, 446). Logue's reminder that seafaring for most was a *youthful* occupation, however, is very helpful in understanding how in both her analysis and that of Byers spacing tended to increase over time (both for all Nantucket women and for just the wives of mariners) *early* in the sequence of child-bearing, where lengthening voyages might most have come to bear upon fertility. The expansion of intervals at both ends of the birth order simultaneously, more than during the middle, becomes less of a puzzle.

60. The authors subtracted 17.5 months from the total interval at each level to focus on current variation and change through time in spacing over and above typical biological delays that follow childbirth, half of which consist of a new period of gestation once conception is achieved.

61. Such movement is also evident for parities 10 and 12, though not for 11, background graphing indicates.

62. That these E curves all target the first years of the 1900s does not mean that increase in spacing in Utah was like that among Kantrow's families. Because Anderton and Bean take out the first 17.5 years of every interval, if the *full* spacings from one birth to the next are graphed, proportional increase over time will be flatter and delayed in target year, generating an appreciably later set of comparable movements in Utah relative to those observed for Philadelphia. For example, for parity 4 with the 17.5 initial months included, from 1863 through 1898 the E trend targets 1931 rather than the 1908 shown for Utah in Figure 6.10b. Still, the upward-accelerating E shape of these movements is preserved even if stretched out noticeably.

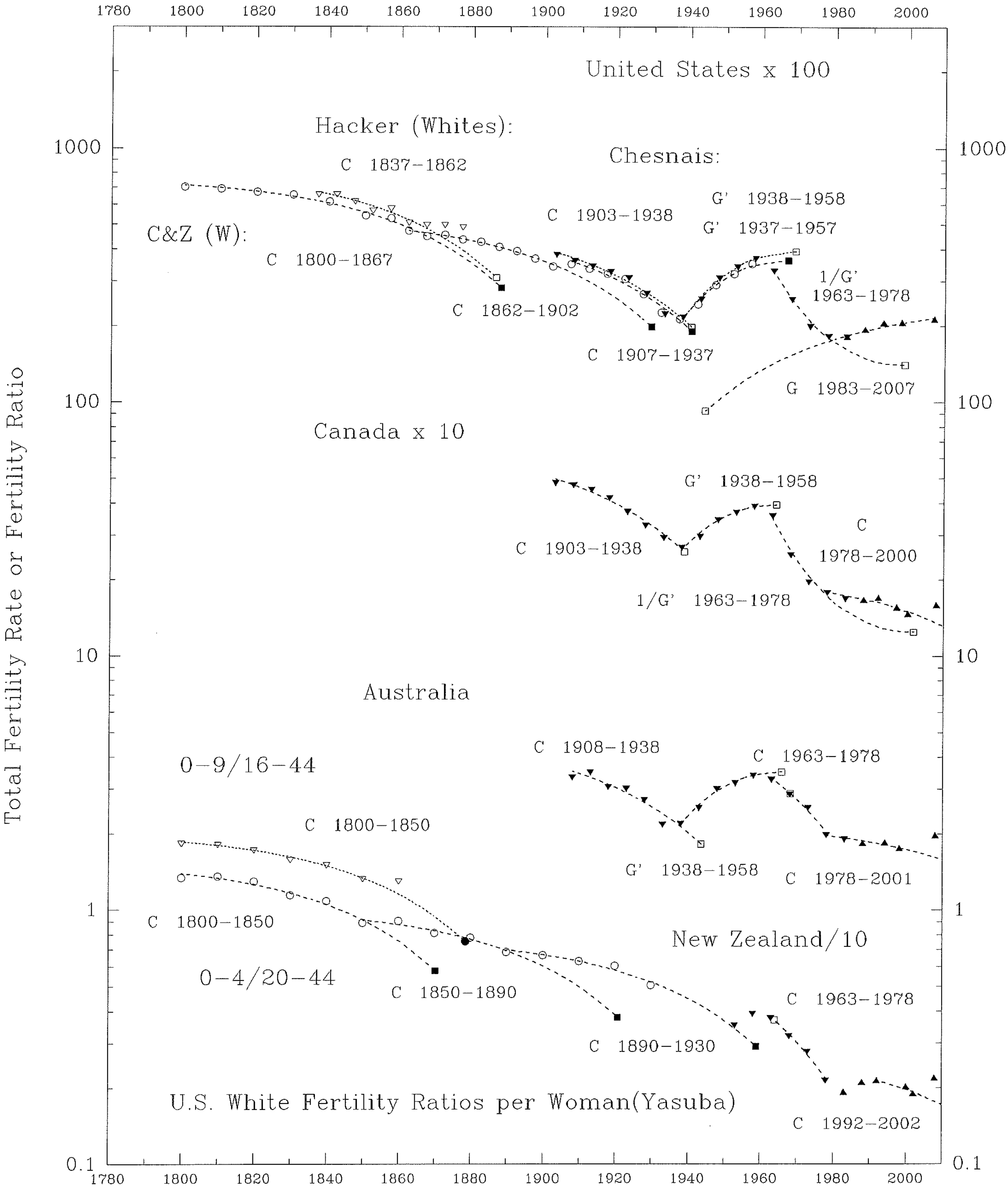
63. Age at marriage made a difference as to whether increase in spacing took E or G shape. . Among those wed before they were 21, spacing for females married around 1868, 1883, 1898, and 1913 (birth cohorts of 1845, 1860, 1875, and 1890) enlarged for parities 2, 3, 4, 7, and possibly 5 and 6 in E shape. For those married over the age of 25, however, *G-type* gains in spacing were the norm instead for parities 2 through 6, while among females married from 21 to 25--the intermediate group--for parities 2 through 7 the increase was generally *log-linear*: it neither accelerated nor decelerated. The net amount of proportional change over 45 years, meanwhile, tended to be about the same for the three categories of women by age of marriage. They just arrived there via different paths (Anderton and Bean 1985, 179). Apparently the number of children ever born was also related to whether extended spacing took E or G shape, or occurred at all (Anderton and Bean 1985, 176).

64. This intermediate trend proposed has its zero year at about the same time as his lower bound calculation from 1808 through 1871. The two curves passed t_0 around 1835, compared with 1849 for *m* between 1820 and 1890. Similarly, the second lower bound G trend for the proportion of white women reducing their fertility also somewhat leads the second pattern of that shape for *m*, with zero years in the middle 1860s and middle 1880s respectively. At least part of the lag of 15 to 20 years in these pairings would seem to derive from matching fertility reducers by estimated age of marriage with *m* generated by births that occurred over a range of years following marriage.

65. The G trend for *m* among Mormons (Bean et al. 1990, 134), adjusted for age of marriage, breaks the .200 level only around 1900, compared with the 1840s for U.S. white women as a whole according to Sanderson, and has a zero year for its late, if steep, change only at 1932, not 1849. On the other hand, contraceptive efficacy--defined as “the monthly probability of averting conception” (ibid., 194-96)--went from zero among Mormon women likely to have been married on average before 1880 to 85 percent among those wed around 1920 in G form with t_0 around 1887, closely parallel with the trend of *m* for U.S. whites between 1890 and 1920.Among the Old Order Amish, meanwhile, values of *m* for women of age to marry around 1908 and 1927 would fit a G curve with a zero year around 1884 but a negligible height at that point of only approximately .105 (Knodel 1983, 88). This pattern, nonetheless--though

Figure 6.1

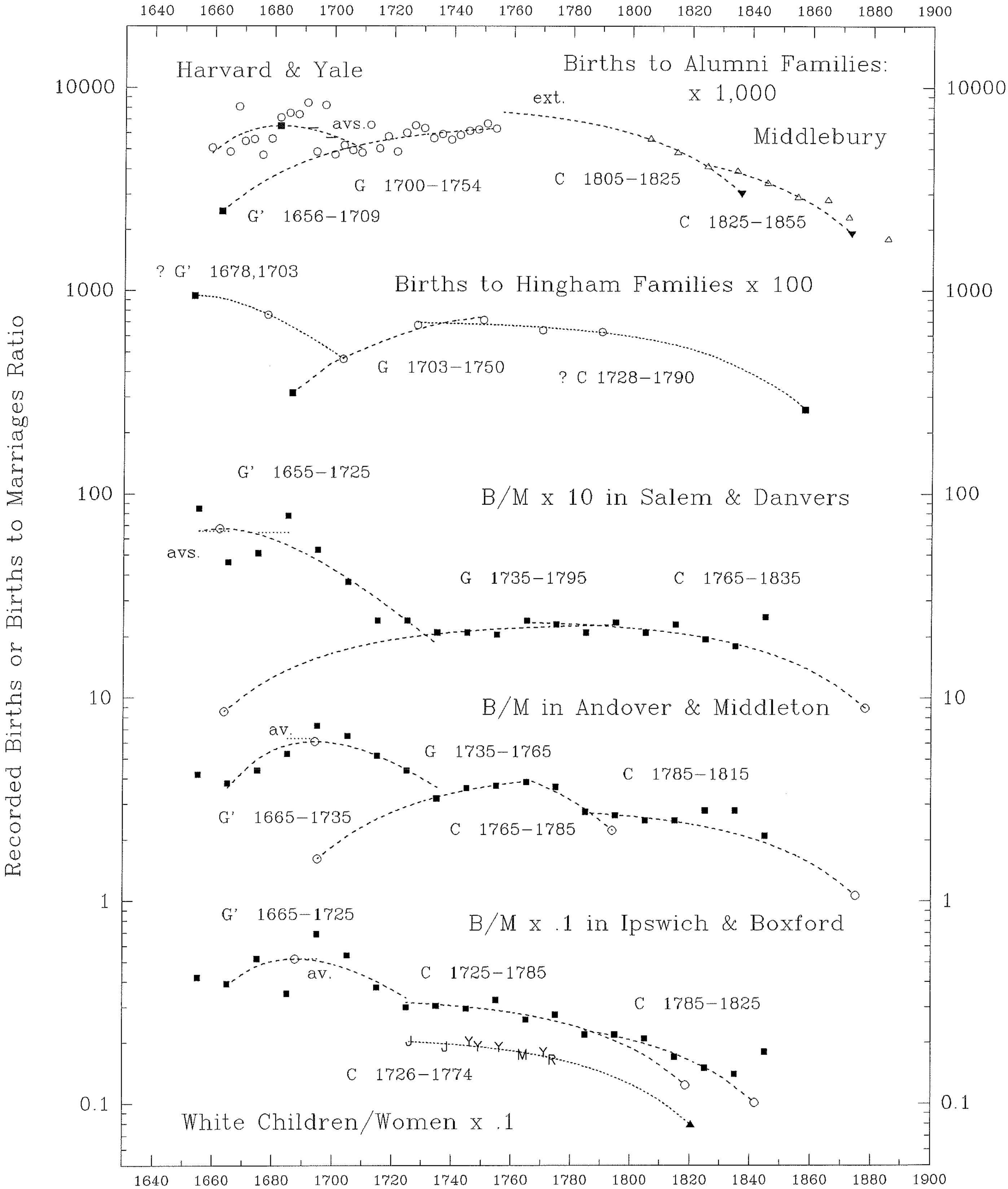
Trends of Total Fertility in the United States, Canada, Australia, and New Zealand



Sources: Coale and Zelnik 1963, 36; Hacker 2003, 612 (15–49); Chesnais 1992, 549–50; Yasuba 1961, 32, 62; U.N. Demographic Yearbooks 1992, 1995, 2000; Goldstein et al. 2009, 669, 672.

Figure 6.2

Some Reproductive Trends in Early America

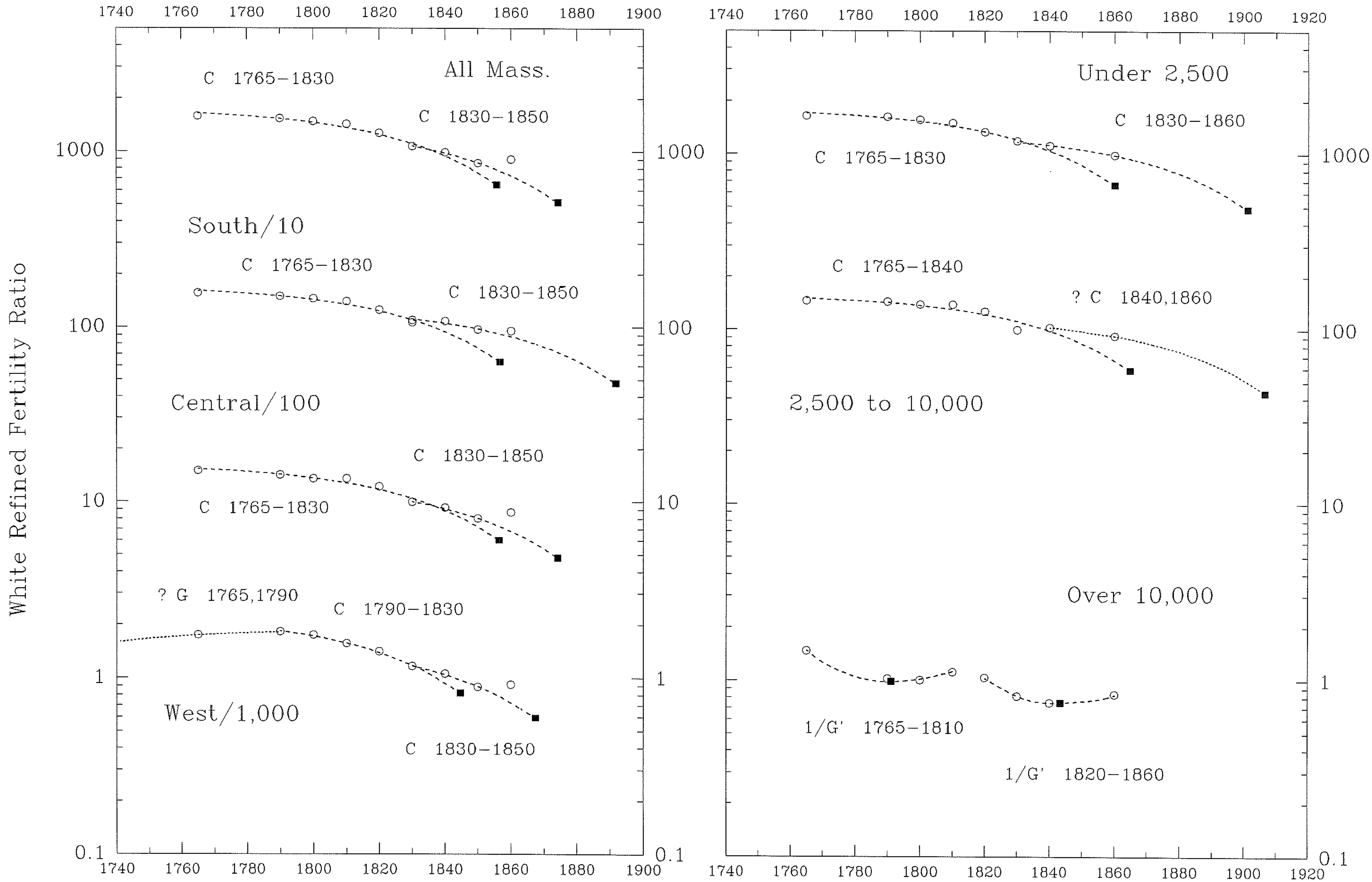


J = New Jersey; Y = New York; M = Massachusetts;; R = Rhode Island.

Sources: Harris 1969, 317; Yasuba 1961, 45–46; D. S. Smith 1972, 177; Vinovskis 1981, 51; Yasuba 1961, 71.

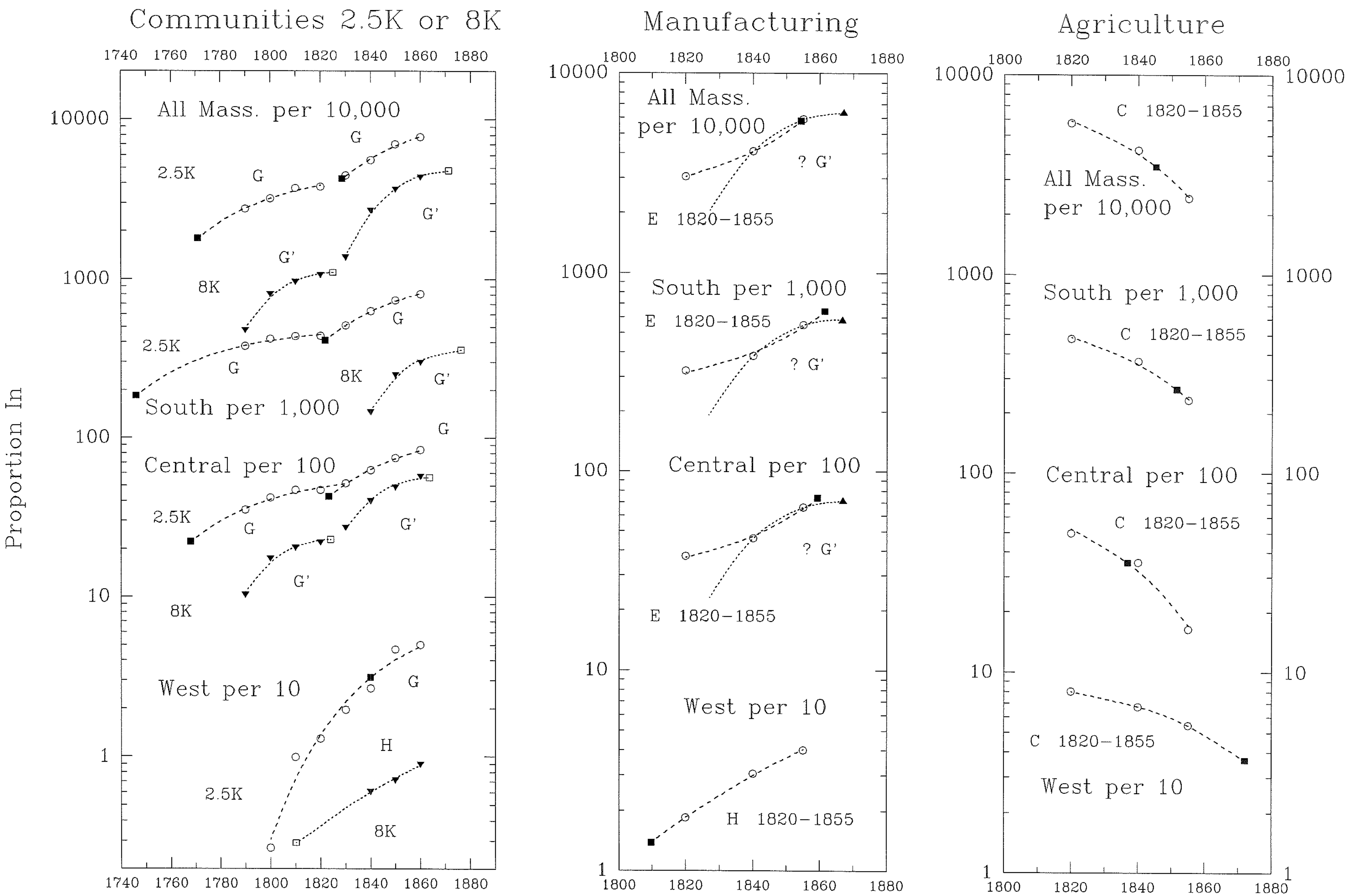
Figure 6.3a

Fertility and Its Context in Early National Massachusetts: Fertility Ratios in Parts of the State and in Communities of Certain Sizes



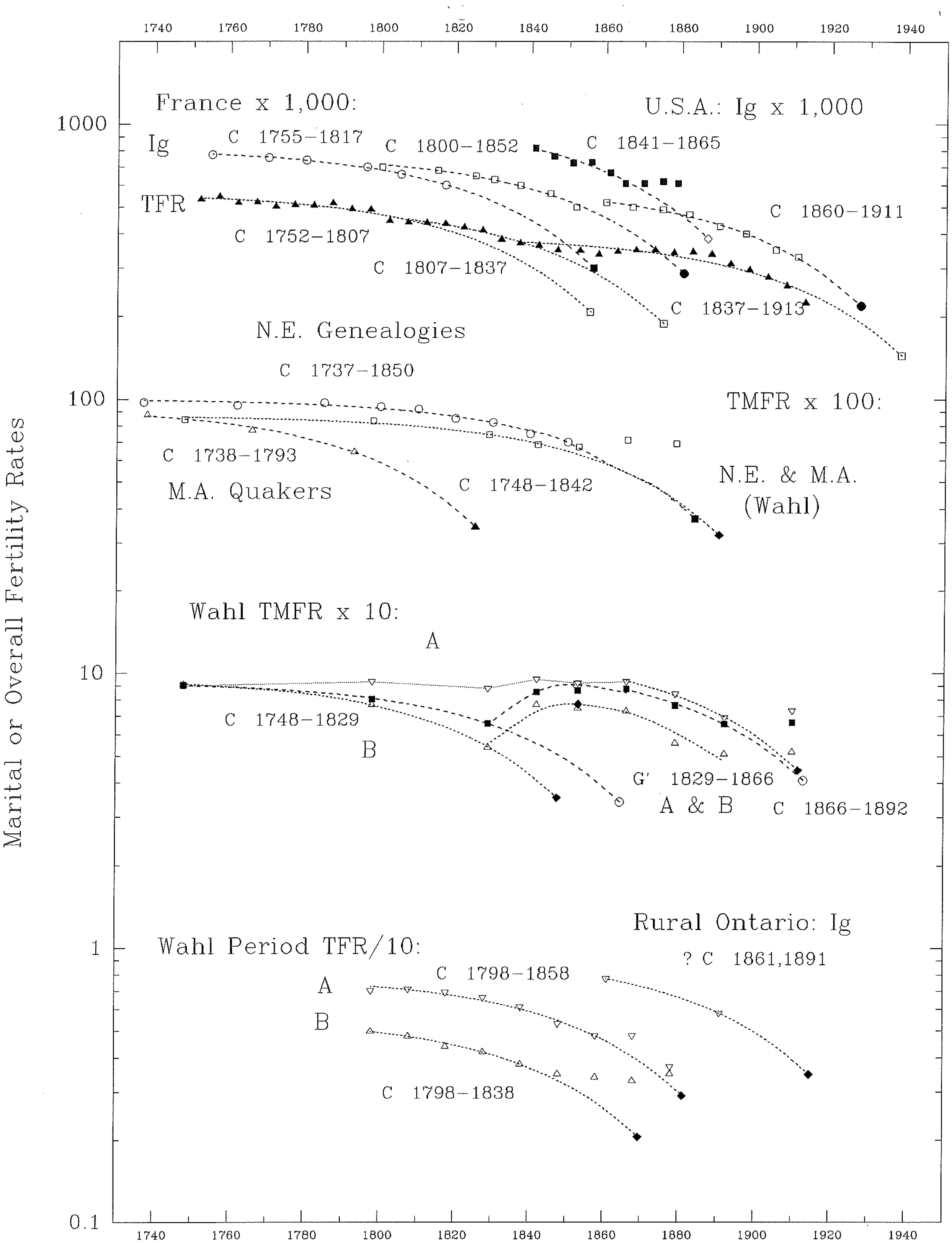
Source: Vinovskis 1981, 212, 230–31.

Figure 6.3b
Fertility and Its Context in Early National Massachusetts: Trends in Urbanization and Employment



For dates of urban trends see Tab. 6.2; possible G' trends for manufacturing all just 1840 and 1855 (extended).
Source: Vinovskis 1981, 228–29, 220..

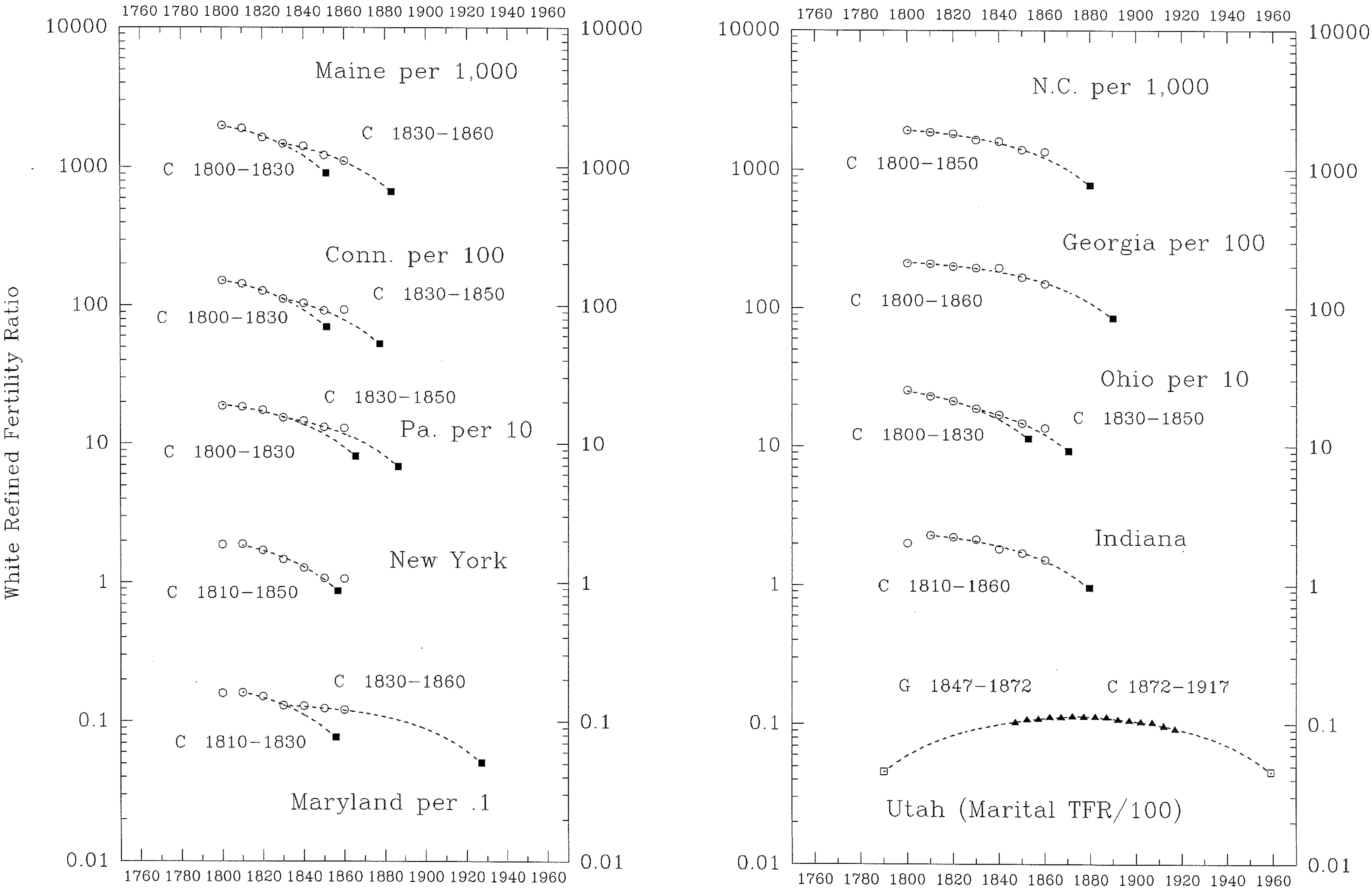
Figure 6.4
Marital and Total Fertility in France and North America During the 18th and 19th Centuries



Sources: Figs. 5.1a, 5.1b; Hacker 2003, 615; Main 2006, '41; Wells 1971, 75; Wahl 1986, 406, 398–99, 396; McInnis 2001, 394, 407..

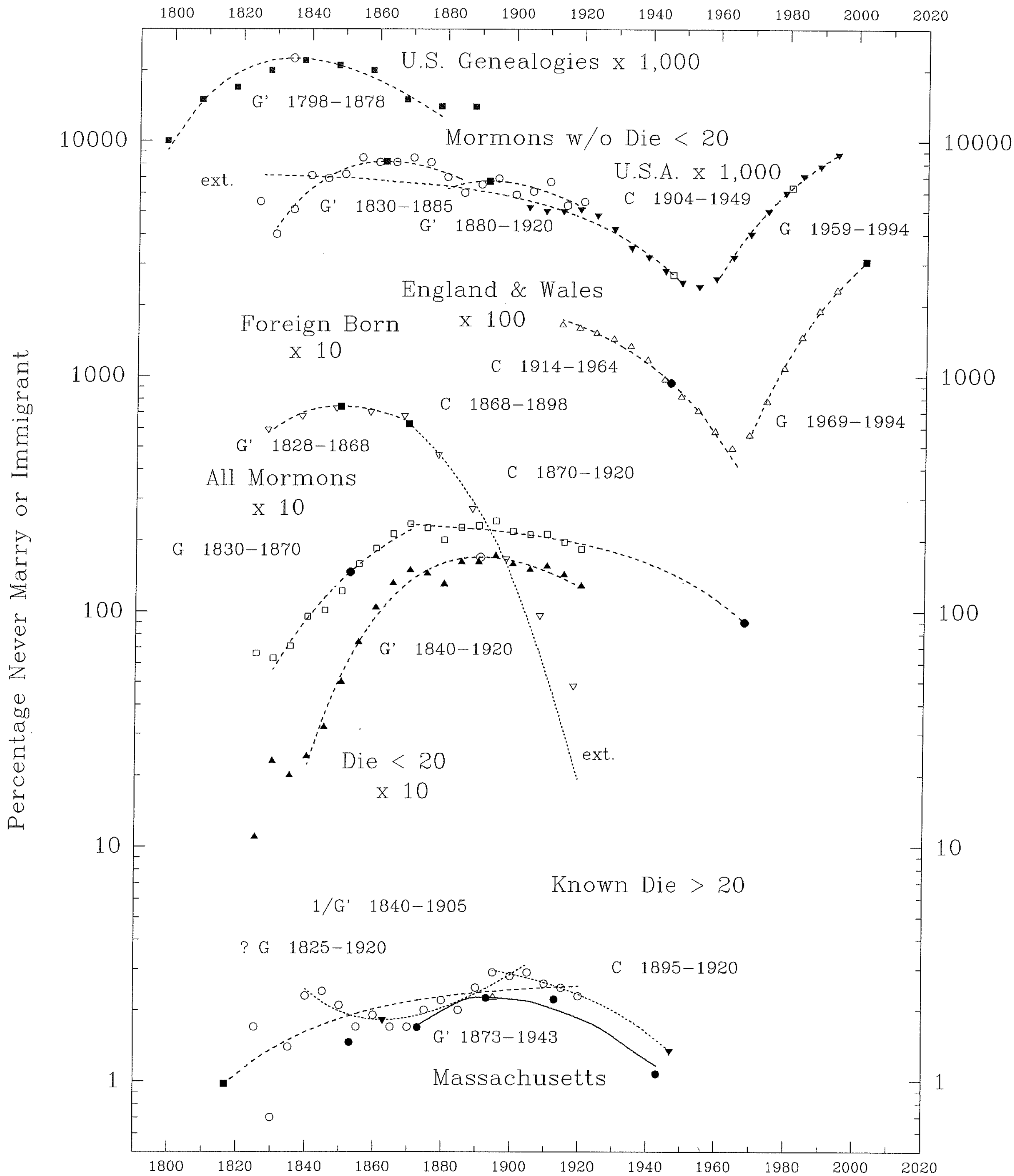
Figure 6.5

Illustrative Trends of Fertility in U.S. States of Various Regions



Sources: Yasuba 1962, 61–62; Bean et al. 1990, 111.

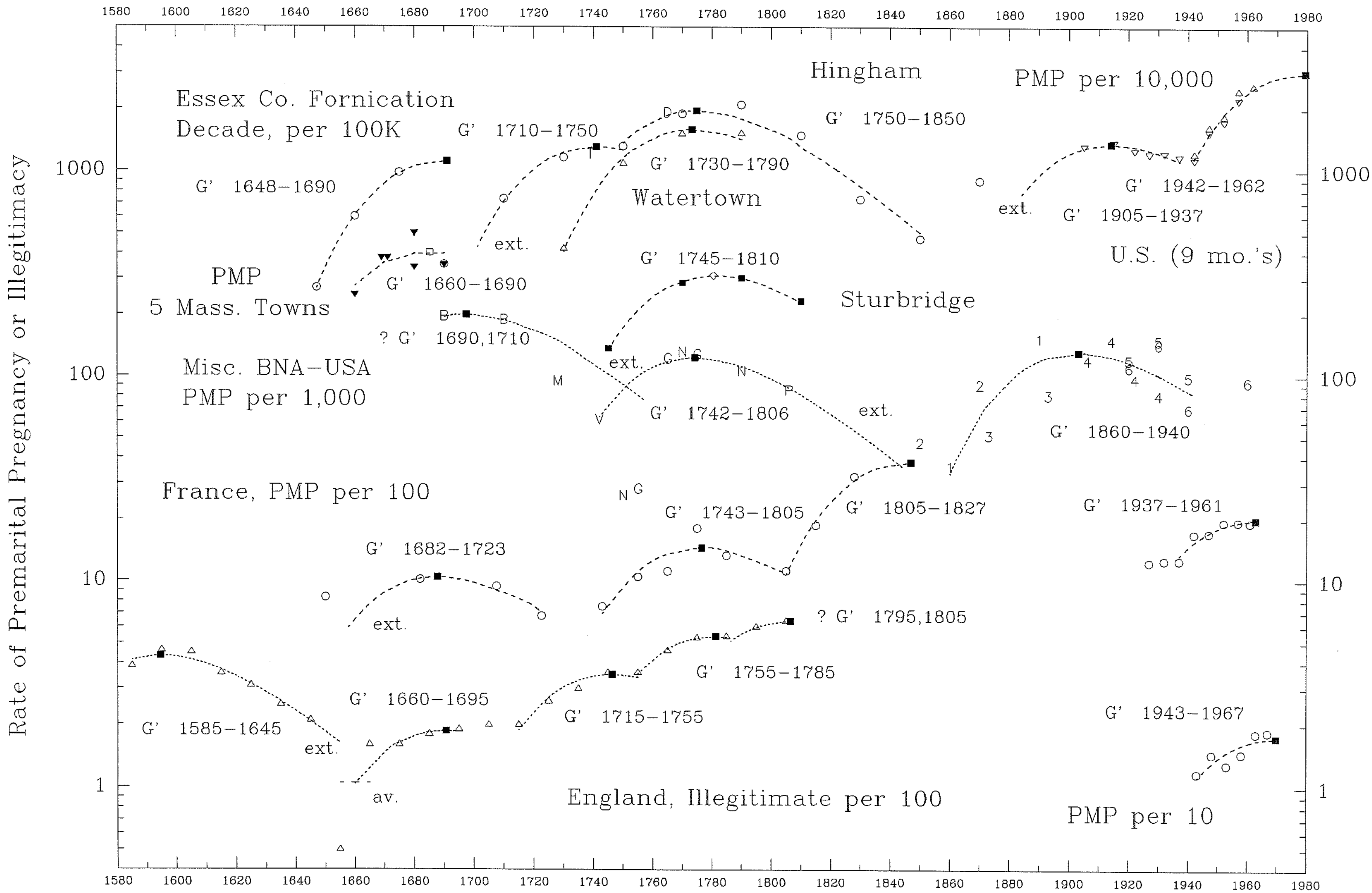
Figure 6.6
Celibacy among Women of Age to Marry 1798-1994: The United States, England and Wales, and Utah Mormons



Sources: Wahl 1986, 402: Hacker 2003, 610; Bean et al. 1990, 82, 142; Schoen and Canudas-Romo 2005, 141; Uhlenberg 1969, 420.

Figure 6.7

Comparing Trends for Premarital Pregnancy or Illegitimacy in America, France, and England

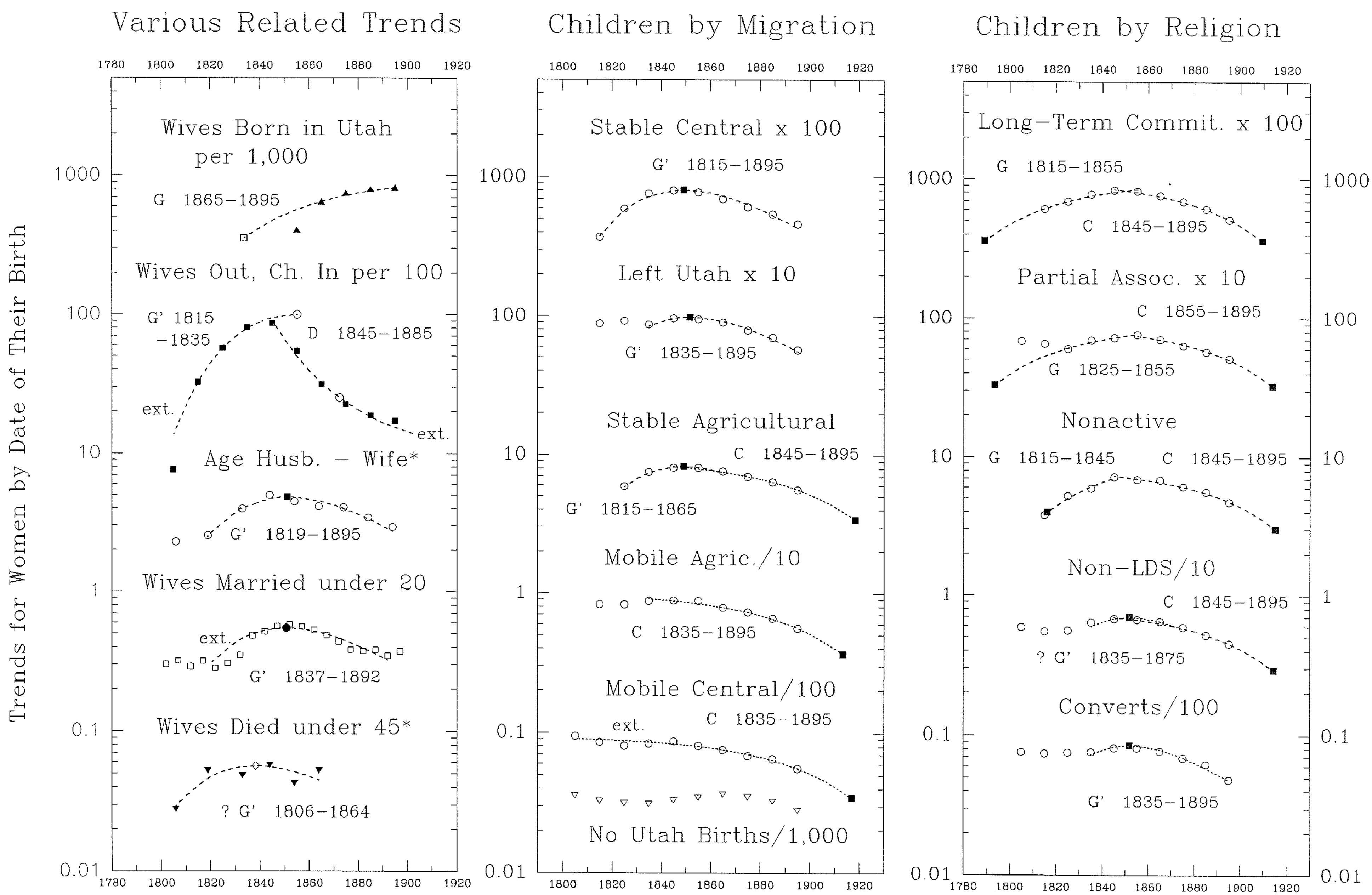


For estimates represented by letters or numbers, see text and notes.

Sources: Smith and Hindus 1975, 554, 561–570; Smith 1973a, 325: Imhof 1975, 1: 536–37.

Figure 6.8

Children Ever Born and Various Fertility-Related Changes among U.S. Mormons

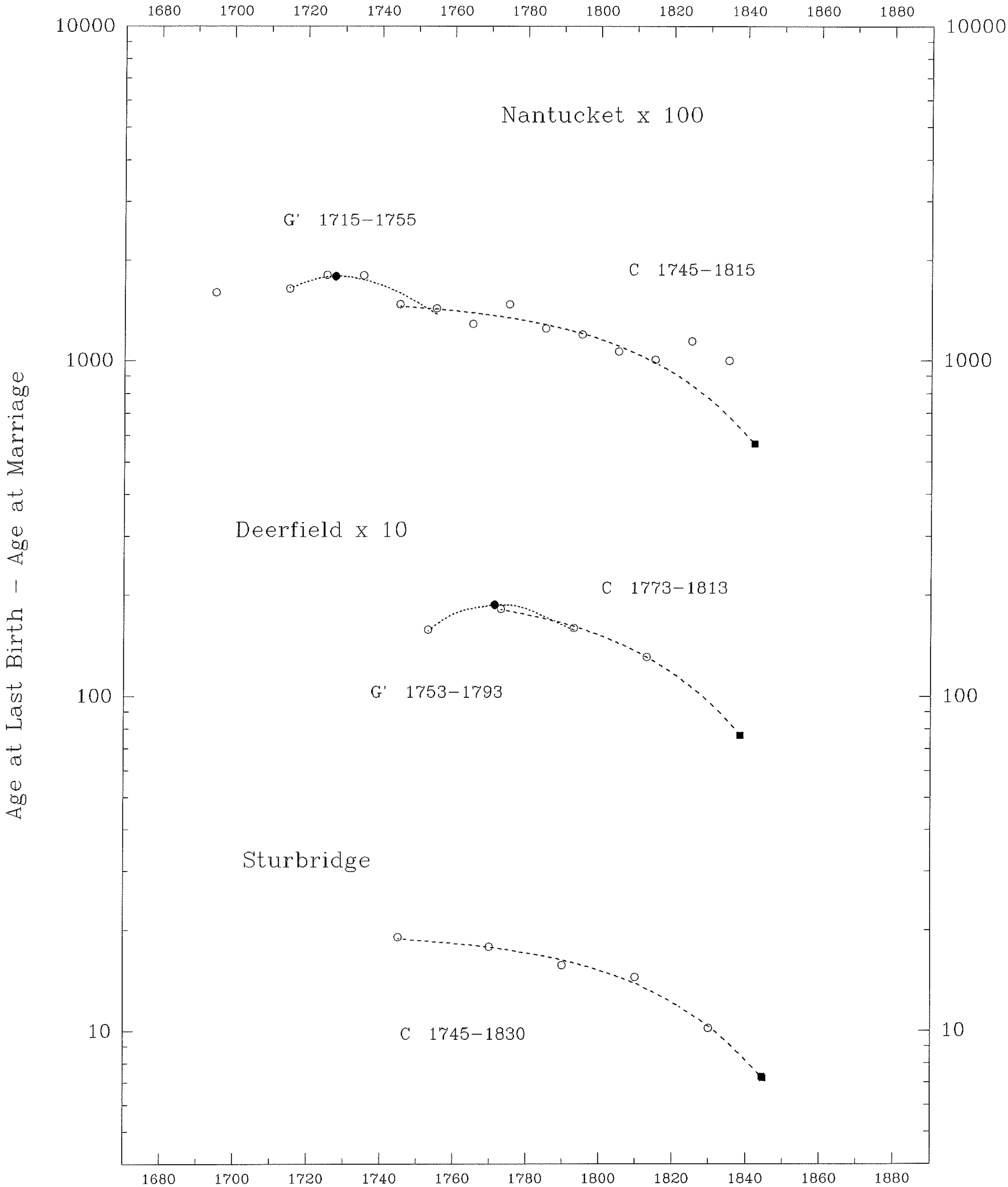


* Adjusted 21 years to estimate average date of birth.

Sources: Skolnik et al. 1978, 14; Bean et al. 1990, 125, 151, 165, 169.

Figure 6.9a

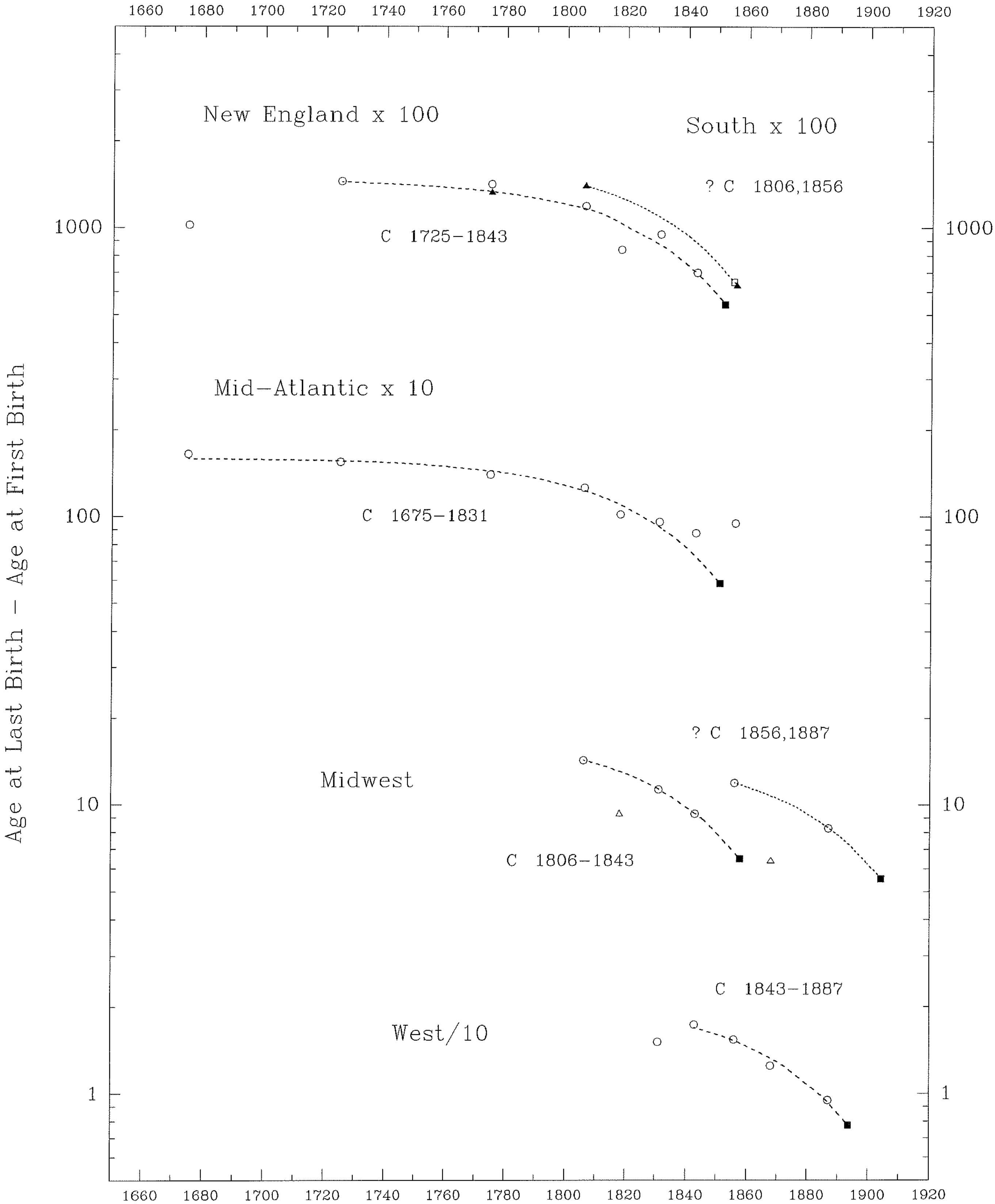
Duration of Reproduction: Women in Early Massachusetts (by Date of Marriage)



Sources: Byers 1982, 29, 21; Temkin-Greener and Swedlund 1978, 35; Osterud and Fulton 1976, 489, 485.

Figure 6.9b

Duration of Reproduction:
Women in Genealogies (by Birth Cohort)

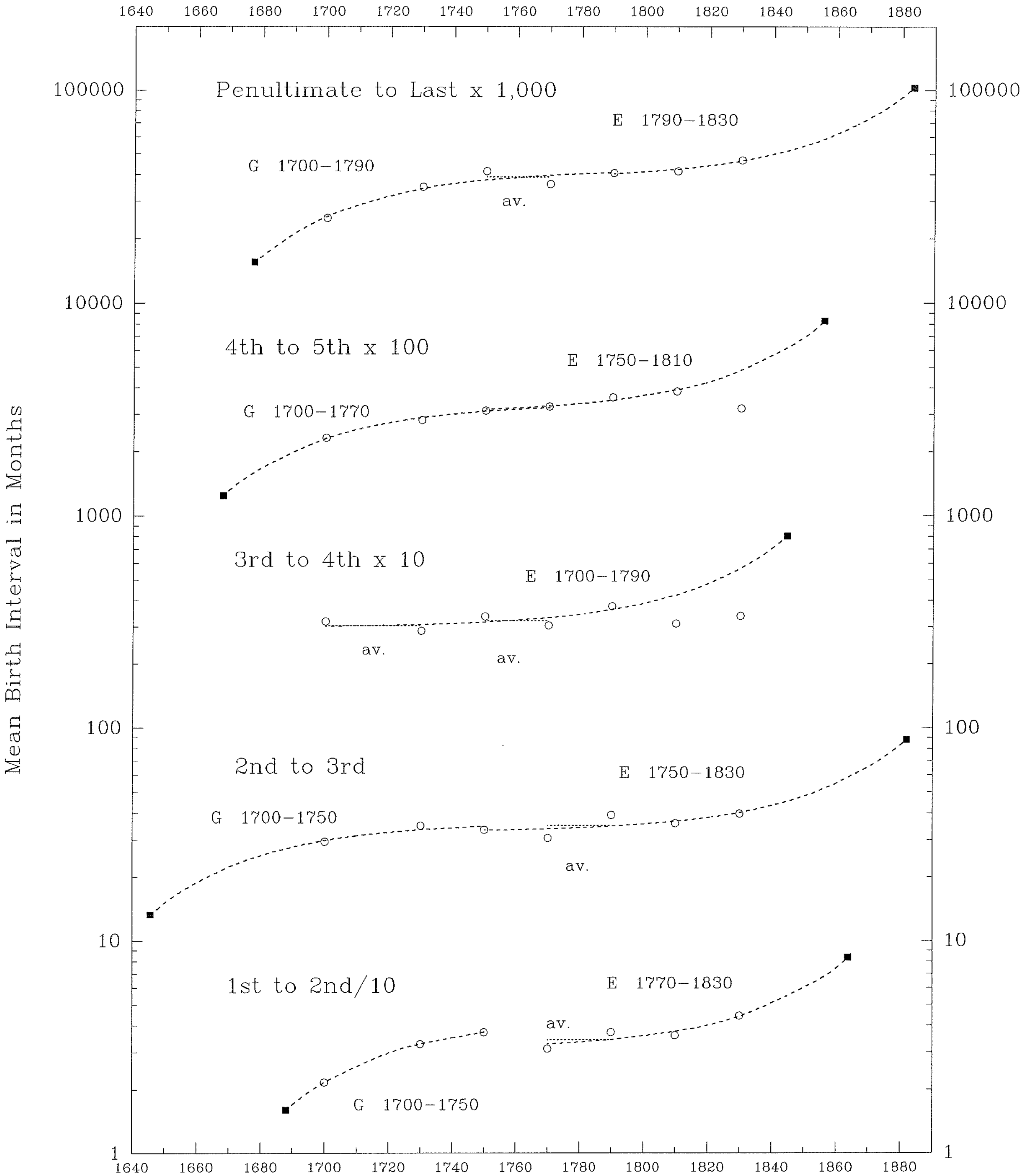


Source: Wahl 1986, 408.

Figure 6.10a

Trends in the Spacing of Births:

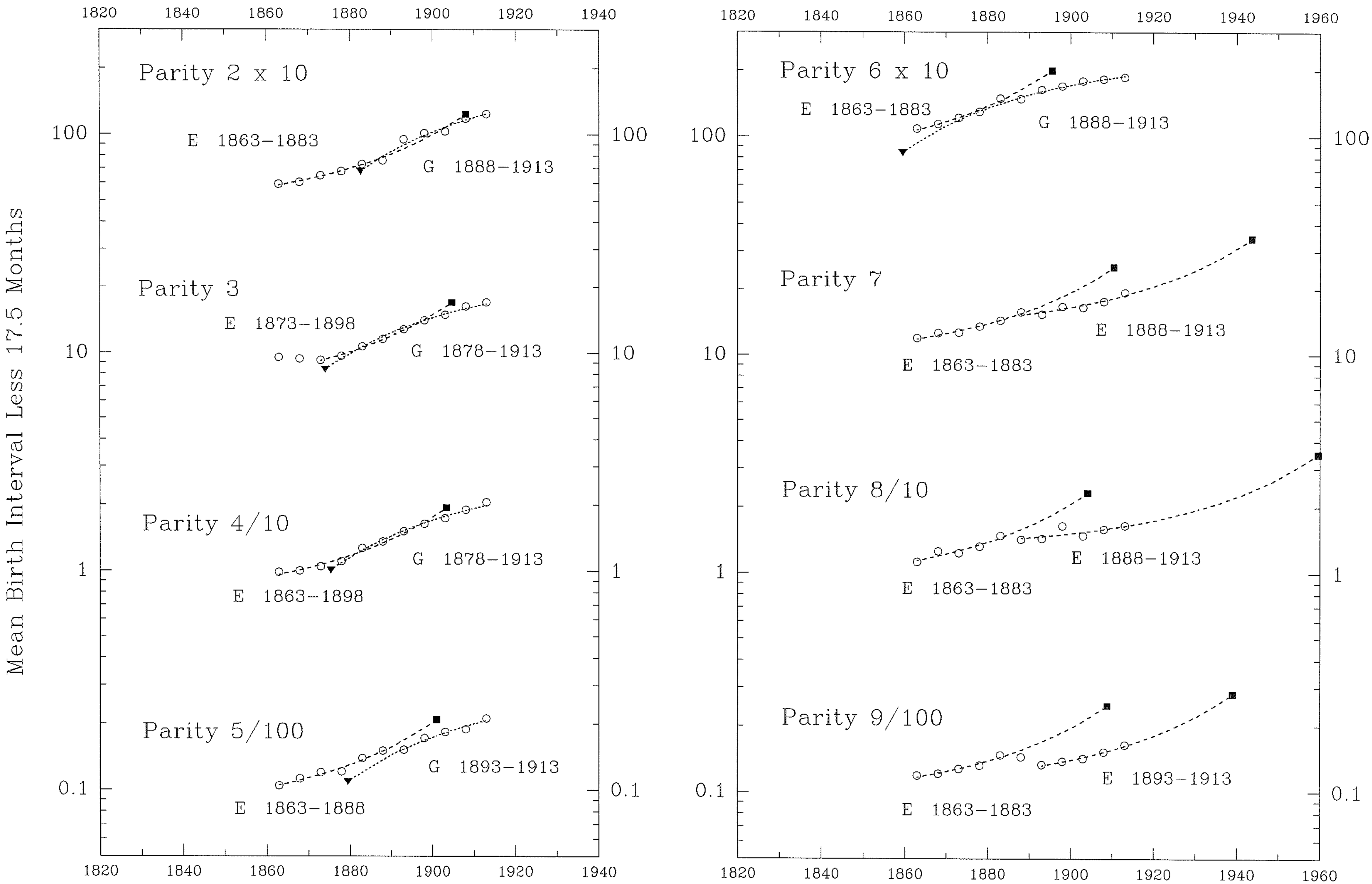
Nantucket 1700–1830



Source: Byers 1982, 35. Compare Logue 1983, 448.

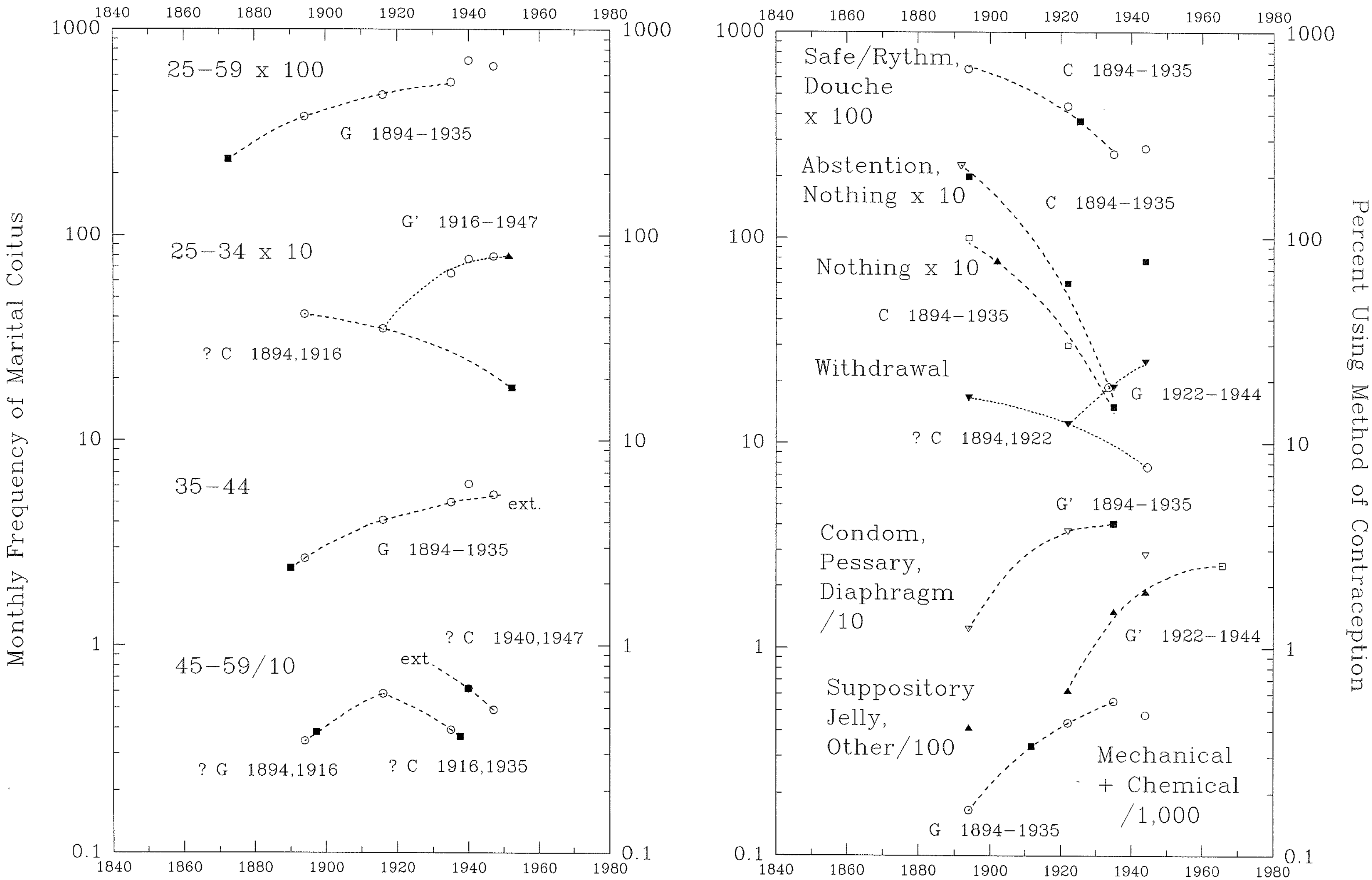
Figure 6.10b

Trends in the Spacing of Births:
Utah 1863–1913 *



* date of marriage estimated from birth + 23 years.
Source: Anderton and Bean 1985, 174.

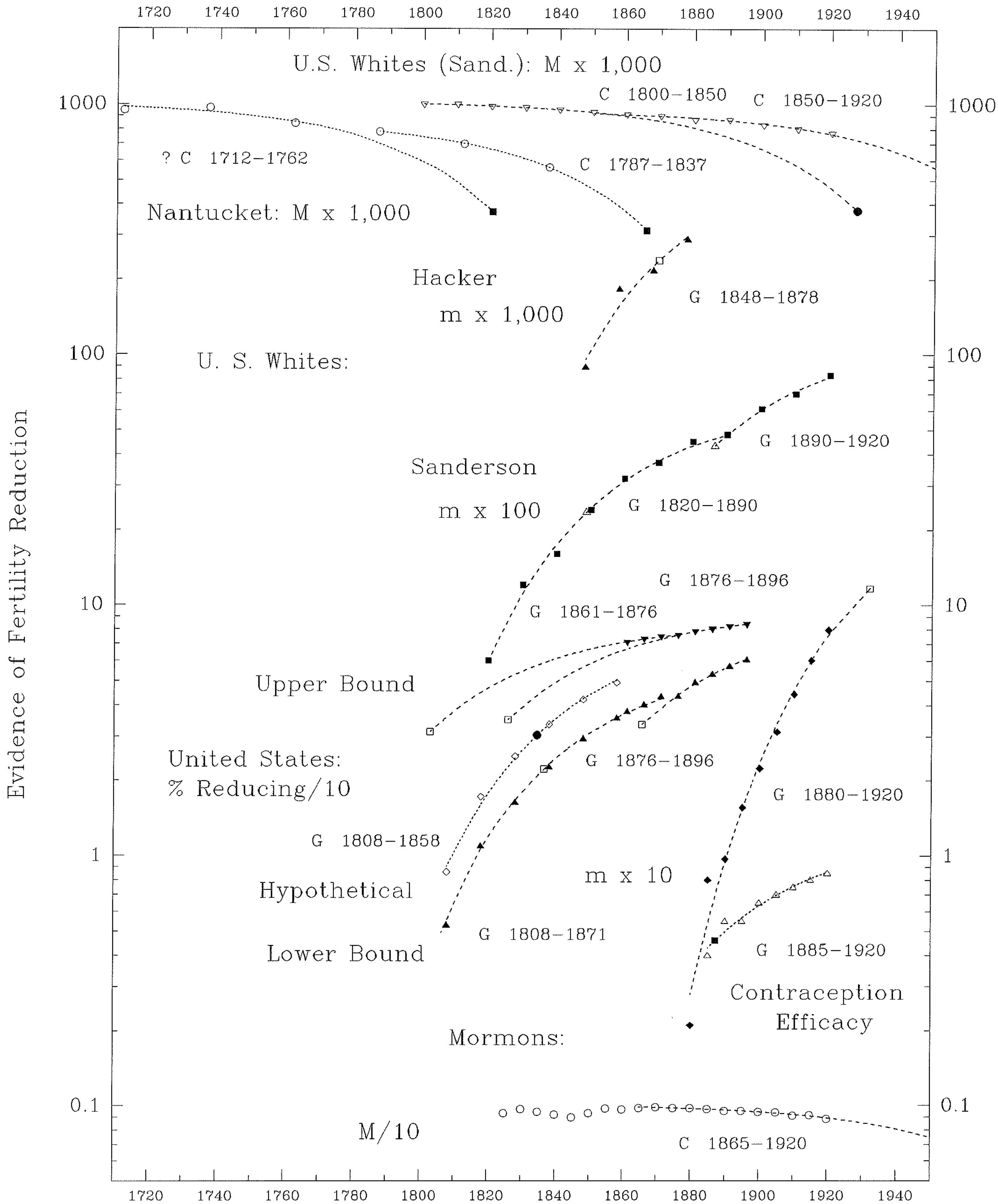
Figure 6.11
Fertility Reduction in Some U.S. Contexts: Coitus and Contraception from the 1890s to the 1940s



Source: David and Sanderson 1986, 336–37, 324–25.

Figure 6.12

Parity-Related Family Limitation in the United States



Sources: Logue 1983, 445; Hacker 2003, 614; Sanderson 1979, 341,350; Bean et al. 1990, 134, 194–95.

Table 6-1

Comparing Some 'New World' Fertility Trends with European Ones

Total Fertility Rate:

England	1661-1726	G	1615	1726-1815	E	1851	1816-1856	D	1787	1851-1933	C	1926
France				1742-1807	C	1855	1807-1837	C	1875	1837-1913	C	1938
Normandy	1700-1730	G	1630	1750-1790	C	1819	1790-1810	C	1866			
SE Paris Basin				1700-1810	C	1849						
Southwest	1700-1760	G	1645	1760-1810	C	1875						
Sweden				1758-1808	C	1880	1813-1908	C	1965	1908-1933	C	1921
Canada										1903-1938	C	1939
Australia										1908-1938	C	1944
U.S. Whites							1841-1865	C	1887[gh]			
" "							1837-1862	C	1886[h]	1867-1902	C	1929[z]
"							1800-1867	C	1888[z]	1902-1937	C	1940[z]
" All										1903-1938	C	1940[c]
New England[m]							1737-1850	C	1882			

White Refined Fertility Ratio:

United States[y]							1800-1850	C	1879
Massachusetts[v]				1765-1830	C	1856	1830-1850	C	1874
Southern				1765-1830	C	1857	1830-1850	C	1892
Central				1765-1830	C	1857	1830-1850	C	1874
Western	1765,1790?	G	1681	1790-1830	C	1845	1830-1850	C	1868
Mass.,RI, NY, NJ#[y]				1726-1774	C	1821			
Maryland#[y]				1755,1800	?C	1850			

Completed Family Size:

N.E. Alumni*[xy]	1681	1700-1754	G	1665	1805-1825	C	1836	1825-1855	C	1872			
Hingham*[s]	1653	1703-1750	G	1686	1728-1790	C	1858						
Watertown*[x]	1646	1676-1739	G	1646	1730-1775	C	1808						
St. Mary's*[wa]	1680	1702-1748	G	1676									
Nantucket*[b]	1712				1745-1795	C	1826	1795-1835	C	1870			
Deerfield*[t]	1763				1753-1813	C	1837						
Sturbridge*[o]	1743				1770-1819	C	1847						
Massachusetts[u]											1873-1913	C	1944
New England[m]								1660-1840	C	1864			
Mid-A. Quaks.[we]					1738-1793	C	1820						
Phila. Elite[k]								1737-1850	C	1870			
Mormons[sk]								1840-1864	G	1790	1864-1915	C	1922

Births/Marriages:[v]

Salem-Danvers*	1662	1735-1795	G	1664				1765-1835	C	1878
Andover-Mdtn.*	1694	1735-1765	G	1695	1765-1785	C	1794	1785-1815	C	1875
Ipswich-Bxfd.*	1688				1725-1785	C	1819	1785-1825	C	1842

* Early G' surge peaks at indicated date. # children 0-15/all white women 16+. [h] = Hacker; [g] = I_g; [z] = Coale and Zelnik; [m] = Main; [c] = Chesnais; [y] = Yasuba; [v] = Vinovskis; [s] = Smith; [x] = Harris; [wa] = Walsh; [b] = Byers; [o] = Osterud and Fulton; [t] = Temkin-Greener and Swedlund; [u] = Uhlenberg; [k] = Kantrow; [we] = Wells; [sk] = Skolnick et al.

Sources: See text.

Table 6.2

Trends in Fertility and Its Environment in Massachusetts 1765-1855

	All Massachusetts	Southern	Central	Western
White Refined Fertility Ratio				
				1765,1790 ?G 1681
	1765-1830 C 1856	1765-1830 C 1857	1765-1830 C 1857	1790-1830 C 1845
	1830-1850 C 1874	1830-1850 C 1892	1830-1850 C 1874	1830-1850 C 1868
		Under 2,500	2,500-10,000	Over 10,000
		1765-1830 C 1860	1765-1830 C 1865	1765-1810 1/G' 1791
		1830-1860 C 1901	1840,1860 ?C 1907	1820-1860 1/G' 1843
Percentage Living in Towns of 2,500 or More	All Massachusetts	Southern	Central	Western
	1790-1820 G 1771	1790-1820 G 1746	1790-1830 G 1758	
	1830-1860 G 1829	1830-1860 G 1822	1830-1860 G 1823	1800-1860 G 1840
Percentage Living in Towns of 8,000 or More				
	1790-1820 G' 1825		1790-1820 G' 1824	
	1830-1860 G' 1871	1840-1860 G' 1876	1830-1860 G' 1864	1840-1860 H 1810
Percentage in Manufacturing				
	1820-1855 E 1854	1820-1855 E 1862	1820-1855 E 1860	1820-1855 H 1810
	1840,1855 ?G' 1867	1840,1855 ?G' 1867	1840,1855 ?G' 1867	
Percentage in Agriculture				
	1820-1855 C 1845	1820-1855 C 1852	1820-1855 C 1837	1820-1855 C 1872

Source: Vinovskis 1981, 212; 230-31; 228-29; 220.

Table 6.3

Marital and Total Fertility in France and North America

during the 18th and 19th Centuries

France *Ig*	1755-1817 C 1857 = .300	1800-1852 C 1881 = .287	1860-1911 C 1928 = .219
TFR	1752-1807 C 1859 = 2.07	1807-1837 C 1875 = 1.88	1837-1913 C 1938 = 1.44
U.S.A. *Ig*		1841-1865 C 1887 = .384	
TFR		1837-1862 C 1886 = 3.10	
U.S. Period TFR Wahl A		1798-1858 C 1881 = 2.90	
" " " " B		1798-1838 C 1870 = 2.05	
Mid-Atl. Quaker TMFR	1738-1793 C 1825 = 3.43		
Normandy *Ig*	1770-1810 C 1828 = .287		
N.E. (Main) TMFR		1737-1850 C 1884 = 3.68	
N.E.-M.A. (Wahl) TMFR		1748-1842 C 1890 = 3.20	
S.W. France *Ig*	1700-1790 G increase	1780-1820 C 1864 = .248	1830-1870 C 1907 = .188
S.E. Paris Basin *Ig*	1700-1790 C 1868 = .306	1790-1880 D decrease	
Wahl A & B TMFR	1748-1829 C 1864 = 3.42	1829-1866 G' 1853 = 9.07	1866-1892 C 1913 = 4.09
" A "			1866-1892 C 1912 = 4.25
" B "	1748-1829 C 1848 = 3.53	1829-1892 G' 1853 = 7.72	1853-1892 C 1910 = 3.20
Wahl Midwest TMFR*		1829-1853 C 1868 = 3.50	1853-1892 C 1917 = 3.00
" West " *		1853-1910 ?G' 1865 = 9.00	
" Midwest-West TMFR*		1853-1892 G' 1860 = 8.30	
Rural Ontario *Ig*			1861,1891 ?C 1915 = .347

* = Estimated. Others fitted.

Sources: Figs. 5.1a, 5.1b, Tab. 5.2; Figs. 6.1, 6.5, Tab. 6.1; Main 2006, 41; Wells 1971, 75; Wahl 1986, 396, 406, 398-99; McInnes 2000, 394, 407.

Table 6.4

Likely Early 19th Century Trends for U.S. States in the White Refined Fertility Ratio and the Proportion of Women of Fertile Age in the White Population

A. State by State

Per 1,000:	1800 WRFR	First C Decline in WRFR	Second C Decline in WRFR	% Women 16-44/All Whites	Pop. Growth: I	Pop. Growth: II
Maine*	1,974	1800-1830 C 1851 = 906	1830-1860 C 1883 = 666	1810-1860 G 1766 = 8.5	-	3
New Hampshire	1,704	1800-1830 C 1850 = 750	1830-1850 C 1871 = 550	1820-1860 G 1774 = 9.0	2	2
Vermont	2,068	1800-1820 C 1825 = 1,200	1820-1850 C 1880 = 600	1800-1860 G 1758 = 8.3	-	3,2
Massachusetts**	1,477	1765-1830 C 1856 = 646	1830-1850 C 1874 = 514	1820-1860 G 1780 = 10.0	1	1E
Rhode Island	1,455	1800-1840 C 1862 = 600	?	1820-1860 G 1780 = 10.0	2	1E
Connecticut*	1,512	1800-1830 C 1851 = 697	1830-1850 C 1877 = 525	1810-1860 G 1767 = 9.0	1	1
New York*	1,895[a]	1810-1850 C 1857 = 871		1820-1860 G 1787 = 10.0	1,3	3
New Jersey	1,822	1800-1830 C 1859 = 780	1830-1850 C 1881 = 650	1820-1850 G 1776 = 8.5	1,2	1H
Pennsylvania*	1,881	1800-1830 C 1866 = 810	1830-1850 C 1887 = 682	1820-1880 G 1776 = 9.0	2	3H
Delaware	1,509[a]	1810-1830 C 1859 = 750	1830-1860 C 1915 = 540	1820-1850 G 1775 = 9.0	2	3
Maryland*	1.585[a]	1810-1830 C 1856 = 766	1830-1860 C 1927 = 506	1820-1860 G 1762 = 9.0	1	1
Virginia	1,954	1800-1830 C 1870 = 750	1830-1860 C 1906 = 630	1800-1860 G 1751 = 8.0	F	1
North Carolina*	1,920		1800-1850 C 1880 = 776	1820-1860 G 1773 = 8.7	2	2
South Carolina	2,030		1800-1850 C 1872 = 800	1820-1850 G 1781 = 9.0	3	2
Georgia*	2,116		1800-1860 C 1890 = 848	1820-1860 G 1772 = 8.2	3	3
Kentucky	2,371	1800-1830 C 1863 = 970	1830-1860 C 1893 = 770	1810-1860 G 1770 = 7.8	-	3
Tennessee	2,424		1800-1850 C 1872 = 950	1820-1860 G 1779 = 8.5	-	3
Missouri	2,375[a]		1810-1850 C 1868 = 1,050	1830-1860 G 1792 = 8.3	-	5

Table 6.4 (cont.)

B. A Suggestive Regional Grouping by Timing and Level of Trends

	1800 WRFR	First C Decline in WRFR	Second C Decline in WRFR	% Women 16-44/All Whites	Pop. Growth: I	Pop. Growth: II
Mass.*-R.I.-Conn.*	1,481	1800-1830 C 1856 = 648	1830-1850 C 1876 = 520	1820-1860 G 1776 = 9.7	1/2/1	1E/1E/1
New Hampshire	1,704	1800-1830 C 1850 = 750	1830-1850 C 1871 = 550	1820-1860 G 1774 = 9.0	2	2
Maine*	1,974	1800-1830 C 1851 = 906	1830-1860 C 1883 = 666	1810-1860 G 1766 = 8.5	-	3
Vermont	2,068	1800-1820 C 1825 = 1,200	1820-1850 C 1880 = 600	1800-1860 G 1758 = 8.3	-	3/2
N.J.-Pa.*	1,852	1800-1830 C 1863 = 795	1830-1850 C 1884 = 666	1820-1850 G 1776 = 8.8	1,2/2	1H/3H
New York*	1,895[a]	1810-1850 C 1857 = 871		1820-1860 G 1787 = 10.0	1,3	3
Ohio*	2,550	1810-1830 C 1853 = 1,138	1830-1850 C 1870 = 929	1820-1860 G 1781 = 8.0	-	4
Ind.*-Ill.-Mich.	2,210[b]		1820-1850 C 1876 = 920	1820-1860 G 1785 = 8.3	-	4/5/5
Iowa	1,837[d]		1840-1860 ?C 1905	1840-1860 G 1782 = 8.5	-	5
*Utah**	2,004[e]	1847-1872 G 1790#	1872-1917 C 1959#		-	6
Del.-Md.*	1,547	1810-1830 C 1858 = 758	1830-1860 C 1921 = 523	1820-1860 G 1769 = 9.0	2/1	3/1
Virginia	1,954	1800-1830 C 1870 = 750	1830-1860 C 1906 = 630	1800-1860 G 1751 = 8.0	F	1
N.C*-S.C.-Ga.*	2,022		1800-1850 C 1881 = 808	1820-1860 G 1775 = 8.6	2/3H/3	2/2/3
Louisiana	1,904[a]		1810-1840 C 1884 = 750	1830-1860 G 1796 = 9.0	-	4
Ky.	2,371	1800-1830 C 1863 = 970	1830-1860 C 1893 = 770	1810-1860 G 1770 = 7.8	-	3
Tenn.-Mo.	2,400[a]		1800-1850 C 1870 = 1,000	1820-1860 G 1786 = 8.4	-	3/5
Fla.-Ala.-Miss.-Ark.	2,216[c]		1830-1860 C 1888 = 895	1840-1860 G 1794 = 7.8		4/4/4/5

I = timing of pre-revolutionary G or other trend; II = order of post-revolutionary trend(s) into late 1800s.
* = fitted in Figure 6.5. ** = fitted in Figure 6.3a. All others estimated by template from graphing.
Maximum recorded fertility ratio other than 1800: [a] 1810; [b] 1820; [c] 1830; [d] 1840; [e] 1860.
= total marital fertility rate.

Sources: Yasuba 1962, 61-63; Bean et al. 1990, 111; Harris 2001, 42, 52-53.

Louisiana	1,904[a]		1810-1840 C 1844 = 750	1830-1860 G 1796 = 9.0	-	4
Florida	1,899[c]		1830-1860 C 1896 = 800	1840-1860 G 1794 = 8.0	-	4,5
Mississippi	2,509		1820-1860 C 1884 = 930	1820-1860 G 1780 = 7.5	-	4
Alabama	2,252[b]		1820-1860 C 1883 = 900	1840-1860 G 1800 = 8.0	-	4
Arkansas	2,205[c]		1830-1860 ?C 1887 = 950	1840-1860 G 1800 = 8.0	-	5
Ohio*	2,550	1810-1830 C 1853 = 1,138	1830-1850 C 1870 = 929	1820-1860 G 1781 = 8.0	-	3,4
Indiana*	2,307[a]		1810-1860 C 1880 = 960	1820-1860 G 1775 = 8.0	-	4
Illinois	2,201[a]		1820-1850 C 1871 = 1,000	1820-1860 G 1784 = 8.0	-	5
Michigan	2,121[a]		1820-1850 C 1877 = 800	1820-1860 G 1797 = 9.0	-	5
Wisconsin	1,569[d]		?	?	-	5
Iowa	1,837[d]		1840-1860 ?C 1905 = 750	1840-1860 G 1782 = 8.5	-	6,5
*Utah**	2,004[e]	1847-1872 G 1790#	1872-1917 C 1959#		-	6

Table 6.5

Trends of Premarital Pregnancy, Illegitimacy, and Extramarital Fertility in America and Europe

	(1)	(2)	(3)	(4)
Essex Co., Fornication		1648-1690 G' 1691		
5 Mass. Towns		1660-1690 G' 1685		
Hingham			1710-1750 G' 1741	1750-1850 G' 1775
Watertown				1730-1790 G' 1773
Sturbridge				1745-1810 G' 1781
Va.-N.J.-N.Y.-N.H.		1690,1710 ?G' 1697		1742-1806 G' 1775
Various U.S. Locales				
N.E. Genealogies		1657-1705 ?G' 1696	1705-1745 ?G' 1735	1745-1805 G' 1775
U.S. Whites				
Flanders, PMP		1637-1687 G' 1660	1712-1762 G' 1732	
" , I_h				
" , Illegit.		1662-1712 G' 1679		1737-1798 /G' 1746
France, PMP		1682-1725 G' 1688		1743-1805 G' 1776
" , I_h				
" , Illegit.				1755-1775 ?G' 1785
Australia, PMP				
England, Illegit.[a]	1585-1645 G' 1595	1660-1695 G' 1696	1715-1755 G' 1746	1755-1785 G' 1781
" , Mixed Data				
" , I_h	1568-1648 G' 1599			1758-1783 G' 1787
Sweden, Illegit.				
" , Mixed Data				
Norway, Illegit.				
" , I_h				
Local Illegitimacy:				
Sérignan			1670-1770 G' 1719	
Le Puy			1700,1730 ?G' 1710	1730-1760 G' 1758
Lille			1718-1743 G' 1720	1743-1763 G' 1761
Rouen[f]				1743-1788 G' 1776
Angers				
Annonay				
Nancy				
Böhringen		1615-1725 G' 1664		1725-1795 G' 1768
Leihgestern			1675-1775 G' 1718	
Frankfurt-am-Main				1708-1773 G' 1757
Basel			1708-1773 G' 1738	

[a] = Imhof 1975, 537 (cf. Wrigley at al. 1997, 219, 224; [b] = I_h for England and Wales; [c] = premarital pregnancy; [d] = extra illegitimate trend; [e] = I_h for Sweden; [f] = enfants de la ville.

Sources: Fig. 6.6; Tab. 5.10; Tab. 4.5; Main 2006, 45; Smith and Hindus 1975, 569 (Australia % of marriages); Figs. 1.4, 5.1b, 5.4, 5.12, 5.19; Fine 1988, 437; Imhof 1975, 1: 536-37.

Table 6.5 (cont.)

(5)	(6)	(7)	(8)
1805-1845 G' 1807		1860-1940 G' 1903	
		1905-1937 G' 1914	1942-1962 G' 1979
1782-1844 G' 1809			
	1846-1866 G' 1858	1866-1930 G' 1888	
1798-1832 G' 1824	1832-1873 G' 1858		
1805-1827 G' 1847			1937-1961 G' 1963
1831-1851 G' 1835	1851-1876 G' 1863	1881-1921 G' 1896	
1795-1815 ?G' 1826	1855-1875 ?G' 1862	1875-1905 G' 1896	
1815-1845 G' 1838			
		1913-1943 ?G' 1886	1943-1963 G' 1970
1795,1805 ?G' 1807			
	1851-1901 G' 1848[b]	1901-1931 G' 1897[b]	1943-1967 G' 1971[c]
1783-1828 G' 1810	1833-1873 G' 1858		
1795-1825 G' 1818	1835-1865 G' 1860		
	1865-1885 G' 1878[d]	1880-1930 G' 1896[e]	
1805-1835 G' 1822	1835-1865 G' 1855	1865-1895 G' 1874	
		1875-1930 G' 1876	
1765-1790 G' 1809			
1760-1785 G' 1799			
1758-1788 G' 1797			
1750-1785 G' 1809			
1745-1790 G' 1793			
1817-1855 G' 1830		1885-1925 G' 1905	
1795-1815 G' 1810			
1768-1798 G' 1803			
1783-1793 ?G' 1830			

Table 6.6

Comparing Trends for Age-Specific Fertility Rates in Europe and America

A. *Europe*

Era:	I	II	III
Geneva*			
45-49	-	-	
40-44	1635-1702 C 1703 = .084	1702-1805 C 1791 = .032	
35-39	1635-1702 C 1727 = .144	1747-1805 C 1803 = .077	
30-34	1635-1726 C 1768 = .161	1726-1805 C 1810 = .130	
25-29	1662-1726 C 1788 = .190	1726-1805 C 1825 = .167	
20-24	?	1726-1771 C 1815 = .190	
15-19	-	-	
	Elites in Milan and Florence	**3 E. Paris Basin Parishes**	
45-49	-	1752-1804 C 1802 = .010	
40-44	1625-1725M C 1726 = .042	1752-1812 C 1828 = .064	
35-39	1625-1725 C 1737 = .090	1752-1812 C 1808 = .150	
30-34	1650-1725 C 1768 = .111	1752-1812 C 1823 = .170	
25-29	1625-1725 C 1765 = .168	1752-1812 C 1829 = .210	
20-24	1625-1725 ?C 1786 = .200	1752-1812 C 1852 = .210	
15-19	-	-	
		S. Transdanubia (av. P&C)	**German Villages***
45-49		-	1762-1812 C 1835 = .011
40-44		1769-1825 C 1808 = .045	1762,1787 ?C 1839 = .070
35-39		1769-1811 C 1831 = .077	1762-1812 C 1895 = .114
30-34		1769-1811 C 1833 = .105	1762-1812 C 1914 = .140
25-29		1769-1811 C 1844 = .125	1762-1812 C 1916 = .159
20-24		1769-1811 C 1841 = .143	1762-1812 G 1756 = .204
15-19		1769-1811 C 1848 = .110	1762-1887 G 1719 = .178
Sweden*			
45-49		1753-1813 C 1852 = .009	1818-1853 C 1896 = .008
40-44		1753-1788 C 1845 = .040	1783-1883 G 1746 = .043
35-39		1753-1788 C 1840 = .076	1788-1888 G 1738 = .076
30-34		1753-1783 C 1830 = .103	1783-1828 E 1891 = .570
25-29		1753-1773 C 1808 = .106	1773-1833 E 1898 = .541
20-24		1753-1773 C 1801 = .065	1773-1828 E 1901 = .307
"			
15-19		1758-1848 C 1843 = .009	
Flanders & Brabant			
45-49	1635-1725 ?G' 1678 = .040		1775-1785 G' 1805 = .032
40-44	1630-1695 G 1596 = .090	1675-1775 C 1824 = .080	1795-1850 G' 1816 = .200
35-39	1630-1675 G 1590 = .140	1665-1790 C 1834 = .135	1790-1845 G' 1808 = .350
30-34	1630-1695 G 1580 = .170	1685-1795 C 1845 = .160	1795-1835 G' 1815 = .450
25-29	1630-1675 G 1610 = .160	1705-1765 C 1834 = .185	1775-1825 C 1858 = .190
20-24	1650-1695 G 1582 = .165	1695-1745 G' 1710 = .540	1805-1855 G' 1831 = .560
"		1745-1785 G' 1772 = .550	
15-19	1625-1725 D 1598 = 1.020	1675-1775 C 1844 = .150	1775-1875 G 1777 = .280
England			
45-49	1612-1662 G 1565 = .091	1687-1737 G 1640 = .091	1762-1812 C 1898 = .088
40-44	1612-1687 C 1719 = .054	1687-1812 G 1655 = .083	
35-39	1612-1662 C 1718 = .100	1662-1737 G 1602 = .097	1737-1787 C 1859 = .098
30-34	1612-1662 C 1720 = .126	1662-1737 G 1596 = .121	1737-1787 C 1871 = .120
25-29	1612-1662 C 1725 = .143	1662-1712 E 1770 = .878	1737-1812 E 1908 = .980
20-24	1612-1662 C 1753 = .152	1687-1737 G 1607 = .158	1762-1812 G 1644 = .157
15-19	1637-1712 C 1746 = .149	1712-1762 E 1774 = .666	1762-1812 E 1875 = 1.279

Please note that Table 6.6 was meant to align the "date" rows across the "era" I, II, II, IV, and V {I was unable to make that happen from the notes I had and could use--MSW, 31 July 2015}.

IV				V			
	?						
1787-1887	C	1916 =	.058				
1812-1887	C	1940 =	.112				
1837-1887	C	1969 =	.141				
1837-1887	G	1757 =	.173				
1812-1887	G	1756 =	.204				
1762-1887	G	1719 =	.178				
1858-1938	C	1908 =	.010		?		
1873-1913	C	1921 =	.058	1913-1933	C	1907 =	.087
1873-1908	C	1931 =	.091	1908-1933	C	1912 =	.133
1823-1908	C	1950 =	.092	1908-1933	C	1918 =	.142
1833-1908	C	1972 =	.079	1903-1933	C	1925 =	.123
1823-1848	C	1862 =	.066	1908-1933	C	1936 =	.069
1848-1908	E	1950 =	.252		?		
1848-1913	E	1907 =	.174				
	?						
1850-1885	G'	1878 =	.230				
1845-1885	G'	1871 =	.400				
1845-1885	G'	1870 =	.520				
1835-1875	E	1899 =	1.080				
1845-1895	E	1921 =	1.370				
1825-1875	?E	1924 =	1.750				

Table 6-6 (cont.)

B. America

Era:	I	II	III
	<u>Nantucket</u>		<u>Philadelphia Elite</u>
45-49	1692-1762 G' 1714 = .040[1]	1735-1815 C 1812 = .005	1737,1800 ?C 1814 = .015
40-44	1695-1765 G' 1726 = .140	1725-1825 C 1808 = .054	1737-1850 C 1847 = .072
35-39	1695-1755 G' 1712 = .300	1765-1825 C 1856 = .090	1737-1850 C 1871 = .130
30-34	1695-1745 G' 1712 = .340	1755-1825 C 1863 = .100	1737-1850 C 1881 = .155
25-29	1695-1755 G' 1720 = .370	1745-1835 C 1863 = .118	1737-1850 C 1892 = .175
20-24	1715-1755 G' 1730 = .400	1725-1825 C 1836 = .150	1800,1850 ?C 1914 = .180
15-19	?	?	?
		<u>Deerfield#</u>	
45-49		1753-1813 G' 1768 = .028	
40-44		1753-1813 G' 1778 = .140[a]	
35-39		1753-1813 G' 1769 = .280	
30-34		1753-1813 G' 1768 = .380	
25-29		1753-1793 C 1815 = .155	
20-24		1773-1813 C 1831 = .110	
15-19		1773-1813 C 1800 = .031	
		<u>U.S. Genealogies (Wahl A+B)</u>	
45-49		-	-
40-44		1698-1829 C 1870 = .078	1829-1901 G' 1849 = .200
35-39		1698-1829 C 1867 = .110	1829-1892 G' 1851 = .300
30-34		1748-1829 C 1858 = .140	1829-1892 G' 1852 = .320
25-29		1698-1829 C 1865 = .150	1829-1879 G' 1853 = .420
20-24		1748-1829 C 1851 = .205	1829-1879 G' 1853 = .500
		<u>Sturbridge</u>	<u>United States</u>
45-49		?	1842-1877 C 1876 = .013
40-44		1790-1830 C 1792 = .018	1837-1872 C 1890 = .050
35-39		1770-1810 C 1826 = .138	1837-1867 C 1887 = .100
30-34		1770-1810 C 1848 = .155	1837-1867 C 1894 = .120
25-29		1790-1830 C 1882 = .160	1837-1867 C 1899 = .120
20-24		1790-1830 C 1876 = .200	1837-1862 C 1887 = .110
15-19		?	1842-1877 C 1900 = .034
		<u>Mid-Atlantic Quakers</u>	<u>Mormons</u>
45-49		?	1857-1927 G' 1875 = .026
40-44		1766,1793 ?C 1798 = .090	1847-1872 G 1801 = .076[b]
35-39		1738-1766 ?C 1788 = .140	1847-1867 G 1805 = .135
30-34		1738,1766 ?C 1796 = .170	1842-1867 G 1806 = .160
25-29		1738-1793 C 1832 = .170	1842-1872 G 1798 = .170
20-24		1738-1793 C 1830 = .170	1847-1872 G 1793 = .180
15-19		1738-1793 C 1829 = .170	1847-1912 G 1810 = .180

* fitted trends, others estimated. # 23 years added to birth to estimate date of marriage.
[1] = from Logue rather than Byers; [a] = alternative 1773-1813 C 1819 = .072;
[b] alternative 1867-1922 G' 1877 = .190; [c] also 1822-1847 C 1898 = .180.

Sources: Fig. 5.7; Pinto and Sonnino 1997, 504; Tab. 5.6; Andorka 1979, 17; Fig. 5.8; Tab. 5.7;

Fig. C.8; Vandenbroeke 1976, 121; Fig. 1.6; Logue 1983, 439; Byers 1982, 27; Kantrow 1980, ?; Temkin-Greener and Swedlund 1978, 33; Osterud and Fulton 1976, 487; Wahl 1986, 398-99 Hacker 2003, 612; Wells 1971, 76; Ericksen *et al*. 1979, 259; Bean *et al* 1990, 256-57.

Please note that Table 6.6 (cont.) was meant to align the "date" rows across the "era" I, II, II, IV, and V {I was unable to make that happen from the notes I had and could use--MSW, 31 July 2015}.

IV V

1879-1910 G 1786 = .170
1866-1892 D 1859 = .480
1892-1910 ?C 1957 = .095
up a little
.
.

Old Order Amish#

1908-1937 C 1953 = .006
1908-1947 C 1968 = .054
1908,1927 ?C 1969 = .110
flat
1927-1957 G 1887 = .180
1937-1957 G 1903 = .220
?

1872-1927 C 1927 = .012
1872-1922 C 1935 = .080
1867-1922 C 1940 = .135
1867-1922 C 1943 = .155
1872-1927 C 1948 = .170
1872-1922 C 1966 = .180
.

1922-1942 C 1914 = .020
1922-1937 C 1916 = .125
1922-1937 C 1920 = .205
1922-1932 C 1923 = .250
.
.
.

IV V

	?		
1787-1887	C	1916 =	.058
1812-1887	C	1940 =	.112
1837-1887	C	1969 =	.141
1837-1887	G	1757 =	.173
1812-1887	G	1756 =	.204
1762-1887	G	1719 =	.178

1858-1938	C	1908 =	.010		?		
1873-1913	C	1921 =	.058	1913-1933	C	1907 =	.087
1873-1908	C	1931 =	.091	1908-1933	C	1912 =	.133
1823-1908	C	1950 =	.092	1908-1933	C	1918 =	.142
1833-1908	C	1972 =	.079	1903-1933	C	1925 =	.123
1823-1848	C	1862 =	.066	1908-1933	C	1936 =	.069
1848-1908	E	1950 =	.252		?		
1848-1913	E	1907 =	.174				

	?		
1850-1885	G'	1878 =	.230
1845-1885	G'	1871 =	.400
1845-1885	G'	1870 =	.520
1835-1875	E	1899 =	1.080
1845-1895	E	1921 =	1.370
1825-1875	?E	1924 =	1.750

Table 6.7

Comparing European and U.S. Parity-Related Family Limitation (*m*)

Europe						*United States*					
3 Northern Italian Cities	1625-1725	G	1632 =	.334	[.908]						
Geneva B & French D & P	1625-1750	G	1658 =	.533	[1.449]						
Florence II	1725,1775	?G	1718 =	.784	[2.131]						
Belgian Aristocracy	1715,1790	?G	1727 =	.181	[.492]						
Hungary: Bakonya & Alsónyék	1770-1825	G	1770 =	.388	[1.042]						
Germany: Werdum, Middels, Ösch.	1775-1850	G	1771 =	.101	[.275]						
Hungary: Besence & Vajszló I	1769,1805	?G	1801 =	.266	[.723]						
Hungary: B. & V. II, Sárpilis	1836,1872	?G	1845 =	.611	[1.661]						
3 Baden & Nonnenweier	1830-1887	G	1840 =	.244	[.662]	U.S. Whites(Sanderson)	1820-1890	G	1849 =	.235	[.639]
3 Bavaria, Rust, Ösch. & Mid. II	1850-1887	G	1869 =	.281	[.764]	U.S. Whites (Hacker)	1848-1878	G	1870 =	.239	[.650]
						U.S. Whites (Sanderson)	1890-1920	G	1884 =	.433	[1.177]
						Mormons, Conception Efficacy	1885-1920	G	1887 =	.460	-
						Old Order Amish	1908,1927	?G	1884 =	.105	[.285]
4 Waldeck Villages	1862,1887	?G	1914 =	1.500	[4.077]	Mormons	1880-1920	G	1932 =	1.170	[3.167]
						Old Order Amish	1937,1947	?G	1957 =	.660	[1.794]

[ ] = maximim level implied by G curve.

Sources: Tab. 5.4; Tab. 5.8; Fig. 6.10; Knodel 1983, 88.

Chapter 7

Historical Fertility Trends in Global Perspective

To what degree were the fertility patterns across time observed in Europe, and in overseas 'offshoots' whose populations were dominated by migrants from that continent, peculiar to peoples established primarily out of European stock and living in contexts of various European cultures? To what extent, to the contrary, do they comparably characterize the history of populations whose roots are largely native American and African, as in Latin America and the Caribbean, or Asian and African in the widely varying array of societies that populate those vast land masses? In short, just how general are the findings so far?

Unfortunately, *data* for the many other global populations, some of them very large and of very long standing, mostly lack the depth of chronological perspective that is available for Europe and overseas European 'offshoots.' Historical demographers, nonetheless, have provided important insights here and there into past eras. A continually growing modern record, meanwhile, supports considerable international comparison for recent decades and frames fundamental questions about the future.

AN OVERVIEW: PATTERNS IN TOTAL FERTILITY RATES

Collective tendencies attributed to **large areas of the world**--to continents or major portions of them--group together individual populations that in fact differ insightfully. Such aggregate patterns for total fertility, however, usefully introduce global demographic comparison

{Please note that the Figures and Tables referenced in Chapter 7 are not interleafed in the text but appear at the end of the chapter (notes). MSW 31 July 2015}

and contrast beyond the crude birth and death rates of Chapter 2. Figure 7.1 plots evidence from the middle of the 20th century into the first years of the 21st (Dorius 2008, 520).

For Sub-Saharan Africa as a whole, C-shape fertility decline starting from high levels, a phenomenon that has historically characterized the ‘demographic transition’ and the ‘fertility transition’ internationally, commenced only about 1970, still continues as of the early 2000s, and heads toward a zero year only in the 2040s.[1] Though identical in form, chronologically this pattern contrasts markedly to European C trends in fertility, which began to appear as early as the later 1700s and were mostly completed between the two World Wars. For North Africa and western Asia (the Middle East), though beginning only about the same time and likewise still continuing as of the first years of the current century, the C trend is considerably steeper--targeting about 2005, or three to four decades sooner.

In contrast, for the likewise mostly still ‘developing’ countries of eastern, southern, and central Asia and for the peoples of Latin America and the Caribbean, while fertility decline also began about 1970, generally it tended to take D rather than C form, starting more strongly but decelerating with time through a zero year in the late 1970s toward a minimum asymptote. By the early 2000s, the level of TFR in each of these broad regions had reached about 2.5 compared with 3.4 in North Africa and western Asia and a still much higher 5.6 in Sub-Saharan Africa.

Collectively, for northern, western, and southern Europe and related ‘offshoot’ populations overseas still a third type of trend appears. In this D’ (1/G’) movement a bottom in total fertility was reached (slightly under 2.0 in the late 1980s) after which the rate has begun to rise. For eastern Europe and Russia, *two* such D’ dips, successively lower, have occurred. The first, under Communist rule from the 1950s through the 1980s minimized somewhat over 2.0 a decade earlier than for the bulk of Europe. The likely second trend of this shape since 1988 would reach a low of only about 1.0 in the vicinity of 2020 (it was already under 1.4 by the first years of the present century), a movement that foreshadows significant population decline should it continue. The data for eastern, southern, and central Asia and for Latin America and the

Caribbean, it should be noted, both include alternatively possible sequences of shorter-term D' sags across their long-term D trends. These run from the late 1960s to the late 1980s (bottoming about 3.0 around 2000), then from there into the early 2000s (targeting about 2.3 a dozen years later). It would seem that a mix of national patterns within both broad zones can be expected.

Average total fertility for the whole of humanity, weighted for population size (think of the numbers in Asia, for instance), between 1968 and 1998 contracted in D fashion from a zero year about 1965 to approximately 3.0 before perhaps commencing new decline in the early 2000s (Fig. 7.1; Dorius 2008, 529). The average for TFR by *country*, however, decreased instead in accelerating C manner (think of the number of nations in Africa) but attained close to the same level by the early 2000s.

Over recent decades, total fertility for **individual countries** around the world has mostly contracted in the same three ways: mostly via C then D'. Table 7.1 compares estimated trends in Latin America and the Caribbean. Figure 7.2 plots movements for the populations of five rather different types of societies from these regions.

Through the last years of the 20th century the C-shape fertility decline of familiar 'demographic transition' most often gave way to a further but not bottomless D' dip of minimizing TFR (Tab. 7.1, col. 3). Only among the 6 regional populations from Uruguay through Paraguay in the table is a shift to decelerating decline missing, while for some reason drops in Venezuela and Panama took D rather than D' form. (The two paths run closely together in the vicinity of t_0.)

Despite exceptions in Argentina, Brazil, and former island colonies of Britain, fertility decrease of C shape in Latin America and the Caribbean mostly terminated only during the last quarter of the 20th century. These C trends followed a path for falling fertility that has been observed (Tab. 5.3) as soon as the late 1500s or early 1600s in some European elites, in England (based on GRR), and in New Castile (intimated by children per completed family).

Unusually, for Brazil as a whole two decades of accelerating E-type gain in TFR followed the end of C decline in the 1930s, while further decrease since the 1960s took place via two D' drops.[2] Such a 'double dip' (found also in Argentina and Costa Rica) was a pattern observed for eastern Europe in aggregate since the 1950s (Fig. 7.1). The E trend of increase, meanwhile, also appeared in Guyana--appreciably earlier, between 1891 and 1953 (Tab. 7.1). In Jamaica and Trinidad, on the other hand, emerges the G' form of fertility gain during the middle of the 20th century which is seen in the United States, Canada, and Australia (and possibly briefly in New Zealand; Fig. 6.1) but nowhere in Europe (Tab. C.7).

General fertility and the gross rate of reproduction in Mexico and Jamaica extend our grasp of movements in fertility back further in time than TFR, especially if low Mexican GFR in the 1920s represents a brief post-revolutionary aberation (Feliciano 2000, 611). In Peru (Ferrando and Aranburu 1996, 419), while TFR for the urban segment began to decline much like the pattern for the population as a whole, in the rural portion the G trend in fertility apparently lasted to about 1970 before beginning to recede that way, widening the gap between the two kinds of populations (Fig. 7.2).

In most of Asia (without its western end in the Middle East), too, contraction of fertility in C fashion was replaced during the later 1900s by D' trends of "bottoming out" (Tab. 7.2, col. 2). Japan and Pakistan represent the major exceptions, but for quite different reasons. In Japan, the two C trends since the 1920s already carried TFR to a very low level without a late-20th-century D' dip. In Pakistan, the transition had just not taken place by 2000: the forces that have so widely pushed fertility down in D' fashion had not yet come to bear. The Philippines present another case of "double dip" D' decline. For China, the two D' entries refer to different sets of estimates.[3] Guandong is China's most developed province.

Among immigrants into England and Wales during the later 20th century, furthermore, C-shape trends of reduction in fertility for peoples of various nationalities, including Asian ones, generally preceded in timing this form of decline in their home countries by about a generation

(Coleman and Dubuc 2010, 19-41): roughly, from the West Indies 20 years (Tab. 7.1), from India 25 years (Tab. 7.2), from Hong Kong and the Far East 33 years (Tab. 7.2), from Bangladesh and Pakistan 28 and 50 years (Tab. 7.2).[4] An exception may have occurred where immigrants from East Africa reduced fertility *behind* women in Kenya; but fertility reduction there significantly preceded that in other parts of East Africa--in C trends targeting more like 2030 than the 1996 for Kenya. Did such pairings also characterize immigrant fertility patterns during the great late-19th-century global relocations as well?

In China, Sri Lanka, and part of Indian Punjab, on the other hand, G-type gain in TFR before 'transition' seems likely (Tab. 7.2, col. 1)--as in some countries of Latin America and the Caribbean (Tab. 7.1, cols. 1 and 2). This upward trend has likewise occurred recently in some populations of 'baby boom' Europe along with the United States, beginning with the Depression or World War II (Tab. C.7, Fig. 6.1). It also appeared in frontier Utah during the middle of the 19th century (Fig. 6.5); during the 18th century in Normandy, the Southwest, and France as a whole, in New Castile, and in several American sub-populations (Fig. 5.1a, Tab. C.4, Tab. 6.2); and earliest of all among Europe's ruling families and in the general populations of New Castile and England during the 1600s (Tab. 5.3, Tab. C.4; Fig. 1.1, Tab. 1.1).

In short, most populations of Asia, like those of Latin America and the Caribbean have apparently experienced, if at later dates, the same kinds of shifts back and forth between G gain and C loss in total fertility as many other earlier-documented European-based peoples have witnessed before them. Asian populations, furthermore, illustrate how cohort TFR as well as period TFR has decreased repeatedly in C fashion (Frejka et al. 2010, 582). South Korea and Hong Kong, followed by Japan and Taiwan, and finally Singapore display C trends in both, though the curves for cohort TFR display a wider range in timing than is evident for period TFR.

Most obviously, for most Asian countries, very recent D' dips in fertility likewise resemble such patterns elsewhere, though the relatively rare D trajectory does not appear (Tab. 7.2, col. 3). In China, urban fertility began to drop in D' fashion at least by the 1950s whereas rural TFR shrank much more gradually in C form from the early 1950s into the 1970s before sagging this way. These diverse trends made the ratio of rural to urban TFR rise then fall in G' shape between 1955 and 1980, judging by the mean for the country's many provinces. Insightfully, total *marital* fertility for China in contrast simultaneously declined along C paths in rural as well as urban and national TMFR into the 1980s, though sooner and steeper for the urban rate than in the other two (Peng 1991, 110, 229, 222, 145). What generated this distinction in trends between overall and marital fertility, and to what extent has it occurred in other populations?

Meanwhile, the recently rare kind of accelerating E-type increase in TFR that emerges in Bangladesh between 1953 (or earlier) and 1973 resembles what has been found in Guyana from 1891 through 1953 and for Brazil between 1945 and 1965 (Tab. 7.1, Fig. 7.2). In late-18th- and 19th-century Europe (Tab. C.7?) this phenomenon was quite frequent, one aspect of the spread of industrialization that exploited cheap labor.

Unlike for Latin America, the Caribbean, and most of Asia (Tabs. 7.1 and 7.2), in Western Asia (the Middle East) and North Africa a limited (and here for the most part only roughly estimated) record since the 1960s (Tab. 7.3) displays, except for Yemen, no G or G' increases that may have occurred during the second half of the 20th century. Only the C declines and the very recent D' dips that have typically followed them in many parts of the world appear. Distinctively, in the southeast corner of the Mediterranean occupied by Egypt and Israel, any 'transition'-era C-shape contractions that had taken place in TFR were over by the 1960s. In Cyprus, too, the initial shift from C to D' contraction occurred about 1968 (perhaps parallel with Egypt) though a second D'dip has already followed--as in Egypt and Israel and, as noted, some populations of other global regions. In Lebanon and Kuwait, the C paths of the 'transition' stage likewise targeted t_0's in the 1970s, though a succeeding D' phase did not began before the 1980s. Still later C trends that have been followed by D' dips appear in Turkey, Iran, Jordan, Syria, and perhaps Saudi Arabia. The flattest (latest targeted) observed C 'transition' adjustment, however, occurred in Saudi Arabia along with neighboring Democratic Yemen, while in the other Yemen G-type increase was followed directly by a D' drop. In Tunisia, Algeria, and Morocco, meanwhile, the 'transitional' C trend of contraction in TFR is known to have lasted to or through the 1990s--unlike the Egyptian shift of the 1960s. In all four of these North African countries, projections have indicated a D' movement into the 1920s. For Iraq, four small Gulf states, and Democratic Yemen trends or projections after 1988 are not attempted. D' dips may or may not have comparably followed the observed C-shape trends of 'transition.'

In Sub-Saharan Africa, Table 7.4 identifies for the majority of countries the shapes of trends in total fertility rates across the second half of the 20th century. Except for South Africa, it just approximates the chronological range and level of these movements.[5] Nonetheless, insightful distributions of historical pattern are suggested and can be related to trends elsewhere.

In 24 of the 34 populations examined (which represent about three-quarters of the nations in the Sub-Saharan region), sustained gains for TFR are evident. In Nigeria, the Democratic Republic of Congo (formerly the Belgian Congo then Zaire), and Zambia the unusual accelerating E path appeared. Did their economies distinctively interact with this demographic growth as has been encountered in several places historically? Elsewhere, the increase after mid-century followed a decelerating G track, on average based in the 1890s.[6] Subsequently, C declines typical of 'fertility transition' became universal except in the regionally marginal, historically French Indian Ocean islands of Mauritius and Réunion, where any fertility increase had ceased already by the later 1960s.

In these two populations, however, the D'-shape, culminating, 'bottoming out,' drop in fertility that is currently so common in North Africa, Asia, Latin America, the Caribbean, and Europe (Tabs. 7.3, 7.2, 7.1, C.7) had emerged by 1968. Elsewhere in Sub-Saharan Africa, it seems to have appeared so far only in South Africa and Kenya (and *possibly* in Ghana). While the dynamics that are so widely producing D' 'bottoming out' in fertility (the wish to have at least *some* children survive, obstetric and pediatric advances, the education of females, economic improvement and the desire to enjoy it) are clearly coming to Sub-Saharan Africa later than in other parts of the world, they are likely not to lag for long. In contrast, fertility shifted into uninterrupted C-shape decline in France and Sweden by about 1750,[7] or roughly two-and-a-half centuries before such 'transition' took place in Uganda and Burkina Faso (the early 2000s), in the former Belgian Congo and Benin (the 1990s), or in the majority of the populations of sub-Saharan Africa (the 1980s). D' fertility decline not only represents change that is more focused in the time it takes to transpire than C decrease. It reflects processes that disseminate globally within a few decades, not over generations or centuries.

In sum, as is well known, the fertility rates of human populations have during the past three centuries very generally tended to increase then decline. Not grasped so far, however, are the few simple, repeated, and related paths along which these changes have unfolded. A recognition of these G-related patterns makes comparison, contrast, and categorization of populations by their fertility behavior both more accurate and more insightful.

Early modern and modern pre-'transition' increase in TFR has by far the largest part of the time taken the **G shape** of constantly decelerating gain with a constant exponential rate of .03. This pattern of fertility increase is found as early as records begin, long before classic 'demographic transition' appeared on the scene. In the historical run-up to 'fertility transition,' its seems to have resulted mostly from early modern improvements in living conditions which, though with continually diminishing returns, encouraged young people to marry and reproduce. Earlier in human history, however, there is evidence that G gains in TFR instead reflected collective responses to *worse* conditions, especially reversals in health that winnowed the young and opened up greater opportunities for surviving adults--as in England from the 1660s to the 1720s and France and New Castile also during the early 18th century or sooner (Tabs. 5.1, C.4). In the latest-developing countries of Africa, dynamics that produce such G increase in total fertility were still at work as of the first years of the 2000s. In England and France, and perhaps other parts of Europe as well, such trends in fertility have been absent since as soon as 1730.

In a group of European countries with early development in their political economies, accelerating **E-type** increase in fertility preceded the reduction of 'demographic transition' rather than decelerating G trends. For a while in these particular societies, and in certain regions of others (including southern New England and part of northern France), economic growth interacted with demographic expansion so as to take advantage of rising fertility via cheapening labor rather than being progressively debased by it (Ch's. 1, 5, and 6). To what extent were similar renforcing dynamics at work in Brazil from the 1940s through the 1960s, and perhaps sugar-growing Guyana with its new South Asian contract labor during the first half of the 20th century (Tab. 7.1)? Or in Bangladesh, Nigeria, the former Belgian Congo, and erstwhile Northern Rhodesia (Zambia) for some time during the second half of the 1900s (Tabs. 7.2, 7.4)? It was having such an E phase of fertility increase before the C of 'transition' that primarily distinguished the demographic history of England from that of France (and Sweden, Tab. 5.1), a comparison that still challenges commentators.

The ubiquitous **C pattern** of fertility decline, everywhere constantly accelerating downward at the one, fixed underlying .03 rate also imbedded in G and E, was not new to mankind in the 18th century, where it universally began to characterize the fertility adjustment entailed in 'demographic transition.' It is evident, for example, in TFR for England from the accession of Elizabeth I to the Restoration (from 1556 through 1661), in New Castile over the second half of this period, and for several European elites also beginning in the later 16th century or early 17th (Tab. 5.3). It has likewise been found in early modern Asia: in the Ch'ing imperial lineage between 1680 and 1710, and at the village level in Japan comparably early (Tab. 7.8).

What distinguishes, say, English contraction in fertility from the C movements in France, her regions, and the European elites studied--or characterizes other historical comparisons--has not been the *shape* of the net adjustment but, instead: *how many* decreases of this type there have been, *when* they have taken place, and *how long* they have lasted; and the extent to which fertility *within marriage* has driven the overall decline. Whatever the mechanisms that generate decrease, however, the resulting path for TFR has been C.

Before World War II, just one clear exception appears--a D-shape decelerating decline in England between 1816 and 1851 (Tab. 5.1). This was *not* a forerunner of recent D' drops of fertility in response to improvements of this shape in early mortality because infant and childhood mortality, to the contrary, surged *upward* in something like G' shape between 1800 and 1830 (Fig 1.8.a). The way that mortality for all under 15 collectively displays a G' rise (Tab. 1.4; clearly among children 1 through 4, somewhat for those 5 through 9) and the way that, among infants, exogenous and post-neonatal deaths show most increase (Figs. 1.8b, 1.8a) suggest that more died because more were being born, rather than the other way around: that more births replaced lost children. Conversely, a sharp D' drop in perinatal mortality indicates that any extant family limitation by means of early neglect of babies became at least temporarily less popular (though it has been argued that fertility within marriage was virtually constant in England up through the middle of the 19th century: Fig. 1.4). Also, by somewhat preceding in timing the temporary surge in fertility, the rise in early mortality challenges the alternative of more deaths because of more births. Further investigation of English fertility during the first half of the 1800s along these lines should, among other things, settle the principal outstanding divergences among proposed English birth rates (Wrigley-Schofield, Lindert, Razzell: Tab. 1.1).

Since the middle of the 1900s, however, **'bottoming out' via D'** has been becoming the internationally dominant trend in TFR (Tabs. 7.2, 7.3, 7.4, C.7; Fig. 7.1). Largely this has been in response to sharp but decelerating decline in early mortality. Though in Europe, between the 1940s and the 1990s the rate of infant deaths took what has seemed to be D shape (Figs. 4.3a through 4.3f; Tab. 4.4), projections into the 21st century frequently indicate D' taking hold instead. Figure 7.1 shows the aggregate effect. In Mexico, the southern Indian state of Kerala, China, and Malaysia, meanwhile, D' trends clearly appear in infant deaths along with fertility, suggesting possibly frequent connections of the two demographic changes on other continents.

As many populations had more than one C trend during the previous stage of demographic development, so since the end of C-shape 'transition' sometimes there has been more than one D' dip in TFR. Recognizing the difference between a second C and a shift to one or more D' sags helps clarify the at times rather confused discussion of "second demographic transition," "late demographic transition," "low, low" levels of fertility, and "fertility crisis." There seem to have been different processes at work in repeated C movements from those that shaped attempts of fertility to 'bottom out' via D'. The more abrupt, but reversible, D' shape can reflect policy, as in China (or other countries with less stringent goals and programs of reproductive control), reductions in early mortality that disseminate quickly, and/or comparable swiftly diffused fashions in family norms and values (analogous to the G' surges of secularization and illegitimacy observed in Ch. 5 and 4 and Appendix C). Specific techniques of contraception, for example, have in the United States been adopted (and in turn become less popular) in G' fashion (Fig. 6.11).

SOME DYNAMICS OF THE VARIOUS G-BASED FORMS OF FERTILITY CHANGE: DEVELOPING AND DEVELOPED COUNTRIES IN GLOBAL PERSPECTIVE

To understand how C, D', G, and E movements of total fertility relate both to long-discussed 'demographic transition' or, before that, 'crisis of the 17th century' and to more recent phenomena such as 'late demographic transition' or 'second demographic transition,' and 'fertility crisis' or entry into and recuperation from 'lowest low fertility,' it is profitable to view contemporary movements in historical perspective. To what extent, from the earliest records to the present, have particular patterns of change in fertility involved similar or different processes? How much have given types of trend in fertility involved mechanisms that have been common to the earliest- and also to the latest-developing societies? Have, for instance, C-shape reductions in fertility, which in the literature are so closely identified with 'demographic transition,' always been responses to greater rates of survival among the young? To what extent, to the contrary, have substitutable inputs produced comparable patterns in fertility? It has been seen, for instance, that G-type increase in fertility can blossom under both better living conditions and worse ones.

Several factors are frequently thought to shape fertility.[8] It is useful to begin by examining some preliminary evidence as to what kinds of demographic and related changes have accompanied the handful of mathematically related sets of G-based trends in fertility that have appeared over and over again in the historical record. It is particularly insightful to compare movements in fertility and their accompaniments among currently developing nations with the experience of earlier cases of historical change.

G-shape gains in total fertility are observed as far back as the 17th century. Certain details vary. In general, however, such movements have repeatedly involved--due to some change in living conditions--openings and/or incentives to have more reproduction, which then have been progressively exploited demographically with continually diminishing success, producing constantly decelerating further increase in fertility. Some particulars of these G-type expansions in reproduction can be identified.

In England between the 1660s and the 1720s trends in GRR and total age-specific marital fertility (Figs. 1.1, 1.6), indicate that TFR increased in G manner. The conquest of Ireland and Atlantic colonization had drawn large numbers of young adults, especially males, overseas (Fig. 1.3) at a time when fresh domestic economic gains to be had from the fundamental agricultural advances of the late 1500s and early 1600s grew less and less. Faced with the widely unfavorable European health environment of the mid-17th century, civil war with its nationwide social and economic disruption, and an exceptionally strong attraction for young adult English men and women to reside in the dangerous setting of cities, mortality rose significantly (Fig. 1.1), further aggravating a temporary depopulation of England between the 1650s and the 1680s.

This 'demographic depression,' one aspect of a widespread international 'crisis of the 17th century, opened the door for more females to marry at some point in their lives (Fig. 1.5 shows a D (1/G) trend in celibacy for those turning 25 between about 1680 and 1740), and hence for overall nuptiality to increase in G form (Fig. 1.4; as did the crude marriage rate between about 1660 and 1750, shows Fig. C.2). That trend elevated overall fertility (I_f) via G, though somehow aggregate *marital* fertility (I_g as computed by Wilson and Woods; Fig. 1.4) did not change in spite of the fact that age-specific marital fertility rates all increased during this period (Fig. 1.6). Meanwhile, with more births taking place into a poor health environment, infant mortality rose in G fashion for almost a century after about 1640, a pattern of increase that resembled the G path for total age-specific marital fertility in England (with t_0's at 1596 and 1608 respectively). The death rates for children 1 to 4 and 5 through 10 climbed even more steeply (with zero years for G at 1663 and 1680; Fig. 1.8a, Tab. 1.4).

Partially similar later-17th- and early-18th-century dynamics of increased reproduction in the wake of 'demographic depression' seem to have been shared by New Castile, in the heartland of Spain (Tab. C.4). Here, following the telling economic drain and social stress of the Thirty Years War and epidemics that accompanied it, the number of children per family from 1640 to 1700 and the crude birth rate from 1640 forward increased via G as the crude marriage rate also advanced from 1640 through 1710 in such form. In contrast to England, however, infant and childhood mortality *declined* in a country where the health crisis and 17th-century contraction of population had probably been both earlier and worse. As one result of this improvement, proportions surviving to age 25 expanded in G manner from 1640 through 1720. As Spain stopped sending armies abroad, in an ultimately vain effort to be the dominant power in Europe, celibacy lessened (via C) from the 1630s through the 1660s, but thereafter resumed increase in G shape as before 1630, presumably due to the long-term impoverishment that national policies since the 1500s had inflicted upon the homeland in spite of great riches being extracted on a global scale, especially from the New World (Elliott 1977).[9]

France--like Italy, Germany, the coastal Dutch provinces of Friesland and Holland, Ireland, the Swedish province of Närke, and many cities and smaller communities of western and central Europe (Harris 2001, 151-52; 2003, 258; 2001 198, Ch.'s. 6, 8, 9)--also lost population during the 17th century thanks to widespread war and disease. Within France, in Normandy and the Southwest (though not the Paris Basin), TFR similarly rose in response in G manner from the end of the 1600s or sooner through the early 1700s. In France, however, fertility *within* marriage (I_g) expanded in this way (Fig. 5.1a, Tab. 5.2), while the proportion of women who never married actually increased (Fig. 5.1b). As in New Castile, but contrary to England, for France the demographic recovery apparently depended less upon nuptiality, more upon the number of children produced per family. In southern Sweden (Scania) G-shape advance in the crude rate of marriage from about 1650 through 1710 suggests that here, as in England, nuptiality contributed significantly to driving demographic replacement following that country's own costly participation in the Thirty Years war and exposure to the damaging disease of the mid-1600s. Fertility rates seem to be unknown for Sweden this early, however. In Flanders and Brabant (eastern Belgium), subsequent to the deeply disruptive revolt against Spain, from the 1630s forward for several decades age-specific fertility rates increased in generally parallel G trends (Tab. 6.6), a feature found for most age groups of English women following mid-century crisis there (Fig. 1.6).

In spite of some observed variations in mechanism, however, G-type increase in total fertility in western Europe during the later 17th century and the early 18th was in essence widely fueled by socioeconomic openings generated by what might be called 'demographic depression.' Long-term international agricultural change and urbanization evident in the 16th and early 17th centuries was slowing, even reversing in some places (Harris 2003, Ch.'s 3, 4), while the religious divisions of Europe were being consolidated by means of costly conflict. The types of fundamental change in institutions and values that shaped the 'first' and 'second' 'demographic revolutions' of more modern eras (Lesthaeghe 2010) are little evident. Rather, life was returning to ‘normal’ in generally familiar terms while a relative scarcity of people was being replenished for the existing demonomic system.

The way fertility rates rose via G in several locales of North America following about 1700, meanwhile, appears likewise to have entailed response to a temporary shortage of reproducing couples. Peopling through European immigration had produced an age-concentrated cluster of young adults whose females gave birth early and often, imprinting a G’ surge on rates of total fertility (Tab. 6.1; Fig. 6.2). As this bulge passed, comparatively few babies became available--a condition that was returned to equilibrium by sustained gains of fertility in G form.[10]

Three other, later G trends in fertility have been identified before the 1930s. In Spain, for both the central region of New Castile and the protoindustrial Catalan market town of Igualada (inland from Barcelona), fertility increased this way during the later 1700s (approximately 1750 to 1790 with zero year around 1702, and 1725 to 1800 near 1665). During this period, the two regionally distinct Spanish populations suffered almost identical G-shape increases in infant mortality based in the vicinity of 1717 (Tab. C.4; Marfany 2010, 966-67). In both places it became easier to marry. As fewer children lived to 25 along a D path based about 1650, celibacy in New Castile declined via D. In Igualada, between 1765 and 1815 women married younger, along a D trend based about 1715 (960). But, in somewhat flatter D-type change, they also had shorter intervals between births as, according to Marfany, breast-feeding became more difficult with the new proto-industrial employment of women (964, 969). In these two simultaneous Spanish cases, did loss of children encourage more childbearing; was infant and childhood mortality higher because more births had taken place; or did altering employment independently cause both demographic developments? Mafany suggests that the economic change of the period created hazardous conditions for the young through disease and dwindling family resources. This contrasts with the contemporary experience of England between about 1750 and 1815, where--though real wages fell via C--early mortality declined the same way. One can argue that England was moving into a more advanced, factory-based stage of industrialization than Catalonia by then. During the *first* half of the 1700s (perhaps more realistically the English era of proto-industrialization), however, wages rose via G and so did childhood mortality, but infant losses improved via C (Tabs. C.x "6.10", 1.4). This is more like the positive relationship between proto-industrialization and the elements of demographic replacement reported for the upland districts of the canton of Zürich during the 18th century (Braun 197x,). What made Igualada different?

In 9 of 14 German villages studied by Knodel (Tab. C.5), G-shape trends in fertility occurred over the first three-quarters of the 19th century. In two communities of East Friesland, this tendency was accompanied by G-type increases in mortality during the first five years of life. In four Waldeck villages early mortality also rose--but more in G' than G fashion. In the Baden settlements of Kappel, Herbozheim, and Rust, the early death rate did increased, but via accelerating E paths instead. Systematic comparison of changes during the proto-industrial and early industrial era--unwinding the interrelated effects of employments, inheritance systems, values, health environments, and reproductive behavior for these English, Spanish, Swiss, German and other historical cases--is insightfully structured by the G-based trends being followed, and needs to be pursued comprehensively.

It could be said that debilitating World War I losses, the Great Depression, and World War II created in the 20th century another temporary international 'demographic vacuum' within a mostly continuing institutional framework which was filled by G-type increase in fertility once peace and stability arrived. Through the 1950s, the dominant thrust in Western Europe was to restore familiar ways of life--identified by Lesthaeghe (2010, 246) as the 'societal background' of the 'first demographic transition' of the later 19th and early 20th centuries. As this happened, in most countries of Europe fertility rose via G (Tab. C.7). Do other patterns of marriage and reproduction in these several countries resemble those of earlier demographic rebounds? Or did alternative mechanisms instead generate G-type fertility increase during an era of modern values and diffusing new methods for shaping a family? Meanwhile, more chronologically focused G' surges appeared in the United States, Canada, Australia, and probably New Zealand (Fig. 6.1). In these societies, migrants searching for conditions of life thought no longer to be available at home increased the abruptness of demographic replacement.

Elsewhere during the 20th century, openings for demographic expansion that included greater fertility in G form seem to have involved exploiting *added* opportunity for reproduction rather than responding to a continuing equilibrium from which births and/or resources to support them had been *subtracted*. With socioeconomic modernization, TFR perhaps rose in G form during the middle of the 1900s in Latin America and the Caribbean as a whole. Nationally it more clearly expanded this way in northeastern Brazil, Jamaica, Mexico, Peru, Uruguay, and perhaps Honduras and El Salvador (Tab. 7.1; Figs. 7.1, 7.2).

In the case of Peru (Fig. 7.4), age-specific fertility rates clearly all rose, mostly via G. From age 20 upward, moreover, the older the women the more steeply fertility increased. This pattern of progression with age had largely also applied in England over the later 1600s and early 1700s. It is less clear for Flanders and Brabant during the slightly earlier G-shape increase of fertility there (Tab. 6.6). In all three instances, though, proportional gain in urbanization was largely a result of the rise in fertility. In 17th-century Brabant and Flanders the changes were approximately parallel (Fig. "6.2"; Tab 6.6), while in modern Peru (Fig. 7.4)--and especially in England during the later 1600s (Harris 2003, 238)--urbanization proceeded at a noticeably faster pace than reproduction. How might these distinctions be related to the presence of progressive (steeper with age) fertility change in Peru and England in very different historical eras but not in eastern Belgium?

In Mexico, meanwhile, between about 1910 and 1940 urbanization expanded approximately along with fertility, both in G form (Fig. 7.5a). Earlier increase via G up until about 1910 appears in the net rate of reproduction for Jamaica, and perhaps GRR for Barbados and Trinidad (Roberts 1957, 277-78).[11] Instead of reducing fertility, as is common during 'demographic transition,' literacy in Mexico before 1940 increased along with fertility, as it did in Peru forward from 1940 or sooner (Figs. 7.5a, 7.4), supporting an interpretation that, during the early 19th century, G-shape increase in fertility responded to greater well-being.

In China through the 1960s, until harshly restrictive policy was enforced, TFR increased in G fashion--especially following the Communist victory and its favorable consequences for the lives of everyday women and men, but perhaps commencing as soon as 1930 or earlier. By the 1940s, if not sooner, fertility in Sri Lanka displays a comparable tendency to increase. In India's Punjab, a similarly bending G trend in TFR emerged as early as the 1880s and lasted until World War II (Fig. 7.3, Tab. 7.2). In Lebanon, Tunisia, and Indonesia through the 1950s and 1960s G-shape increase through the 1950s and 1960s seems possible (Fig. 7.3).

In other parts of Asia--except for Japan, where 'transition'-type C contraction in TFR was under way already by the 1920s--the necessary evidence seems to be lacking (Tab. 7.2). But it is easy to conceive of many populations, the majority of them still under colonial rule, with better--though more slowly improving--conditions, resulting from socioeconomic changes, which stimulated forming families and/or having more children within unions (both official and unofficial). Fertility, for instance, increased in the G pattern in Yemen as late as 1988 (Tab. 7.3).

It seems likely, too, that similar dynamics have been at work recently in the many countries of Africa where G-shape increase in TFR is observed during the second half of the 20th century (Tab. 7.4). Freshly obtained independence reinforced the effect of improved economies in encouraging more births. To some extent, gains in countries with commodity-driven economies may have reflected the impact of post-Depression recovery among colonial rulers. For example, the G trends in TFR for Kenya, Tanzania, Uganda, and other former British colonies follow, though more flatly, such movement for modern England and Wales between 1938 and 1963 (Tab. C.7). The same holds true for populations in quondam possessions of France, Belgium, and Portugal.

While in diverse populations around the globe, particularly recently, *adding* opportunity has encouraged fertility increase rather than response to a demographic shortage in a relatively unchanging environment, adjustment in fertility still unfolds in much the same G-shape manner. Some specifics in age of marriage, female celibacy, age-specific fertility, and the practice of family limitation, which have contributed to that G-type adjustment in fertility, are discussed shortly along with the role of such particulars in other patterns of change in reproduction. Unfortunately, throughout the historical record demographic detail on the workings of G-shape fertility increase in either context of opportunity remains thin.[12]

Following setback or not, however, G-shape *population increase*--which is likely to entail an expansion of fertility in that pattern--has been a common phenomenon during earlier periods in many countries on all continents (Harris 2001, 250-51, 280-82; 242-44). It occurred in China as far back as the first century of the present era--sometimes in recovery following well-known disasters, elsewhere as new demonomic regimes provided resources for growth (258-61, 266). How consistently did G-type fertility gains accompany population growth in that shape? For one example, as Chinese society re-estabilized in G fashion following the Manchu conquest of the mid-1600s--1657 to 1705 with t_0 at 1586, then 1710 to 1734 from a base at 1662 (Harris 2001, 243-44, 251)--the number of male births per first wife and per husband in the Wang (Tongchen, Anhui province) and Zhu (Jiangdu, Jiangsu) lineages of the lower Yangzi region also increased in G paths anchored for all sons in the middle 1500s and for sons of just first wives more steeply in the early 1600s (Liu 1990, 336-38). Later, furthermore, during the final decades of Tokugawa Japan, fertility ratios for four districts of Suwa county all increased between 1775 and 1860 in G paths based in the vicinity of 1705 (Hayami and Uchida 1972, 500) as from 1792 through 1852 the national population expanded via G from a t_0 at 1719 (Harris 2001, 249, 251). In certain communities in the vicinity of Osaka, meanwhile, the number of family members per household--largely but not wholly determined by fertility--mostly increased in G fashion for house owners and also for renters and tenants between the late 1700s and the middle 1800s with base years from about 1720 and 1760 (R. J. Smith 1972, 445-55).

In nations, regions, and communities of Europe, meanwhile, G-shape increase in population has been the dominant pattern in evidence that begins with Rome in the 5th century before the current era. Such gain notably made up for D-type demographic loss after the Black Death of the 14th century and the return of plague along with protracted and widespread warfare in the 17th. Otherwise, increase in the G form apparently reflects a progressively decelerating exploitation of new “room” for demographic expansion provided by economic or socio-political changes (ibid., Ch.’s 5, 6, 8, 9).

In Latin America and the Caribbean, following the notorious decimation of native population and accelerating initial repopulation of the 16th and 17th centuries further recovery often settled into decelerating G growth (Harris 2001, 104-06). In the Mixteca Alta of southern Mexico, the crude birth rate, fell then rose in D then G patterns between 1635 and 1742 (Fig. 7.5b), suggesting that fertility may have moved comparably to shape the pattern of decline and recovery in population, which (as in the Cuchumatan Highlands of neighboring Guatemala) followed a D then a G path without an intervening E (Harris 2001, 105-6). Elsewhere in early Latin America even inference from the birth rate about the movement of fertility is usually lacking. The G trend offered for CBR in the Queretaro region between 1900 and 1960 in Figure 7.5b, if accurate, occurred as the population of Mexico as a whole expanded in E shape based at 1952 (Harris 2001, 114-15). G, however, was also the national pattern for fertility in this period (Tab. 7.1); and birth rates of the states covered in Figure 7.5b rose in some fashion to contribute to this trend.

Widespread D-type loss of whites in various Caribbean and mainland plantation colonies was replaced in the later 17th century by G-form increase in blacks in a yet another historical case of demographic growth in that pattern to fill a relative vacuum (Harris 2001, 69-79; 2003, 307-21, 409-36). An increasing weight of children within these replenishing and soon dominant slave populations, along a G track, is likely to be due in part at least to TFR gains in that pattern as well as some change in the character of human imports (2003, 347-60). In still mostly

European populations of North America, meanwhile, the late 17th and early 18th centuries witnessed G-type increase in fertility for several localities from New England to the West Indies as the 'baby bust' that followed the chronologically concentrated 17th-century 'boom' of immigration by young adults generated room for more reproduction in regional demonomic systems and pressured outnumbered females to bear children early and often (Fig. 6.2; Tab. 6.1; Harris 2003, 413-14).

Both similarities and differences in how, and with what consequences, G-shape trends in human fertility have been generated over the past several centuries throw light on historical and present demographic processes.

E-shape increase is a G-related trend infrequently observed historically in total fertility. The classic historical case (judging by GRR in Fig. 1.1 and Tab 1.2 or I_f in Fig. 1.4) occurred in England between 1726 and 1815 as entrepreneurs in that country tapped cheap labor from E-type demographic expansion to pioneer industrialization. The phenomenon likewise appeared in towns of 10,000 or more in Massachusetts between 1765 and 1810 as southeastern New Englanders copied English factory development (Fig. 6.3a), the only recorded instance of fertility gain in E form so far observed in a group of major British overseas colonies. Comparably, TFR increase via E is possible in the British peerage between 1725 and 1775 (along with the country's general population), in the aristocracy of Milan somewhat later (though not evident in other parts of Northern Italy), and among the bourgeois families of Geneva in the 19th century, though not for the population of that city as a whole (Tab. 5.3, Fig. 5.3). In Sweden, age-specific fertility for women 20 through 34 increased from about 1775 to 1830 this way, making the total advance via E with t_0 in 1870s, only slightly behind the English change (Fig. C.8; Tab. 6.6).

Inferring from E trends of the crude birth rate, though, fertility gain in this form may also have emerged in the Netherlands and Denmark during the later 1700s and early 1800s along with

England, then again in the later 19th century with Scotland, Iceland, Germany, Austria, Hungary, Romania, and Portugal, and perhaps a century afterwards in the Soviet Union. Local examples appear, meanwhile, in Bavaria, Antwerp, and Brabant (Tabs. C.3, C.5, C.6). Generally, the phenomenon seems to be historically associated with urbanizing early, factory-based industrialization, a connection probably relevant for Brazil from the 1940s into the 1960s and at least plausible for Bangladesh more recently. Industrialization and urbanization, however, did of course appear at other times and in other places *without* this E-shape input from fertility.

In Guyana through the first half of the 20th century the benefitting economic development behind E-type gain in fertility occurred in the sugar industry, fed in large part by imported Indian contract labor.[13] Could mining and petroleum extraction, on the other hand, have generated demonomic conditions for the E-type increases in TFR observed in the former Belgian Congo, Zambia (Northern Rhodesia), and Nigeria between about 1950 and 1990 (Tab. 7.4). What might the rise of the birth rate (by implication, fertility) in E form for the Mexican state of Guanajuato (Fig. 7.5b) have reflected? The increase of completed fertility in China via E between 1770 and 1830, on the other hand, largely appears to have either contributed to or resulted from infant losses that rose in a parallel path (Fig. 7.6). Yet the national population managed to grow in H fashion from 1775 through 1850 (Harris 2001, 243-44), a phenomenon historically associated with sustained, if slowly decelerating, economic development not unsustainable acceleration.

The mechanisms for the seminal English historical case of demographic expansion involving fertility gain in E form are fairly clear. From the middle of the 1700s into the early 1800s, the population grew along an accelerating E path aiming at a zero year in the early 1820s. Demographic replacement was actually rather stronger than that because the net rate of emigration (in spite of an intervening low in the 1770s and 1780s, thanks to disruptions in North America) generally rose over the period. Both an increasing birth rate (1726 to 1816, E at 1862) and a falling death rate (1761 to 1831, C around 1880) contributed to the net trend of demographic growth (Tab. 1.1; Fig. 1.3).[14]

In the contribution of fertility to these changes, the gross rate of reproduction rose in E form toward a zero year about 1850--a path followed by overall fertility (I_f) between 1718 and 1818 (Tab. 1.1; Fig. 1.4). While total age-specific marital fertility also expanded in accelerating fashion, it did so more flatly (1762 to 1812, E only in the vicinity of 1922). Separately, only rates for married women 15 to 19 and 25 to 29 increased this way. For wives in their 30s, an up-tick appears only with the turn of the century. For those 20-24 and 40-44 very gradual, decelerating G-shape advance occurred instead, while for women 45 through 49 fertility *declined* via C (Fig. 1.6). As a result of these diverse age-specific movements, the Coale index of marital fertility (I_g) displays virtually no change (Fig. 1.4).

Instead, GRR and total fertility rose largely because nuptiality (I_m) advanced via E between 1758 and 1818, toward a zero year almost as early as that for overall fertility (Fig. 1.4). This did not result from a higher proportion of women marrying. To the contrary, celibacy was *rising* from a low point about 1760. Rather, fewer females married only after they reached 35 and more wed under 25 or even 20. The interval between average age at marriage and average age at the birth of the last child--the duration of reproduction--increased in E fashion, but slowly. It was the shift toward child-bearing at earlier ages, where females are typically more fertile, that principally drove the change (Fig. 1.5). This did not occur because real wages rose. In fact, they fell oppositely, via C, as more workers became available with population increase (unless families based their nuptiality and/or fertility upon a 'money illusion' of rising *nominal* earnings). Instead, nuptiality--taking overall fertility with it--increased along with the pace of urbanization, industrial output, and shift of workforce to manufacturing rather than agriculture, changes that all took E shape with target years in the vicinity of 1835 (Harris 2003, 225; Tab.C.x "6.10"; Ch. 10/11 below). While economic change provided more opportunity for young women to wed than under the typical restraints of rural life, the crude rate of marriage declined oppositely via C (Fig. C.2) from 1761 through 1811 because a smaller fraction of the population was of age to marry as rising fertility expanded the relative number of the young--and mortality harvested fewer victims (Fig. 1.1).

Indeed, the effect of rising fertility upon population numbers was magnified significantly through declining mortality. In particular, the later-18th-century initial phase of factory industrialization benefited from C-shape decline in nationwide infant mortality between 1750 and 1810 that headed for a t_0 in the 1850, *inverse to* the rise in overall fertility (Tab. 1.4; Fig. 1.4). This change was steeper than the decline in the crude birth rate (zero year at only 1880) and was generated especially by stronger C-type improvement in neonatal and endogenous infant losses (t_0's in the 1830s). Maternal deaths with childbirth decreased in comparable C fashion, contributing to overall reproduction (Tab. 1.4). In spite of often wrenching social change and crises for living conditions regionally, notably in the new industrial centers, clearly *nationally* there was increasingly shared improvement, for baby and for mother, in the risky event of childbirth. The observed concentration of more female marriage into the fertile 20s and away from older women contributed to this. English life expectancy at birth and perhaps at 25 improved into the early 1800s in E paths targeting about 1860, or timed comparable to infant mortality; but step by step such improvement progressively disappears at older ages (Fig. 1.10).

Already during the later 1700s and early 1800s, similar C-shape trends of improvement in young deaths likewise pressured population size in France, Sweden, and Finland and probably in certain localities of Belgium and of Germany or its environs--though not in central Spain or Catalonia (Figs. 4.3a, 4.3b; Figs. 5.11, C.9; Tabs. C.5, 5.9; Marfany 2011, 966).[15] For some reason--perhaps an improvement in diet through the introduction of the potato and an increase in dairying or (alternatively or additionally) better sanitation or other control of disease, the young (and perhaps, as in England, also their mothers) became less at risk during and following birth. E-shape increases in population that also occurred during this period for the Netherlands, Denmark, and Lombardy, where the birth rate rose in parallel E fashion (as in England)--and for Iceland, Ireland, and Scotland, for which there survives no record of CBR this early--seem likely to have reflected, at least in substantial part, such improvements in early mortality. Perhaps relevantly, Norway and the Czech lands of Bohemia and Moravia shared with England, the rest of Scandinavia, and certain localities of Germany a D’ (1/G’) sag in the overall death rate into the middle of the 1700s (Tab. 2.1a). These dips tended to bottom out rather earlier than local C trends in infant mortality, where those are recorded.

While there was a widely shared pressure from falling infant mortality of C type that most frequently (though not always) contributed to demographic growth in accelerating E form,[16] the consequences of these combinations for the *birth* rate in populations of Europe during the later 1700s and early 1800s could contrast markedly. Was fertility shaped comparably, or did its movements depart from those of CBR? Parts A and B of Table C.8 summarize these and other parallel or diverging demographic relationships across early modern Europe.

In England, Belgium, and Germany, where C-type decline of fertility is known, and in Denmark, the Netherlands, and perhaps northern Italy, where evidence is lacking but context suggests similar developments, CBR accelerated upward via E, along with the size of the population and *opposite* to the widespread underlying force of falling infant mortality. Conversely, in France, Sweden, and Finland, where C-shape decrease in infant mortality appears, and in Norway, where such evidence of early death is lacking, CBR *fell* via C *along with* infant mortality. Declining birth rates limited rather than enhanced demographic expansion. Among cases with evidence this early, in France and Sweden total *fertility* rates also--not just crude birth rates--contracted in C fashion. In England, perhaps Germany and Belgium, and possibly in Denmark (judging by CBR), in spite of accelerating population growth TFR managed to *rise* via E as well.[17]

In England through the later 1700s and early 1800s birth rates--and, more strongly, population--climbed in E fashion even as crude rates of marriage fell oppositely in C form. They could do this because nuptiality expanded with more early marriage and longer-lasting unions, raising fertility rates, while--in addition--fewer children were culled by early death. Crude rates of marriage declined similarly at the time via C in France, Sweden, and East Flanders (Fig. C.2; Tab. C.8). In New Castile the 18th-century decline of the CMR took D shape (Tab. C.4).

Nuptiality is not known this early except for England. In East Flanders, though, the average age of women at first marriage rose during the later 1700s via E (Tab. “6.10” C.x), opposite to the decline in England, which extended the duration of English unions in E form (Fig. 1.5). The proportion of females who never wed, however, increased over this era more generally: in England, via H (or possibly E, ibid.); in France, according to successively higher G trajectories up through 1815 (Fig. 5.1b); in East Flanders along an E path with comparable long-term results (Tab. “6.10”or C.x).

In England and East Flanders (ibid.), these tendencies reflected patterns of urbanization and economic change. In demographically “crowded” rural society, it became more difficult to wed. Relocation to urban life and new employment in England, however, in national average allowed females who did marry to do so sooner, elevating fertility. In Flanders, instead, brides as a whole became older. Their fertility, nevertheless, did also increase during the early 1800s--but apparently in more of a shorter-term G’ surge than a sustained E trend. What differences in the nature of employment and marriage may have shaped these distinctions? In Belgium, for instance, dissemination of the values of the French Revolution had significant social consequences (Fig. 5.12).

In sum, during the later 1700s and early 1800s--most definitively in England, probably in parts of Germany and Belgium, and possibly in Denmark (lacking evidence on infant mortality this early, but experiencing E-shape population growth and gain in the birth rate)--protoindustrialization and early factory industrialization capitalized upon population increase from falling infant mortality in a manner that allowed reproduction to swell.[18] Some of the demographic mechanisms by which accelerating growth was sustained were comparable to the dynamics observed in England. Others varied or still need to be documented. But further inquiry should be fruitful for understanding these and other E-shaped historical demonomic interactions.

By the middle of the 1700s **C-type fertility decline** was occurring extensively in France, a direction of change long well known but a path of decline not yet realized. It also began to unfold in Sweden and probably Finland and Norway (part B, Tab. C.8). Decrease of this shape during the period likewise appears in Geneva, in the Jewish communities of Florence, Leghorn, Verona, and Modena in northern Italy (inferring from CBR), in some villages of Bavaria, Baden, and Friesland, and in certain locales of Hungarian Transdanubia--both Protestant and Catholic (Tabs. 5.3, C.5, and 5.7). The demonomic adjustments of the era in these places have been used to mark an international beginning of the so-called 'demographic transition.' It is important to note, though, that the phenomenon of C-shape decline in fertility is recorded earlier: for New Castile, the overall population of England, and perhaps the elites of England, Geneva, Genoa, and Milan from the later 1500s to about 1650 (Tab. 7.5a).[19] First recorded C trends of fertility for Geneva as a whole, Rouen, Normandy, both the aristocracy and the Jews of Florence, and European ruling families began and declined somewhat later.

In 18th-century France and Sweden, decrease in fertility occurred as the population grew via G. In England, demographic expansion during earlier fertility decline took more slowly decelerating H form, though here, too, falling fertility curbed growth but did not eliminate it. In New Castile, however, from 1600 through 1670 the population also shrank along a C path, albeit one more gradual than the 1600-to-1640 C trajectory for completed family size. C-shape decline in total fertility and also in marital fertility that occurred in the missions of Paraguay between 1705 and 1764 with target year about 1810 likewise served to reduce population there between 1754 and 1815 via C with t_0 at about 1809 (Livi Bacci and Maeder 2004, 206).[20]

A positive relationship between reproduction rates and population numbers also occurred in Japan during the 18th century, where fertility ratios in Suwa County (Hayami and Uchida 1972, 500) or family size in the vicinity of Osaka (R. J. Smith 1972, 445-55) that declined in C fashion between 1685 and 1775 (t_0 in the vicinity of 1800)[21] contributed to the way in which the national population contracted from almost flat G growth in the early 1700s into D-type decrease between 1732 and 1792 (Harris 2001, 249, 251). In 18th-century China, however, the relationship between changes in fertility and population size were more like those of France and other parts of contemporary Europe. Compensating for declining infant mortality, completed fertility comparably contracted in C fashion between 1710 and 1750 with t_0 at 1781 (Fig. 7.7)--much as in Japan (and a little more steeply than in 18th-century Paraguay)--while the population *increased* first via G, then even more slowly decelerating H, rather than contracting along with fertility.

On the whole, though, late 18th-century France--if the shapes of trends are better understood--continues to provide a prototype for ‘demographic transition.’ While following the Revolution the number of people in the country did begin to expand briefly in accelerating E form along with the “A” populations of Table C.8, as culling by early mortality lessened, fertility--and thereby the birth rate--was curbed in C fashion rather than allowed to rise via E (the way that socioeconomic changes encouraged demographic growth to accelerate in contemporary England and elsewhere in northwestern Europe). The crude rate of marriage, in contrast, contracted as it did among those “A” populations during this period.

In France and Sweden, probably Finland and Tuscany, and possibly Norway, from the early 1800s into the middle or later decades of the century much the same combination of reduced fertility and/or birth rate with decreasing early mortality appeared again (part D of Tab. C.8), once more predominantly taking C paths. Population increased anew, but in decelerating rather than E or approximate E fashion.[22] Now, crude rates of marriage increased--opposite to the previous experience of these populations during the later 18th and early 19th centuries.

In the northwestern European countries of section A of Table C.8 (except northern Italy), meanwhile, such C-shape decline fails to appear through the middle of the 19th century (section C) *either* in early mortality *or* in fertility and the birth rate. And these formerly “A”-category populations now consistently expanded in quite parallel slowly decelerating H fashion. Only Austria and Portugal, among 4 countries with partially comparable demographic behavior, displayed the E pattern of growth that had characterized the “A” group during the preceding era of the late 1700s and early 1800s. In the 9 populations of section C collectively, early mortality instead *increased*, mostly via G, while the birth rate (especially before about 1850) contracted oppositely in D fashion. This juxtaposition suggests a negative impact of the environment (presumably the notorious living conditions of early industrialization in institutionally poorly developed, employer-dominated communities) upon health, on the one hand, and marriage and reproduction on the other.

Directly measured fertility, however, altered in quite diverse paths. Only total fertility in England and marital fertility in Denmark resembled the movement of the crude birth rate.[23] In the Netherlands and some German villages as of the 1840s, C-shape declines in fertility ran *opposite* to E-type gains for the birth rate. What does that signify? Except for the D’ sag of nuptiality in England, meanwhile, the sparse evidence on CMR or nuptiality indicates expanding rather than contracting marriage. Did greater opportunity to marry in these countries during this period take place in settings that aggravated rates of infant and childhood mortality? In Sweden (and perhaps Tuscany?), meanwhile, the marriage rate declined in C fashion along with early mortality, the birth rate, and fertility, as part of a demonomic system that reduced both death and reproduction. In New Castile through the middle of the 1800s, conditions improved enough to allow simultaneously a temporary D’ dip in early mortality and G’ surges in completed family size and the frequency of marriages, while the birth rate--near the end of several generations of G-shape increase--now ran almost level. In France and Finland, the marriage rate could rise as C-type decline in early mortality was countered by contraction in the birth rate and level of fertility that fell comparably (the typical pattern for these countries that was already evident in the preceding period of the later 1700s and early 1800s).

It would be fruitful to explore further these permutations and combinations of demographic trends during the transitional early- and mid-19th century within and between groups of populations that here (or elsewhere) display certain similarities or differences. This study is of course hardly complete. There is undoubtedly material already available that is not identified. And new relevant information may well still be found, even for much-studied Europe.

The second portion of section D in Table C.8 summarizes the patterns taken in most of Europe by fundamental demographic trends during the later 19th and early 20th centuries. These movements, everywhere including C-shape contractions in fertility, record what became in the 20th century a worldwide diffusion of 'demographic transition.' This was not a single international historical event, but a repeated process of local adjustment that has occurred from place to place since at least the 1600s, and is still unfolding in quite a few societies today. The later 1800s and early 1900s, among other things, constituted the period in which European populations that had previously coped with the pressures of widespread falling early mortality during the later 18th and early 19th centuries by means of adopting fundamental socioeconomic change rather than fertility control (section A, Tab.C.8), and had subsequently accepted rising infant and childhood losses that allowed their populations to expand robustly and persistently through the middle of the 1800s (section C),[24] at last all turned to join the pathbreaking countries of 'transition' (section B and the early group in section D) in adapting to early mortality that fell in C fashion by means of declines with this same shape in fertility and the birth rate.

In 4 of the 5 countries (not Germany) that had during the later 1700s and early 1800s apparently coped with expanding survival among infants and simultaneously rising birth rates by means of economic growth (Tab. C.8, section A), populations grew from 1850 forward again in the robust, only slowly slowing H fashion--as they had just done between about 1815 and 1860 (section C). Now, however, they were joined in such sustained H-type demographic expansion by Sweden and Norway, and by Hungary and Italy, while the populations of France and Finland (which like Sweden and Norway had previously been participants in "B"-type adjustment) increased only via the quickly decelerating G path (like the peoples of Luxemburg, Poland, and various Balkan countries, where the thin evidence is limited principally to just late data on population size and is not included in Tab. C.8). Whatever the internal demographic mechanisms in each case, this G pattern indicates less leeway available for population increase from further development even during an era in which industrial growth and socio-political liberalization spread widely across Europe.

Meanwhile in Germany, Switzerland, Austria, Bohemia and Moravia, and Spain (section D, Tab. C.8), and in Romania and Portugal (section C), during the later 1800s and early 1900s population expanded in accelerating E manner. In the first 5 countries, this occurred even as C-shape decline in fertility and the birth rate worked to reduce the expansionary effects of having less young mortality, which decreased significantly via C. Reproduction increasingly was not curbed *enough* to offset the consequences of this better survival. The Austro-Hungarian Empire (which included the Czech lands) and especially Germany were notably expansionist powers in this era (even given their heavy emigration at this time--Harris 2003, 24). In Portugal and Romania, in contrast, demographic growth via E directly followed the path of the birth rate, which rose opposite to the C trends found in the "D" countries.[25]

During the widespread C-type fertility reduction in response to lessening mortality that characterized the later 1800s and early 1900s in Europe (the second group of populations in section D of Tab. C.8), nuptiality most frequently (in 10 of 15 countries) increased in G fashion,[26] abetted by better health for adults as well as among infants and children. In Spain, Italy, Hungary, and Finland, however, it contracted via C along with early mortality, the birth rate, and fertility. In England, exceptionally, from 1890 into the 1930s nuptiality slowly accelerated upward opposite to the C-shape demographic challenge of less mortality and offsetting fertility decline--but in all rose only very flatly.

In modern times, C-shape decline in fertility has kept appearing globally. In the former British colonial populations of the United States, Canada, Australia, and New Zealand, even subsequent to the 'baby booms' that followed World War II such a trend has reemerged. In the latter three cases it lasted to 2000 or later (Tab. 7.6). In Latin America and the Caribbean, meanwhile, fertility contracted in this form up to about the war in Argentina, Brazil, Jamaica, Grenada, Barbados, and Trinidad, to 1980 or later in at least 10 other countries (Tab. 7.1). In East, Southeast, South, and Central Asia, a substantial 20th-century span of C-type decrease in fertility is virtually universal (except in China), persisting sometimes past 2000 (Tab. 7.2). Among known trends for North Africa and West Asia (Tab. 7.3), Israel, Egypt, and Cyprus had apparently shifted to a different trajectory by about 1960, Turkey shortly afterwards. Only Yemen lacked such movement during the second half of the 20th century. In Sub-Saharan Africa, fertility has contracted in the majority of populations, much of the time commencing a C path only in the later 20th century (Tab. 7.4). These trends are currently projected to extend for a while into the 21st century.

Internationally, C-shape decline in fertility has been virtually universal at some point in fairly or very recent history, outside Europe--where ‘fertility transition’ was first identified--as well as within. Table 7.6 will provide a basis for assessing generally the extent to which such contraction has responded to decline in mortality, the expectation of ‘transition’ theory.

Before probing the tie to early mortality, however, we should be note the way that relatively abrupt, but soon limited, **D’ drops** in fertility rates subsequently became almost as common as C decline internationally during the late 20th century. These movements mostly have commenced only since the 1980s, though some D’ patterns appear two or three decades before (Tabs. 6.1, 7.1, 7.2, 7.3, 7.4). Just one significantly earlier historical trend of this type is observed in fertility per se. That occurred in overall fertility (I_f) for England between 1823 and 1858 (Fig. 1.4). D’ trends for fertility-implying *crude birth rates*, however, appeared in Denmark between 1857 and 1877 and Sri Lanka for 1927 through 1947, while somewhat similar decelerating, downward *D* movements in CBR are evident in England, Denmark, the Netherlands, Germany, Austria, and Italy during the first half of the 19th century and in Ireland, Austria, Czechoslovakia (twice), and Fiji in the later 1900s (Tabs. 2.3a and 2.3b). The D and D’ trajectories run very close together during certain phases.

As one would expect from ‘transition’ theory, there was some tendency of D’ or D dips in fertility or birth rates in northern and central Europe to accompany D’ declines in overall *mortality* (Fig. 2.1). But during the 18th century Norway, Sweden, Finland, and Czechoslovakia experienced D’ drops in the CDR without D’ or D declines in birth rates, while in the early 19th century the Netherlands and Italy had such declines in reproduction without a dip in the death rate to stimulate them. In Austria a D’-like sag in the rate of infant mortality did encourage a cut in the birth rate at this time. On the whole, nevertheless, before the 20th century there is little national evidence that infant mortality rates triggered parallel D’ or D drops in fertility. The two instead mostly came down together progressively faster via C (Figs. 4.3a through 4.3f).

Tab. 4.4, though, has assigned D shape to declines of infant mortality in several European nations after about 1950. D and D’, again, can run close together, and the latter may in the end prove more appropriate. Because these changes are still at work, discussion of frequent manifestations of fertility trends in this shape in present-day Europe are best explored with their concomitants--especially strong, maximizing reductions in early mortality--when very recent data and reliable projections for the near future are combined.

The new, intercontinentally ubiquitous (Figs. 7.1, 7.2 7.3, and 7.4) D’ movements in fertility seem to represent a “bounce” or “bottoming out” of a C-type reduction that has “overshot” an appropriate demographic equilibrium. Goldstein et al. (2009), for example, explore the workings of a “bottoming out” process, primarily for European countries. The 5 East Asian cases in their sample (Hong Kong, Japan, South Korea, Singapore, and Taiwan) as of 2008 had, on average, experienced the lowest minimum annual TFR (1.11) at the latest point observed (2005). In each instance the contraction took D’ shape with zero year estimated between 2012 and 2017 (Tab. 7.2). For 5 countries of northern and western Europe (The Netherlands, Denmark, West Germany then united Germany, and Sweden), in contrast, the average lowest year had typically arrived about 1990 with a considerably higher average TFR of 1.37. Of these countries, only in Germany does a dip of TFR in D’ (1/G’) shape seem possible so far.

For 19 countries formerly in the Soviet Union and the Communist bloc (including Cuba outside Europe and the exceptionally fertility-reducing East Germany) the average minimum in TFR arrived more like 1.19, but at a later date than for northwestern Europe. This was also the case for southern Western Europe (Portugal, Spain, Italy, Switzerland, Austria, Greece) where about 1.27 in 2000 represents the average.

Generating these minima, D'-shape contraction in TFR is evident in the Russian Federation, and is possible for Poland and Hungary beginning in the 1990s, also in Italy, Austria, Spain, and Greece (Tab. C.7), much of the European Communist bloc covered in Table C.7 (though without Belarus, Ukraine, the former Czechoslovakia, and Romania), and 4 of 6 countries of southwestern Europe. Thus in all groups of populations whose average lows in TFR so far have reached under 1.3, there is some indication of a link between D'-type decline and the lowest minimum levels. The connection is clearest for the 5 East Asian cases, where the lowest lows have occurred.[27]

In level, the *highest* 'lows' so far have come in the United States (at 1976, also distinctively the earliest "bottom"--though perhaps temporary--on the list of 40 populations studied), metropolitan France (1993), the United Kingdom, Australia (2001), and New Zealand (2002). In these 5 populations the lowest TFR reached by 2008 averaged only 1.73. One could readily surmise that immigration of fertile peoples affected these countries more than others, underwriting a higher 'bottom' to fertility decline, at least for the time being. The role of immigrant women is discussed at a weaker level of impact for several European countries (Goldstein et al. 2009, 679-82). This immigration process, however, occurred much earlier in the United States (1976) than in France (1994) and in the United Kingdom and two large "Europeanized" British Commonwealth countries, which diversified demographically about a generation later (2001). As of 2000, in France and in England and Wales no D' trend stands out in the record (Tab. C.7). Further, successive C trends, meanwhile, serve better to pattern the movement of TFR in Australia and New Zealand since the 1960s (Fig. 6.1).[28] For the United

States (as for Canada) probably 15 years of such D’ contraction does appear following the ‘baby boom’ (ibid.), but that trajectory is broken at a high level a generation before the expected zero year is reached.

The absence of D’ movements after C trends *earlier* in human history (a frequently missing sequence in Europe and the United States before the later 20th century) perhaps then reflects that the C decline of early mortality, a critical determinant of fertility, had simply not yet approached a minimum level. On the other hand, being a derivative or marginal function, D’ may reflect an event, rather than an accumulative process--perhaps a change of demographic policy (as in China) or the introduction and popularization of a new technology for limiting reproduction (as in various family planning programs). If this interpretation is correct, then D’ trends in fertility probably do not appear until recently because policy enactments and distinctly more effective new methods for regulating reproduction did not become globally significant until the middle or later 1900s. To the extent that fertility continues to follow early mortality, however, D’ movement in it may simply constitute a response to a concentrated shock of that shape in mortality, for instance a relatively sudden improvement in the health of the young. Readers are invited to consider how recognizing the shift in fertility reduction from C to D’ form clarifies what was happening in recent decades as ‘late demographic transition,’ ‘fertility crisis,’ ‘second demographic transition,’ and ‘lowest low fertility’ occurred. In this rethinking it should be remembered that, as with C trends, more than one D’ contraction can occur in the history of a population, and already has (Tabs. 7.1, 7.2, 7.3, 7.4).

One puzzle in this intercontinental comparison is how, in a minority of populations, sagging downward movement in TFR, when it occurred, has taken D shape rather than the D’ that has recently been so prevalent. While it should be remembered that these two curves closely follow each other for certain segments of their bending (and precise comparative curve-fitting for the many trends that have only been estimated might here and there shift preference from one form to the other), might there sometimes be a *substantive* reason for occasional more gradual, less reactive D contraction, particularly in earlier historical times? Phenomena such as the availability of methods for curbing fertility, shifts in reproductive and sexual norms, or health practices, for instance, may tend to have been largely episodic in most societies, especially recently, encouraging fairly abrupt change-- including encounter with minimum levels in a kind of “overkill” from which the D’ pattern then recovers. In a few others instances, however--particularly before the present era--the change driving fertility may have been more cumulative and gradual, and not inviting “correction.”

REPEATED PATTERNS OF CHANGE IN MORTALITY THAT AFFECTED FERTILITY

On a global scale, to what extent have the elements that shape fertility, like the trends of fertility themselves, evolved in G-based forms historically? And do they continue to unfold this way in the 21st century? Some findings[29] suggest that they do, and facilitate insightful contrast and comparison. The evidence clusters into certain broad topical areas: 1) the impact of mortality, especially death rates in infancy and childhood on fertility; 2) relevant changes in the institutional setting for reproduction in various societies; 3) where how births are distributed across the lives of women; and 4) methods for conscious control of procreation. In each area, trends of familiar shape--often also with familiar connections to each other--appear.

Mortality, especially the **loss or survival of infants and children**, is well known to have shaped fertility in many historical settings. Table 7.6 summarizes some readily accessible trends in infant mortality for 31 populations outside Europe: 4 former British colonies of North America and Oceania, 9 populations of Latin America, 9 located in Asia, and 9 from Africa. It compares these movements with current or recent paths for total fertility and population increase in order to structure thinking about how these demographic changes are connected.[30]

First of all, the *roughly parallel C declines* for both infant mortality and fertility that characterized the demographic behavior of the United States, Canada, and Australia into the middle of the 20th century[31]--and appeared in many European countries as well (Tab. C.8)--are also found, if sometimes significantly later, in Argentina, Brazil, Peru, Japan, South Korea, Taiwan, South Africa, Algeria, Nigeria, Cameroon, and Chad. In Singapore, Malaysia, the Philippines, and India, meanwhile, a C trend in fertility lagged well behind one in infant mortality, sometimes beginning only as that ended. In Uruguay, Mexico, Chile, and Sri Lanka to or through the 1930s--and Venezuela, Costa Rica, and Cuba rather later--C-shape decrease in infant mortality is evident but the current trend for fertility is just, in this incomplete summary, unknown. Only in China, the former French island colony of Mauritius, and Egypt is there definite evidence that the ubiquitous paring of C trends is unlikely.[32]

As infant mortality and fertility have thus widely declined along C paths in the modern era, as ‘demographic transition’ visualizes, population accelerated upward in size along an E path simply from a lag of C-shape fertility reduction behind a decline of early deaths in that form in Cameroon after 1970, in Taiwan around mid-century, and possibly (one trend of the pair is unclear) in India, the Philippines, Venezuela, Costa Rica, Cuba, and Chile, and Mexico among the 31 societies covered in Table 7.6. A precursor of such expansion had appeared in France briefly between 1792 and 1827 (Ch. 3, Figs. 3.2a, 3.1b; Tab. C.8). Elsewhere E increase in population resulted from other combinations of trends in fertility and early mortality (Peru, Chile, Korea, Sri Lanka, Egypt, Nigeria, Cameroon, Kenya), or lagged C movements failed to produce an E-shape result in size of the population.

In the United States, Argentina, and Brazil (before 1950)--possibly Mexico, Chile, and the Philippines--paired C-shape reductions in early mortality and fertility generated population growth in slowly slowing H fashion instead, as they had in several European countries during the later 1800s and the early 1900s (section D of Tab. C.8).[33] In India and Egypt after 1960, like Kenya through third quarter of the 20th century, H expansion appeared another way. In Peru, Taiwan, and Algeria two C trends generated population increase at the constant F (.03) rate. In a few other places this constant form of demographic expansion resulted from other combinations of trends in fertility and early mortality.

In short, the present evidence indicates that: 1) Around the globe, fertility and infant mortality, the principal molders of ‘demographic transition,’ have both characteristically decreased in the specific C trajectory as societies have acquired ‘modern’ social, economic, and cultural characteristics. 2) Contrary to a popular conception of ‘transition,’ however, decline in fertility has not consistently and significantly lagged behind improvement in infant mortality, thus causing ‘population explosion.’ 3) C-shape declines in fertility and mortality together have not appeared just once in the history of particular societies. Second, even third, pairs of C-shape contractions are evident. In recent manifestations these have sometimes been labeled ‘second’ demographic transitions; but in France, Sweden, and probably Finland earlier, already secondary C-type parallels can be found already in the first half of the 19th century--and a third round appeared during the later 1800s (Tab. C.8). C decrease in each variable, furthermore, has occurred here and there independent of comparable movement in the other.[34] 4) Populations have not uniformly ‘exploded’ in accelerating E-type growth, as theorized, due to ‘transition’-type divergences between the timings of decline in infant mortality and fertility. Instead, they have expanded in all four familiar G, H, E, and F patterns according to the relative *levels* at which the C-shape declines in fertility and mortality have taken place as well as their relative timing and--especially in the United States, Canada, Australia, New Zealand, Argentina, and Brazil--the amount of net immigration that occurred. 5) Though childhood, particularly infant, mortality continues to have disproportional weight, still another factor in recent demographic expansion has been some lessening in modern society of early losses as a proportion of total death rates.

By the middle of the 1900s, though, initially steeper but quickly decelerating *D’ drops* in early mortality and fertility began to replace accelerating C declines. In 15 to 18 of 31 populations of Table 7.6, D’ decrease in fertility approximately paralleled reduction of this decelerating shape for infant mortality.[35] In Nigeria, Cameroon, and Chad--but also Australia and New Zealand--C declines are currently still at work in both fertility and infant mortality during the early 21st century. The widespread shift of pattern has simply not yet arrived. Resistance from approaching a limit to further change is not yet reflected. In the United States, Canada, the Philippines, Egypt, and Kenya, early mortality is still accelerating downward via C while fertility is ‘bottoming out’ in D’ fashion. The reverse is true in Uruguay, Japan, and Egypt.

In India, China, and Egypt, meanwhile, a pair of D’ movements has recently helped create population increases in the slowly slowing H form. In Argentina and Brazil, D’-shape declines timed about a generation earlier similarly contributed to H trends of expansion.[36] In the population of Mexico, on the other hand, proportionally constant F-type growth resulted from paired D’ drops in infant mortality and fertility.

Continued C-shape decrease is still *decline*. When it continues alongside D’ descent in another variable, both are contracting--perhaps by equal amounts over a certain period. That fact can be deceptive, however. The difference in shape of curve reflects a distinction in the *origin* of the two movements, and implies before long very different *consequences*. D’ bottoms out; C becomes more and more extreme. Distinguishing the two shapes among recent international changes in fertility and early mortality clarifies the confusion evident in recent discussions of which populations are experiencing ‘fertility crisis,’ ‘second’ or ‘late’ demographic transition, and ‘lowest low fertility,’ where divergences of *pattern* in change are not at present adequately appreciated. The new perspective on the nature of contributing trends helps untangle the relationships of developments in fertility and mortality to each other as current developments approach limits in the improvement of early mortality and the reduction of fertility.

Table 7.7 presents some other calculated or approximated particulars concerning infant or early childhood mortality for several diverse populations. Figures 7.4, 7.5a, and 7.6 fit G-related patterns encountered in Mexico, Peru, and China. The Peruvian trend is included in Tab. 7.6, while the official Mexican rate for 1975-1990 extends there the estimates of Feliciano (2000, 604).

Within peninsular Malaysia rates for Malay, Chinese, and Indian infants all decreased together in C fashion for some time after 1950 (accompanied by fertility), though the large Malay component abandoned this trajectory sooner, taking the national average with it. It would be interesting to know what change in the health environment of the very young was ethnically common for a while and just how the Malay population then diverged from the Chinese and Indian minorities. And what then happened among the different ethnic sub-populations as national rates of infant mortality next dropped in D' shape along with a shallower decline of that type in fertility (Tab. 7.6)? Infant mortality in the state of São Paolo continued to improve in C form throughout the 20th century, though the national trend for Brazil took a D' trajectory between 1942 and 1971. Judging by just the 1990s, maternal mortality for Brazil as a whole decreased via C--more like the infant rate for São Paulo rather than the comparable national trend. How did the health of the mother and the conditions of delivery in this one more highly developed state resemble or differ from national circumstances? For rural Kerala in southern India, two probable successive D' drops in infant mortality since the 1950s resemble the national trends (Tab. 7.6) but are timed about two decades later. In China, occasional estimates suggest that from 1930 to 1981 reported infant mortality for males and females together probably decreased along a C path with zero year in the vicinity of 1957 (Lee and Wang 1999, 56; Peng 1991, 81). Fertility, meanwhile, *increased* via G, and as a consequence the population grew in a new H trend (Tab. 7.6). This was stronger (had a later base year, at 1923) than the H path in the contemporary United States and Argentina (1895 and 1905) but more gradual than those of India and Brazil (1947, 1948) or Egypt (1956).

In Argentina, Brazil, India, and China (though not Egypt and the United States) H-type population growth has recently resulted from simultaneous D' drops in infant mortality and fertility. This parallel of trends has begun to replace the pairs of C-shape declines that previously, during classic ‘demographic transition,’ generated growth in H form (Tabs. 7.6, C.8). These H-type increases in population--like such growth three centuries before as the English people multiplied via H from the 1560s to the 1650s (Tabs. 1.2, 1.4; Fig. 1.4)--had been shaped together by the relative timing and the level of these contributing C trends, by factors that intervened between fertility and the crude birth rate or infant mortality and the death rate, and by net migration.[37] In a third set of dynamics that produced H-type growth, meanwhile, the populations of England, Germany, Belgium, the Netherlands, and Denmark expanded in H fashion during the first two thirds of the 1800s even though infant mortality was *worsening* via G, not improving.[38] Fertility, meanwhile, mostly decreased (Tab. C.8). Sometimes it did so in C form. The D’ pattern is also evident: in England, Denmark, and (rather later) Portugal. In this period, however, the change in fertility neither paralleled nor directly counteracted the movement in infant mortality.

Part B of Table 7.7 next shows how, among infants or all children under age 5, for a short period rates in mortality for males in China and India declined *relative to* those for *females*, all in C form, (Das Gupta et al. 2009, 404-5). The male/female ratio for infants fell more strongly in China (with an earlier t_0); but by the age of 5 the cumulative paths of change for children in India and China became quite parallel. The implication is that through recent years Chinese couples have for the most part less aggressively distorted the sex ratios of their offspring by means of infanticide or very early neglect, while the balance for Indians has mostly become more equal because female children 1 through 4 received better care. The resulting male/female ratio of *survival* for children 0 through 4, meanwhile, increased in E fashion targeting the middle of the present new century in both countries--and also South Korea--in fairly comparable fashion. (That is, until the increase of the Chinese ratio began to decelerate via G in the 1990s.)

Meanwhile, between 1975 and 1990 the surplus ratio of male to female *births*, accelerated upward from about 1.9 to more like 12.5 percent in a very steep E trajectory (based around 1940) as ‘one child’ policy and low fertility induced Chinese couples, in order to be sure that they had the prized *son*, to risk not reporting the births of females who "disappeared" (Das Gupta 2005, 532). Even more biologically unrealistic excesses had been reached near the middle of the 20th century, before the Revolution, as between 1920 (or sooner) and the late 1930s the male/female ratio of reported births surged along an E path (based in the first years of the 1900s) from about 7.5 percent above par to more like 16.5 as first internal wars, then Japanese invasion, stressed conditions of sheer family survival, putting an even more abnormal premium upon males, who were considered to be more beneficial for collective interests. In the more recent period--under improved conditions for mere continuation of the family--the ratio rose again thanks to a re-emphasis upon deep-seated cultural preferences that survived the Revolution. But the accelerating path taken by the sex ratio in response to politically forced family limitation was similar in shape and degree of change.[39] In between, from about 1940 to the 1970s, the Communist ideological emphasis upon equality of the sexes (a cultural pressure that worked in the opposite direction from the subsequently revived prizing of sons), drove down the male/female ratio in reported births to an internationally more familiar degree of imbalance. From the late 1930s to the late 1970s this decline took D shape, heading toward a t_0 in the vicinity of 1980 with a level just under 2 percent (Das Gupta 2005, 532).

In a much earlier era of Chinese history (the left panel of Fig. 7.6 and Tab. 7.7), between 1700 and the final years of the 18th century, childhood mortality for males and for females in the imperial lineage declined along approximately similar C paths (t_0's at 1765 and 1757), assisted significantly by mandatory inoculation for smallpox (Lee and Wang 1999, 46). Was this practice a source of C-shape decline in mortality also in contemporary Europe and the United States? The decrease--if also characteristic of families outside the nobility (by the 18th century, indeed, all Manchu children were inoculated)--helped Ch'ing China initiate only slowly decelerating H-type growth to 1851, the first manifestation of this trend among populations outside Europe. With base year in the 1660s, the expansion ran roughly parallel with contemporary H trends of growth in Russia, Norway, and Spain (Harris 2001, 243-44, 451, 148- 29).

In the meantime, *infant* mortality for males also ameliorated in C fashion, though somewhat more flatly (aimed at a zero year for the curve in the late 1780s rather than about 1760). Infant mortality for *females*, in contrast, *rose* almost exactly oppositely: in E form with t_0 at 1773. It was perinatal mortality for girls that surged the most (via E based at 1737) as a long-standing Chinese penchant for infanticide (traceable to the first millennium) strengthened as a custom among even imperial families. Overall, perinatal death for females of this lineage in effect expanded then contracted over time in G’ shape, a penchant for the practice which surged then receded between 1740 and 1830 (or later)--like a local or ethnic migration (Harris 2003, passim) or the adoption of a particular behavior like for family limitation in modern China (right panel of Fig. 7.6 and the final section of this chapter). Most specifically comparable internationally, during the same period observed for female infanticide within the Chinese imperial lineage, in 18th century France and neighboring regions of Europe local illegitimacy and abandonment or neglect of babies similarly rose and fell in this G’ form (Figs. C.4, C.7). Illegitimate fertility also commonly rose and fell this way periodically in 18th and 19th century Europe, sometimes accompanied by more frequent young marriage and reflecting bursts of secularization in modernizing cultures (Tabs. 4.5, 4.6; Tabs. 5.12, C.6). The ‘booms’ that increased marriage and reproduction following World War II likewise could take G’ shape (Chs. 5, 6).

Subsequently, through the later 1700s and early 1800s, both male and female mortality during childhood for the Chinese imperial lineage rose back in E fashion, with the female rate increasing more strongly and giving back most of the improvements it had gained against male while culling still earlier in life by means of infanticide rose to a peak (Fig., 7.6, left panel). Though completed fertility rates for the lineage families between 1770 and 1830 closely paralleled the upward E path for male infant mortality from 1760 to 1830, infant mortality for females in effect oppositely *improved* even more strongly via C as losses among male babies worsened in E fashion. The E-type rise of fertility fed the H-shape population growth in China between 1742 and 1851 in a relationship not observed in other cases of historical demographic expansion of that pattern.[40]

Adopting boys became more fashionable in the imperial lineage between 1700 and 1730. In an upward-accelerating movement, adoptees rose to 6 percent of all sons. This was followed by a longer E trend across the remainder of the century, which reached above 12 percent before the practice was markedly reduced during the early 19th century (Fig. 7.6, left panel).

This contemporaneous adoption of more and more sons did not come as response to losses among young males. To the contrary, it increased *opposite* to the C paths along which more boys survived infancy and early childhood. Still, it did rise reciprocally to the way that completed fertility declined during much of the 18th century. The latter decreased this way, however, as *females* were more and more vigorously pruned during their early days by infanticide. Letting fewer girls survive and simultaneously adopting more boys were manifestations of the same sex preference in China, "a primordial prejudice against daughters" rooted in the "ancestral worship of the second and third millennia B.C." (Lee and Wang 1999, 47).

Also during the 18th century, in the village of Yokouchi (Suwa County, Japan) the death rate for male and female children 1 to 10 together fell via C from 1685 through the 1762 toward a zero year approximately in the early 1770s (part D, Tab. 7.7). This trend was largely parallel with the decrease of fertility in the community (Hayami and Uchida 1972, 509-10). The size of the village, meanwhile, expanded from 1720 through 1790 in G shape with base year in the 1690s.

These C trends in early mortality and fertility were very similar between at least one village in Japan and the families of the Chinese imperial lineage during the years before the Chinese population shifted into H-type expansion as of about 1740--a persistent growth fed by E-shape increase in fertility and what was probably C-type decline in female infant mortality. On an even broader international stage, Table 7.8 indicates comparable (if somewhat later and weaker) movements for early mortality and for fertility in France and Sweden as the populations of these European countries grew along G paths very closely parallel with the examples from China and Japan. In each case, C-shape fertility decline lagged behind change of that form in early mortality, which is considered an earmark of 'demographic transition,' though growth was uniformly curbed in a decelerating G path rather than producing some form of the unrelenting expansion or 'population explosion' that has been so evident in more modern transitions.

To what extent and by what means were the other demographic similarities generated at bottom by a common international climate for health in this era? It seems less likely, on the other hand, that the economies supporting these populations were of themselves integrated enough to shape identical change in population size in a manner that then forced common adjustment in early mortality and fertility.

Here, in the behavior of early mortality and its relationships with other demographic changes, is another example of the way that identifying the G-based trends involved can improve how one addresses and comes to resolve the issues that emerge from the comparison and contrast of population histories. Important international historical studies currently known to be in progress--likewise investigations of more modest scope and narrower focus on societal, regional, or even local populations--should benefit in their analysis and their interpretation from understanding the ubiquitous tendency of demographic change to repeatedly follow a few G-related forms.

CHANGES IN THE INSTITUTIONAL SETTING OF DEMOGRAPHIC PROCESSES

In the later-developing parts of the world, as in countries with more advanced economies and other dimensions of modernization, institutional changes interacted with alterations in the demographic regime. A few examples in Table 7.9 illustrate how these, too,[41] took G-based forms as they shaped or reflected processes in the population. Particulars not identified for certain variables in this simple collation[42] can be added by the interested reader, and data from other developing or developed societies similarly compared in order to follow up implications about connections and/or differences that are raised here. Nonetheless, even the limited evidence of the table illustrates how a G-based framework of analysis facilitates contrast and comparison and help understand the varying relationships among some key forms of demographic and institutional change.

First should be noted the wide variety of trends--and combinations of them--among the seven variables, though all follow G-related forms. Second, while instances of familiar theorized linkages do appear here and there, no universal, consistently repeated relationships of change are indicated. Even when countries experienced closely similar patterns of growth, for example, they did so with quite different combinations of institutional and demographic trends.

In Mexico, both before and after about 1940 **urbanization** and **literacy** among those 12 years old or more increased in parallel G fashion (Fig. 7.5a). Before the 1970s, these changes accompanied a comparable G-shape *rise* in fertility rather than fulfilling the common expectation that urbanization and education, especially for females, would encourage *lower* rates of reproduction.[43] What is more, as fertility increased via G along with urbanization and education to the 1970s, early mortality already dropped sharply in D' manner. This discrepancy helped thrust the expansion of the Mexican population into accelerating E-type growth. Only since about 1980 have fertility and infant mortality fallen together in Mexico, but at relative levels for their D' trends that have merely held population increase at the still challenging constant F or .03 rate, not held back the rate of growth into decelerating H or G form..

An additional insight, into comparative urbanization, arises from the role of Mexico City for the population as a whole. From 1910 through 1970 the residents of this one dominant central place expanded as a proportion of all Mexican people from 3.1 to 18.2 percent along an H path with a base point at about 8.2 percent in 1940 (Feliciano 2000, 624). It has been noted how--much earlier, between about 1600 and 1740--the population of London as a fraction of the

English total likewise rose via H. This happened, from a base year in the vicinity of 1525 (Harris 2003, 187). That change occurred as, during most of the period, the proportion of the rural population of England that was no longer in agriculture comparably rose via an H path anchored about 1540 (ibid., 237). The London trend of 1600 to 1740 was flatter than the recent increase for Mexico City, however. It rose more like from about 5 to approximately 15 percent, depending on the method of estimation (ibid., 187). In contrast to the E-shape ‘explosion’ of modern Mexico, during this era the population of England grew mostly via a flatter (earlier) H, separated from 1656 to 1686 by a brief period of D contraction (Tab. 1.1). Fertility fell via C up to this interval of decline, then afterward rose in G fashion into the middle 1700s (Fig. 1.4). Infant mortality moved in the same sequence of patterns, though it began its second trend about 1640 (Tab. 1.4). How else did the demographic and institutional contexts of these exceptional urban concentrations resemble or depart from each other? Are comparable particulars for extreme central places to be found elsewhere?

In Peru, another developing Latin American country, population during the bulk of the 20th century followed that of Mexico by growing first via E and then in F form. Here, as one would expect, for two decades or more G-shape gain in urbanization mirrored upside down the D trend in proportion of the population in agriculture. Literacy, meanwhile, expanded twice in G trends, as found for Mexico--again along with urbanization. After rising in decelerating G form to the 1960s parallel to the change in literacy, as in Mexico, fertility then contracted in C fashion following infant mortality while literacy expanded a second time via G. Mexican fertility now also dipped, but in D’ fashion rather than via C. While some of these are commonly expected relationships, they are made clear and more specific by recognizing the G-based trends involved. Not just the direction and degree of change can be compared, but the paths taken from initial to subsequent states. What made some of the institutional and demographic changes in Peru resemble comparable developments in Mexico while others diverged from the Mexican pattern?

Like these two Latin American countries, if more forcefully under the new Communist government, China engaged in economic development during the second half of the 20th century,. Her pattern of population growth, however, resembled that of England in the 1560-to-1730 era and modern H trends in the United States, England and Wales, and Sweden (and many other European nations)--but also Malaysia, Indonesia, and Thailand (Harris 2001, 250-51). Chinese urbanization--as in Mexico--first increased slowly in G shape, then much more vigorously along a second decelerating path of this shape. The shift from one G trend to the next, however, occurred in the vicinity of 1980, not 1940. Divorce rates in China meanwhile increased from 1950 forwards in a G path similar to that assumed by urbanization (but only after 1980).

Likely more causal is the connection between an earlier-based gain in Chinese fertility between 1930 and 1970 and the G trend in urbanization from 1951 or sooner to 1980. Demographic increase pushed people into the nation’s many fast-growing cities. This pairing of movements resembles the relationship of the G trends for urbanization and fertility in Mexico for some of the second half of the 1900s (with zero years there in the vicinity of 1935 and 1892 rather than the 1895 and 1857 of China). Earlier, as urbanization in England expanded via H from about 1670 to 1750 (Harris 2003, 225), fertility from 1663 through 1723 increased in G fashion (Fig. 1.4), not exactly the same path but, in result, quite close. And as fertility next rose in E manner from 1718 to 1818, English urbanization during this next era probably climbed via E--targeting the 1830s as opposed to the 1850s (urbanization again rising more strongly than fertility). To what extent in these widely scattered historical cases of positively paired movements of fertility and urbanization did the parallel reflect an impact of better opportunities to marry and support children (probably the conditions in England from the middle 1600s into the 1700s)? How much, conversely, was it pressure from higher fertility that fed urbanization
(the case in England during the subsequent era of E-shape change)? Patterns for wages help choose between those alternatives, at least in the experience of that one country (Ch. 10?).

A recently documented, unusual, trend of institutional change in earlier Chinese history may be related to the demographic practice of its era. During the mid-Qing epoch the frequency of government **relief** per calamity that occurred (flood, famine, etc.) at first increased between about 1720 and the middle of the 18th century as the state centralized under conditions of "dynamic change in the commercial economy and state capacity" under the guidance of resurgent neo-Confucianism. Thereafter, into the 19th century relief per calamity decreased as corruption returned to government and revenues failed to keep up with the growth of the population (Hung 2009, 80-81). These up-and-down changes tend to follow a G' curve with crest at about 1755. That G' movement happens to resemble closely the G' trend for perinatal mortality observed in the imperial lineage between 1740 and 1830 (Fig. 7.6--with t_0 rather later, about 1790), which is thought to reflect female infanticide in the face of falling natural mortality among the young that resulted from a favorable socioeconomic environment during these years. To what extent did the dominant neo-Confucianism of the age encourage within the Chinese leadership both social responsibility in public action and family limitation in private life (as part of a cultural emphasis on matching population to resources while preserving the essential *male* lineage)? [18th-century Chinese Malthus?]

The **nature** of protests demanding government action, meanwhile, altered significantly. They became markedly less proactive as the capacity of the government dwindled and peaceably talking the language of officials in seeking help no longer paid off for supplicants (ibid., 100-1). The proactive share of all complaints fell from the 1750s into the 1770s along a steeply accelerating C path with base year about 1738.[44] This is the opposite of the E-shape increase in perinatal mortality for females that constitutes an alternative trending between 1700 and 1770 in Figure 7.6. To what extent were ordinary Chinese under pressure to prune their families along the same path as the imperial lineage? And did this demographic strain foster more reactive and more violent protest as response to proactive demands diminished?

In peninsular Malaysia as a whole, the frequency with which females had worked in agriculture before marrying probably declined opposite to increase in urbanization.[45] Unlike the comparable reciprocity in Peru, however, the trends for some reason took C and E rather than D and G shape.

The likelihood that a Malaysian marriage would end in **divorce** or **separation** within the first five years, meanwhile, decreased via D as the proportion of females who had some **education** before marrying rose oppositely in G fashion (Hirschman and Teerawichitchainan 2003, 226, 230-31). The spread of female education,[46] furthermore, for some reason paralleled the growth of the population, which (an exception among the countries covered in Table 7.9) unfolded only in G form during 25 years or more of the later 20th century. Fertility and infant mortality, meanwhile, both declined first via C then in a D' drop, with the lag of fertility reduction (zero year around 1990 rather than 1949) substantially determining the expansion of the population. But no close connection appears between any of the four institutional variables and fertility or early mortality.[47]

The major ethnic groups that comprised the Malaysian population had rather different experiences. Through the middle of the 20th century, among women married between 1940 and 1970, variation in education was least. Malay, Chinese, and Indian brides alike decreasingly lacked any schooling, along C paths based in the vicinity of 1937.[48] At a higher level of training, completion of primary school or having any secondary education increased via E for all three groups. This is the pattern that is evident collectively for all Malaysia, for both any education and completed primary schooling in Indonesia (ibid. 228-29), and for any schooling for girls in Pakistan, where (before topping out through 1997 in G' fashion toward a peak about 2021) fertility fell oppositely, though more tardily and flatly: via C--with zero year at 2016 for 1963-2000 vs. about 1973 for 1975-1984 (Hirschman and Teerawichitchainan 2003, 226-27; Tab. 7.2).

With regard to female **employment prior to marriage**, from the1940s through the 1960s, among Chinese and Indian minority women in Malaysia fewer had not worked at all, the one in D decline the other via C. Among Malays, a G’ crest was passed about 1950 before continuous decrease. For those who *had* worked, the frequency of unpaid agricultural labor (and unpaid activity of any type) generally lessened: via D with t_0 in the neighborhood of the late 1940s for Malays and Chinese, via C based at 1930 for Indians. Paid non-agricultural employment, on the other hand, for the Indians and Chinese became *more* common via a G’ path that would maximize roughly in the 1990s, while for Malay women the gain accelerated upward in E form based about 1930 (ibid.). What might have generated these different forms of change in pre-marital employment for the three ethnic groups in Malaysia following World War II, and how long did the patterns last?

In Malaysia as a whole, paid non-agricultural work before marriage between 1940 and 1970 surged in G’ fashion toward a crest about 1998, opposite the D’ for fertility decline from 1973 through 1985. This pushed all paid work up via a G path based about 1970 and all non-agricultural work in similar manner rather later (t_0 about 1982). Though the postwar years saw increases also in Indonesia and Thailand, in the former the recorded G’ changes in all three variables crested in the later 1950s, while in Thailand all took G form instead--with zero year at about 1958 for paid non-agricultural work, 1948 for all non-agricultural activity, and 1930 for all unpaid labor.

Participation in the labor force for Japanese women 25 to 29, 30 to 34, and 35 to 39 each increased in G fashion between 1975 and 2004. Fertility meanwhile contracted via C. In Singapore and South Korea, during the same period participation crested instead in G’ manner targeting a maximum in the vicinity of 2010 for Singapore but maximizing as early as the 1990s for South Korea.[49] These trends made fertility fall opposite to female labor participation in Singapore (via D’ bottoming around 2014), and in South Korea some two decades following the G’ surge of labor (also D’ toward 2014 between 1970 and 2005). In Japan, in contrast, from 1958 through 2005 fertility continued to decline via C as participation in the labor force expanded along a G path (G. W. Jones 2007, 469; Tab. 7.2).

In several developing countries of Latin America, meanwhile, after the 1960s live-in and live-out **servitude** among teenagers became less common in accelerating fashion (Levison and Langer 2010, 130-31). In Chile, Argentina, and Costa Rica this decline was especially abrupt, perhaps captured by C' patterns (G' reversed with respect to time). In Colombia, Brazil, and (for live-in servants) Mexico, the more gradually accelerating C path seems likely. In any case, this form of participation in the labor force prior to adulthood and marriage went out of fashion rapidly. Only in Colombia, however, did fertility decrease much the same way (via C). Elsewhere, more sudden D' drops were the rule (Tab. 7.1).

In probability of **divorce or separation** within five years of marriage (Hirschman and Teerawichitchainan, 232-33), the D trend for *rural* Malay women wed from the 1940s through the 1960s much resembled the national pattern of decline. For *metropolitan* Malay females the trend took C shape instead. Did a marked conservative religious shift rooted in the countryside, including norms about marriage, only first gradually take hold in the cities?

In Indonesia, another predominantly Muslim country, though, risks of early divorce or separation fell in C fashion as the education of females before marriage oppositely increased via E (much more strongly, with zero year around 1933 rather than 1990). Premarital work in agriculture became less frequent in D fashion--the shape of decline found (more prominently) for *all* agricultural labor in Peru but different from the C trends for Malaysia and Thailand. Up through the 1980s, the C-type decreases in fertility and early mortality for Indonesia likewise resembled those in Peru. They, however, produced population growth via decelerating H rather than increase according to constant F. This happened in large part because, in Indonesia, the downward trend in fertility *preceded* its counterpart in early mortality by a decade rather than lagging it by about a quarter of a century.

The population of Thailand grew in H fashion very close to that of Indonesia. Here, from the mid-1960s into the mid-1980s fertility and infant mortality declined along closely comparable C paths. The decrease in agricultural work by girls before marrying took C form as well, but very shallowly (t_0 only in the vicinity of 2014) and not close to the track for fertility, as in Malaysia. Possible G-shape expansion in the education of Thai women before marriage seems unconnected to fertility or early mortality--or divorce. But it may resemble improvements in Mexican literacy during the second half of the 20th century (Fig. 7.5a). Thai and Mexican fertility trends, and that for China, also took similar D' trends after about 1980, lagging the pattern for Malaysia slightly.

Among societies that developed sooner (Tab. 7.9), across the years before World War II closely timed C declines of early mortality and fertility in the United States, Sweden, and--with more of a significant lead for fertility--England and Wales resemble trend pairings in Peru, Indonesia, and Thailand after about 1960. These patterns represent early and later manifestations of classical 'demographic transition.' In Malaysia, while the C trend in fertility resembled those in the three other later-developing countries, the C path for infant mortality was more like that in the United States, England and Wales, and Sweden. Ironically, Malaysia --with the greatest lag of fertility decline following decrease in early mortality, supposedly the hallmark of 'population explosion' during 'demographic transition,' contains the one population to increase only in rapidly decelerating G form, not some more robust and durable manner (mainly H).

Urbanization in all three of the early-developed countries expanded in H fashion close to the nation's H path for population growth, a parallel not found among the 9 later-developing countries examined in Table 7.9. Did that connection help them be early-developing? In England and Wales across the later 1800s and up to about 1910, G-type advances in primary education expanded inverse to the shrinking engagement via D (Ch. 10) of male workers in agriculture and extraction. Likely though this connection may seem, while both trends appear separately in other populations, for some reason they do not move oppositely this way.[50] Educational trends in the three early-developed countries do not parallel or counterpose change in either fertility or infant mortality. In Sweden, into the first half of the 20th century there was some tendency for fertility to decline in a C path while divorce increased oppositely according to E. In the United States, as far as 1950 divorce became more frequent in an H trajectory that was steeper than the one for urbanization.

In a recent insight into institutional change in the form of family structure (Ruggles 2009, 254-56), the proportion of adults 65 and older in the United States who lived with any kin decreased between 1880 and 1980 in accelerating C fashion from about 72 to 22 percent through a zero year in the vicinity of 1975. Up to mid-century, meanwhile, the share living specifically with descendants declined also via a C trend based about 9 years sooner, and the fraction living in 3-generation households contracted in C form still another decade earlier. Then, between about mid-century and 2007, the percentage living with any kin and the proportion residing with descendants bottomed out in D' shape--in both instances minimizing in the vicinity of 1990.

Similarly, since 1880 fewer and fewer currently married *men* over 60 in the United States lived with their children (Gratton and Gutmann 2010, 337). From 1880 through 1960 this decline took C shape with zero year about 1955, which means that it, too, paralleled the long-running C-type decreases observed in agricultural employment, fertility, and early mortality (Tab. 7.9). From 1950 through 1990, then, the proportion dropped further via D', bottoming about 1980. This was somewhat in advance of the D' sag in fertility that followed the postwar 'baby boom' (toward a minimum in the vicinity of 2000), while farm work contracted similarly but more gradually, via D, and infant mortality followed an independent C path. 'Empty nest' living for these men, meanwhile, increased oppositely via E between 1880 and the Depression (t_0 in the vicinity of 1934). From 1940 through 1980 new increase surged in G' form to crest about 1972--a level held to 2000. Alternatively, between 1900 and 1940 this change could be said to take G shape based about 1884. That path is parallel to the G-type advance of education during these years (Tab.7.9). The values of 'modernization' that have fostered more and longer-lasting education, and also the more common and more equal employment of women, have meanwhile also altered the perception and treatment--and the expectations--of the elderly. To what extent does this relationship appear in other societies? How universal an aspect of 'development' is it?

Internationally, since 1880 there is--among 138 countries--an accelerating curvilinear relationship between the year that fertility began to fall as an aspect of modern ‘demographic transition’ and the average length of education as of 2002-04 (Newson and Richerson 2009, 147). In spite of substantial spread around the average, from 1880 through 2010 (including some projections for recent actual decrease in fertility) the underlying relationship takes C shape with t_0 for 6 years of schooling at about 2004. In other words, an additional year of demographic change near the *beginning* of fertility transition is typically associated with more increase in schooling than the same amount of extra time later on in that demographic process. And this relationship takes C shape.

For most countries, meanwhile--without the education-emphasizing Confucian cultures of China, Japan, South Korea, and Singapore, whose results lie significantly above the trend--average national IQ as of 2002 also decreases with the starting time of the fertility transition in ever faster C shape--targeting something like 40 in about 2021 (ibid.). In short, improvement in IQ, as one might expect, is proportionally greatest early in ‘fertility transition,’ when the duration of education advances the fastest. And extension in the early years of schooling makes the most difference. The *start* of ‘fertility transition’ apparently benefits most from improvements in education, while returns diminish thereafter. (C is the reverse of G with respect to time.) Cultural change valuing education is both most extensive and--in one sense (IQ) most effective--as populations accept and initiate systematic fertility decline.

Both education and fertility are thought to affect and/or reflect economic development. Table 7.10 compares estimated trends in literacy, fertility, and GDP per capita for the mostly later-developing countries of Latin America across the 20th century (Astorga et al. 2005, 790, 788).

With very few exceptions (E’s in Guatemala and Venezuela prior to 1950) literacy spread across these 20 populations in G fashion--initially during the first decades of the 1900s (I) then a second time since about mid-century (II). GDP per capita simultaneously increased in G form (except for E-shape gains in Peru I and Nicaragua II, and G' movements in). In Mexico and El Salvador and Brazil, Uruguay, and Chile during the first half of the century (I), and El Salvador and Honduras during the second (II), the G gains in GDP per capita advanced quite parallel with such trends in literacy. Elsewhere, they had later zero years, which made them steeper than for literacy at any given time.

Change in fertility mostly behaved quite differently. In perhaps 5 countries (including perhaps Colombia) during the middle of the 1900s it increased in G fashion along with literacy and GDP per capita. For Chile and Ecuador before mid-century, and Costa Rica after, the path for fertility is simply not determined here, and may or may not have followed the other G trends of the time. These several cases, along with Peru to the 1960s, support the hypothesis that has been advanced to explain G-type fertility gains prior to 'transition'--from France during the first half of the 1700s to many countries of recent Africa, where G-shape increase in fertility lasted to about 1990 (Tab. 7.4). Namely, improvements in economic and social conditions that took G form encouraged more fertility in that pattern. In the majority of Latin American countries, however--in Argentina and Brazil as early as about 1900, elsewhere more like 1960--'transition'-type, C-shape reduction in fertility commenced while literacy and GDP per capita meanwhile continued to improve via G. The forces that pushed fertility downward along a C path did not respond directly to education or to prosperity the way they so consistently followed C-type decrease in early mortality. The proximate dynamic that drove contraction in fertility was mortality-motivated choice within households, not national change in education or wealth (though the national shifts of employment out of agriculture could be a factor--as for the United States, Malaysia, and Thailand in Tab. 7.9).[51] There is evidence that these same dynamics comparably applied to the C-shape fertility declines that occurred before the conventional era of 'transition' (as in 17th-century England and New Castile or China before 1750) though others have argued that nuptiality caused the decline instead (Tab. 1.4)? What, furthermore, was a consequence of the types of work in which women and households were engaged?

Some of these possible relationships between institutional and demographic changes will prove to be coincidental. Others may need to be respecified as more and better data are brought to the analysis. (Many movements are only roughly estimated here ; and many available series are short.) Nevertheless, recognition of the various G-connected paths apparently involved seems to sharpen the picture of what changes took place and how, and to open up some topics and questions worth further exploration beyond explanations currently advanced for these phenomena.

THE DISTRIBUTION OF REPRODUCTION WITHIN THE FEMALE LIFE CYCLE

Historically, **when females marry** has done much to shape the childbearing of a population. The just-discussed effects of institutional change on fertility, for instance, have largely been exercised through the ways that education, the labor market, and the rights of women (to select their own husbands, to support themselves with or without wedding, to obtain a divorce) have affected marriage. This has been no less true in Asia, Latin America, and Africa than in the earlier-developed societies previously examined. Tables 7.11 and 7.12 show how, in several countries on these continents, changing age at marriage has been related to fertility via G-based trends.

First of all, the proportion of females marrying at ages 15 through 19 has fallen off sharply (Tab. 7.11). For Malays, Chinese, and Indians living in peninsular Malaysia, decline in D’ fashion is evident (Leete 1996, 101, 67, 87). Though teenage weddings contracted via C instead for Malay females as far as about 1980, and their D’ trend approaches a later bottom (only in the vicinity of 2020), these drops broadly resemble the fall in fertility for the nation as a whole, which from 1973 through 2005 displays the D’ form with zero year near 1998 (Tab. 7.2). The same type of D’ pairing of teenage marriage and fertility appears separately for both Malay and Chinese females in Singapore, where each movement targeted a later minimum--more like 2013 (Leete 1996, 161, 149).

In the Chinese populations of Hong Kong and Taiwan and among Malays in Brunei and Indonesia (ibid.), in contrast, the proportion of females married 15 through 19 decreased in C fashion. In each case, fertility also contracted this way. The pairs of trends for the Chinese each declined via earlier C paths than the Malay changes. In Bangladesh, meanwhile, the percentage of women wed between their 15th and 20th birthdays likewise shrank in C fashion along with similar decrease in fertility, approaching a bottom more like 2000 (McEachran and Diamond 2001, 162; Tab. 7.2).

Appreciably earlier, from the later 1800s through the first quarter of the 1900s, in the two Mexican states of Oaxaca and Guadalajara the percentage of women wed under 18 comparably decreased in C shape toward t_0's about 1933 and 1953 (Fig. 7.5b). Fertility in Mexico is not directly known for most of this time, but is presumed to have declined--on the basis of later marriage for women and more failure to ever marry (McCaa 2000, 292). Fragmentary evidence on the national crude birth rate from 1900 through 1910 (the year of the Revolution) suggests something like a C trend with zero year in the vicinity of 1945, over a generation later than the two regional CBR's shown in Figure 7.5b. If fertility altered comparably, that would make it contract along a C path that resembles such trends for marriage under 18 in two states, a matching of C trends that resembles those identified for several recent Asian populations.[52]

The average age of marriage, though affected by the frequency for teenagers, reflects more than just what happened to that age group. Table 7.12 shows how, for Malays and Indians in Malaysia, for Malays dwelling in Singapore, Brunei, Sarawak, and Indonesia, for the indigenous peoples of Sabah, and for the women of Pakistan up to the 1970s, the average age at first marriage for females increased along a G trend based somewhere between 1917 and 1934. In contrast, for rural China, urban China, China as a whole, the Chinese populations of Malaysia, Singapore, Sabah, Hong Kong, and Taiwan, and also all women in Japan, South Korea, Indonesia, India, and Pakistan after 1972 the rise in age took E shape instead, targeting somewhere between 2010 and 2042 (Leete 1996, 161, 149, 87, 143; Frejka et al. 2010, 587;

Hakim and Miller 2001, 143; Alam and Leete 1993, 155; Coale and Freedman 1993, 228; Peng 1991, 120; Fig. 7.6).[53] In the Democratic Republic of the Congo, meanwhile, the average age of women bearing children, not unrelated to age of marriage, likewise increased in E fashion between 1956 and 2007--toward a zero year in the vicinity of 2052 (Romaniuk 2011, 5).

In the lower Yangzi macroregion of China, though, the proportion of women who had their first births by age 24 contracted between 1970 and 1980 in D fashion (Skinner et al. 2000, 635), evidence that presents the same picture as G increases for females who were *not* married at young ages in Indonesia, Thailand, Malaysia, and Bangladesh (Hirschman and Teerawichitchainan 2003, 226-27; McEachran and Diamond 2001, 162). Across the 1980s, however, first births before age 24 for the women of various areas within the lower Yangzi macroregion bounced back significantly in what may have been G' fashion thanks to the ability to control further births by means of the G' surge in adopting contraception that is shown for China in the right-hand panel of Figure 7.6. In all 8 zones established by Skinner and his associates, by the time of women bearing their last child in the 1980s the typical C-shape decline in children ever born, which has been associated with fertility transition in so many parts of the world, was mostly spent and further reductions slight. Meanwhile, women in all zones aged between 25 and 64 (or most of that span) as of 1990 display a G-shaped echo of increasing total offspring with age that mirrors inversely the D shape of TFR between 1972 and 2002 shown for China in Figure 7.6 and Table 7.2 (Skinner et al. 2000, 238, 237).

Though the *amount* of increase in age of marriage over about three decades up to 1990 is approximately the same as in Chinese populations of Asia and several other peoples, through 1990 for Malays wherever they lived, and for Pakistani women before 1972, the change took decelerating G shape rather than accelerating E form. To what events or processes might this difference in curvature be due? Trends in *fertility* from country to country, to the contrary, do not seem to distinguish Malay or Pakistani populations. All tended to shift from C to D' modes of decline (Tab. 7.2) as the age of first marriage for females rose. Though in Malaysia and

Singapore teenage marriage did contract sharply in D' manner, it did so for Chinese and Indian females as well as Malays, while Malays in Brunei and Indonesia display the C pattern of their neighbors. Curtailment of teenage marriage, in other words, appears to be a *national* phenomenon--related to policy (such as changes in schooling?)--whereas average age of first marriage for females looks more *ethnic* (guided by what values or customs?). What did Malays, and Pakistanis before 1972, have in common that others did not share? Did whatever it was also affect other aspects of demographic development?

Changes in age of marriage along G-related paths are familiar features of evolving demographic regimes since at least the 17th century. Indeed, for long they have been considered the chief pre-transition determinant of rates of reproduction. Overall fertility expanded in England across the late 1600s and early 1700s in large part because, along a C path, fewer and fewer females married young (under the age of 20) between 1600 and 1725 (midpoints 1612 and 1712 in Fig. 1.5). Over the next hundred years this tendency was more than reversed in G fashion. And an E-type increase in young marriage into the early 19th century helped shape how fertility gained this same way, driving the population of England up in comparable accelerating fashion (Fig. 1.4; Tab. 1.1). At least as early, declines in proportions marrying young have played a similar role in generating C-type decrease in fertility for many continental European populations (e.g, Perrenoud for Geneva: 1990, 247, as graphed in Harris 2003, 204), though by the time of wide dissemination of family limitation in the 19th century the patterns and their connections to fertility become more complicated (Figs. C.3a and C.3b).

While the significance for fertility of mean age of first marriage for women has been stressed since the 1950s--for instance, the Flemish studies cited by Deprez (1965, 615)--changes typically maximize at 3 years or so over several decades, sometimes considerably less than that. This makes *proportional* trends very flat and a weak tool for comparison and contrast.[54] The English and the American colonial evidence (Figs. 1.5; 6.9a and 6.9b) has been used to demonstrate how the known or estimated duration of childbearing (last birth minus age at marriage or first birth) better reveals the G-based curving nature of the age changes taking place.[55]

The slight E-shape increase of mean age for first female marriages in England from the 1620s to the 1670s was, for example, just 1.0 year or 4 percent, though it accompanied C-shape fertility decline of proportionally about 5 times that much (20+ percent) into the 1660s (Wrigley et al. 1997, 134; Fig. 1.4). In England between a crest at about 1715 and the end of the 18th century the accelerating C-type *decrease* in average age of first marriage for females then amounted to 3.2 years or about 12 percent in all while nuptiality and overall fertility rose oppositely in E fashion more than twice as much. Yet another C-shape decline lowered the average age 0.9 year more over the half century between the 1780s and the 1830s. Now, however, fertility (and nuptiality) dipped in D' manner, the form of change observed for proportion marrying 15-19 for several recent populations in Table 7.11--though average age at first marriage in those populations mostly rose via E (Tab. 7.12), the opposite of the C decline found in early-19th-century England.

In 17th- and 18th-century Flanders, meanwhile, average ages for first female marriages in 3 of Deprez's 4 communities rose in E form, targeting the late 1700s (1965, 615; the 4th remained virtually flat). They advanced at a net rate of from 0.33 to 0.52 years per decade compared with 0.17 and 0.19 for the English gain from the 1610s to the 1670s and the contraction there from the 1710s to the 1780s. While Flemish fertility at the time is unclear, the ratio of births to marriages in one of the local populations studied (Le Vieuxbourg of Ghent) declined along a C path with zero year in the early 1800s (Harris 2003, 206-07), implying that fertility in this area rose very reciprocally as the female age of marriage fell. This is what also happened in England across the later 1700s, but with one-fifth the change in average age than occurred in fertility, while in this part of Flanders age of marriage probably altered proportionately somewhat more than fertility.[56]

Compared with these early modern European changes in age of marriage, the recent shifts in other parts of the world cited in Table 7.12 are notable for *how much* increase occurred *how fast*. In just 3 to 4 decades, the average rose 3.2 years for Chinese females in Singapore, 3.7 in Hong Kong, 4.2 in Malaysia, 4.6 in Taiwan, 4.0 in rural China, and 5.8 years in urban China. Whereas for India the increase was 3.6 years in the mean and for the United States 4.4 in the median, for the women of Pakistan average gain amounted to 5.1 years, while rises of 6.8 and 7.3 years appeared among Malays in Malaysia and Singapore and 7.6 years for Indians in Malaysia. These changes amounted to from 1 to 2 years per decade, not the 0.20 to 0.25 average for England or about twice that much in Flanders (excepting 1.08 for the decline of 1730 to 1770 in Le Vieuxbourg).

Among recent populations, within approximately the same span of time the G-shape trends--fast at first, then decelerating--were generally greater than the E-type increases. What does that reveal about what caused the two types of gain?

In most of the Asian populations covered in both Table 7.12 and 7.2 there occurred during the second half of the 20th century an E-type increase in average age of marriage and a decline of opposite C shape in fertility (Tab. 7.13).

In several of these populations, it should be remembered, either trend may have begun sooner or lasted longer than the dates with evidence. Nevertheless it is clear that, as ‘demographic transition’ took place, in at least several leading developing countries of Asia the average age of women when they first married usually accelerated upward in an E path as fertility began to fall reciprocally faster and faster with time via C. Exceptions occurred in Malaysia and Singapore, where Malay people predominated. There, while fertility consistently decreased via C, the increase in mean age at marriage, while substantial, took decelerating G form rather than an accelerating E pattern. In China, meanwhile, between about 1945 and 1970 E-shape increase in the average age of female marriage was insufficient to prevent fertility from continuing to climb via G until rigorous policies of family limitation were enacted.

In all the cases where both E in age of marriage and C in fertility appear, furthermore, the proportional decline in fertility is greater (has an earlier t_0) than the percentage change in age of marriage. Mostly this is a consequence of the narrow range for changes in the age of marriage that has been noted. Still, not all pairings are equal. In India the discrepancy is only about 5 years, making the proportional change almost equivalent. In Taiwan, South Korea, and Hong Kong, in contrast, the lag for mean age of marriage comes to as much as 60 to 80 years. (Most of these timings are estimated rather than fitted.) The share of fertility decline attributable to increasing average age when women marry, in other words, varies significantly while the shapes of paths followed by the two variables remain constant. When one year of delay in wedlock *could* mean up to one less child, some multiplier is necessary when relating proportional change in an average age of marriage that tends to lie in the early 20s to percentage trends in the much smaller total number of births a women will typically produce. These observed differences in the relative timing of E trends in age at marriage and C trends in fertility nonetheless identify significant distinctions, both among countries and between national populations at different times in their history, as to how much age at marriage has contributed to change in fertility.

The weak (and late) role of rising marriage age for females in the decline of English fertility during the first three-quarters of the 17th century with its 70-year lag, for example, resembles the relationship of these trends for South Korea in the later 1900s. After that, on average *earlier* marriage played a stronger part in the *rise* of English fertility between 1718 and 1808 (with almost equal zero years in the 1850s). In the United States, meanwhile, during the fertility reduction of the 1700s and early 1800s the two trends were significantly more parallel than in England leading up to about 1670--closer to the recent case of India. Through the middle of the 19th century, however, fertility *declined* in spite of the fact that American women on average married younger, along a somewhat weaker C path.

In England up into the 1660s, while age of marriage rose in an E trend timed 70-odd years later than the way fertility contracted via C (Tab. 7.12), *nuptiality* as a whole decreased right along with the C path of fertility (Fig. 1.4). Much of the difference is due to the way that **celibacy**--never marrying--expanded among women from about 6 percent during the last years of the 1500s to over 24 percent as of 1670 or so (Fig. 1.5). Later, as nuptiality (I_m) and overall fertility (I_f) in England from 1758 through 1818 *rose* in parallel E fashion, the average age of first marriage for females contributed by falling oppositely via C. Now, however, the lag between fertility and nuptiality on the one hand, and age of marriage on the other, disappeared (t_0's for all three arrived in the vicinity of 1857). In between, from the 1680s through the 1730s D-shape decrease in celibacy helped nuptiality as a whole expand via G as from the 1660s to the 1720s average age at first marriage for females hovered around a level of just under 26 years (Wrigley et al. 1997, 134).

A further C-type decline in celibacy from 1704 through 1759 lowered the proportion from about 12 to more like 4 percent. In spite of a significant drop in female age at first marriage from 26.3 to 24.0 between the 1710s and the 1780s, nonetheless, nuptiality now held mostly level. How could nuptiality just remain stable when more women married, and also more of them married young? nuptiality should rise significantly. This apparent anomaly requires more investigation. Change in mortality for the reproductive age groups, for one thing, does not seem to provide a simple answer (Fig. 1.9, Tab. 1.5).

Finally, E-type increase in celibacy (from about 4 back to approximately 12 percent) from the 1760s into the 1800s worked against the trend of that shape in nuptiality from 1758 through 1818. Female age at first marriage, meanwhile, further declined from 25.0 to 23.8 years between the 1750s and the 1820s. Did this alone suffice to override the effects of greater celibacy upon nuptiality, and allow it to increase as has been argued?

Modern data from currently developing societies display comparable G-based trends in celibacy. In 20th-century China, for example, the proportion of females not married by age 30 fell in D fashion as national fertility increased oppositely along a flatter G trend--with zero years about 1909 and 1857 respectively (Fig. 7.6; Tab. 7.13). Such reciprocity of the two trends resembles the paring of celibacy, on the one hand, and overall fertility, on the other, that occurred in England between the 1680s and the 1730s. In both cases late first marriage and celibacy contracted together to increase reproduction. In modern China this happened, however, as the average age at first marriage for females rose via E, an internationally familiar trend. Unlike other observed cases, however, this was a movement not reflected in fertility though it did take a G-based shape.

Having **sex outside marriage** is not as clearly or as significantly relevant for fertility as celibacy. In present-day China, however, the proportion of married women who reported currently indulging in such behavior as of 2000 decreased in C fashion from 8 percent among those 20 in the 1990s to 1 percent among those who had been that age in the early 1950s--or from wives 20 at the time of the survey to those now in their early 50s (Parish et al. 2007, 743). Some of this trend doubtless reflects simply the greater attractiveness of younger females in the eyes of most men. Still, some change in sexual norms and conditions over time also seems likely. For rural wives, the practice as of 2000 even more steeply became less common with age via G. For urban wives, however, its frequency became *most* common among women in their 30s before decreasing among older females (via C' rather than C). While that pattern might suggest the adoption of a practice in G' fashion among relatively young urban wives between the 1950s and the 1980s that crested around 8 percent,[57] also likely is a tendency for women at the height of their desires and already married for some time to be tempted to indulge in extra-marital sex--a age-related phenomenon also evident for urban and rural husbands but, for some reason, not for rural wives.

The duration of marriage at the time of reporting for both men and women, meanwhile, rose via G from those age 20 to those age 53 on average--from 4 to 35 years with t_0 at 46. If this survey sample is representative of all Chinese unions, as of 2000 the increasingly less than log-linear relationship of marriage duration to age implies either earlier and earlier weddings since the 1950s (which is contra-indicated by the E trend in Fig. 7.6 for age at marriage among females) or a schedule of mortality by age that has been cutting off marriages in G-related fashion (the topic of the next chapter).

Among husbands, meanwhile, after rising by a third from the rate for those 20 during the 1990s, the proportion currently having extramarital sex fell more abruptly: from 21 percent of men at 30 to only 5 percent among those in now their early 50s. This trend, with D' shape, was determined primarily by rural men, among whom the increase from age 20 to age 30 (from 12 to 18 percent) was followed by a drop to 1 percent for the oldest husbands. As evidence that sexual norms and circumstances were indeed changing, and that current age alone did not account for the observed pattern of extramarital activity, the *youngest* men most often reported *ever* having paid for sex, though a G-based trend for this practice was evident only for urban husbands. Among them, the frequency rose via G from those who had been 20 in the 1970s to those of that age only in the 1990s. For rural husbands, meanwhile, paying for sex surged in some extreme accelerating form from 0 to 14 percent from among those 20 in the early 1950s to those still in their 20s at the time of the survey. In all, however, paying for sex like having sex outside marriage tended to evolve in China between the 1950s and 2000 mostly along G-related lines--like other demographic practices that have been observed.

Systematic patterning in **age-specific fertility** has been found to be a major feature of historical demographic change in early-developing societies (Chs. 1, 5, 6). These adjustments have also taken G-related forms in populations which have much more recently experienced modernization.

The righthand panel of Figure 7.4 illustrates how in Peru age-specific fertility mostly increased via G until the 1960s, then declined in C fashion. As fertility rose from 1940 or earlier into the 1960s, between 20 and 49 the older the cohort of women, the more steeply reproduction expanded proportionally. This suggests that the conditions that generated the pre-transition increase of fertility in G form that has been observed in many developing countries (Tabs. 7.4, 7.1, 7.3) affected older women most. Was a continuing supply of children more useful to the household, and multiple heirs less of a strain, as has been argued for certain types of protoindustrialization (Braun 1978)? Peruvians, for example, shifted out of agriculture in D form during this period (Tab. 7.9). Older women were apparently *not* having more births to make up for increasing losses among prior children: infant mortality, to the contrary, declined. Mothers, on the other hand, may have been healthier, prolonging their reproductive lives, while fewer husbands died, ending the union.

Then, as fertility decreased from the 1960s forward, the C trends fell most of all for the oldest fertile females and less for each successively younger age group (except again for teenagers). In all, older women were most responsive, first to the forces that elevated fertility across the middle of the 20th century and then to the stimuli that reduced reproduction as of the 1960s. This is largely how age-specific fertility had, long before, behaved in Flanders and Brabant, rising via G between 1630 and about 1700, then falling in C fashion into the later 18th century (Tab. 6.6, part A), though in each direction sequencing by age is somewhat less distinct than for the modern Peruvian example. As Mormons settled in the American West, furthermore, up to the 1870s their fertility likewise first increased in G fashion, proportionally most among older women, then contracted via C to the 1920s, again most strongly among more mature females (ibid., part B). In England, sequenced reductions by age in fertility of C shape between about 1600 and 1675 historically *preceded* mostly G-type increases from there to about 1750 in which the oldest women raised fertility most (part A). Arrays by age of C-shape fertility decline from oldest to youngest females, though unaccompanied by a known prior or subsequent increase via G, are evident in several European populations between the 1630s and the 1930s and among American women between the early 1700s and World War II (Ch.'s 5 and 6).

Peru was not alone among more recently developing countries to experience such trends. In Colombia, particularly rural Colombia, beginning in the 1960s or sooner the age-specific array of C-shape reductions in fertility closely resembles the patterns by age for Peru (Prada-Salas 1996, 312). Though the series is again brief, it appears that in Mexico as well (Mier y Terán 1996, 326) from 1970 through 1986 or later age-specific fertility decreased in C trends, consistently more substantially for older women than for younger ones.

Table 7.14 presents age-specific fertility patterns in the later 20th century for half a dozen populations of Asia. In Sri Lanka, the Philippines, Singapore, and Pakistan C trends of reduced fertility predominate. With some exceptions for women in their 40s in Pakistan and Bangladesh, however, there is little systematic differentiation in the timing of these movements for older and for younger women. Is greater simultaneity of change from age to age a consequence of the methods through which fertility is reduced in modern societies as opposed to earlier populations? Is it a product of how the consequences of having fewer children, or techniques for family limitation, are communicated across a population? Or, instead, do the forces reducing fertility in certain contexts simply bear equally on women of all ages, such as perhaps a change in religious expectations?

China, on the other hand, stands out for having age-specific fertility reductions that took D rather than C shape. These, though, were steeper (had later zero years) for females 30 and over than for younger women. China, of course, is distinguished for having a significantly enforced *policy* of one child per couple. Enacted in the 1970s, this by definition worked to eliminate further births after the first, which event is likely to have occurred by the time a woman reached 30. Thus births after the 20s can be expected to have been more affected by policy than those before 30.

In all, observed patterns of age-specific fertility--in populations from the early 1600s to the present, in both developed and developing countries--indicate how the reproduction of females of various ages tended to respond in G-related forms to forces that encouraged having more children or limiting their number. Sometimes systematic relationships appear from age to age. Elsewhere, patterns are shared simultaneously, without a significant order in timing or varying strength of change according to age. In still other cases--most often seen among the earlier-developing countries of Table 6.6--quite distinct G-based trends occurred at particular ages. All of these instances nonetheless enlighten how the conditions of reproduction changed and knowledge and values about fertility permeated the populations observed.

Among Asian women of typical age to marry for the first time (about 22) during the last third of the 20th century, meanwhile, there was a marked tendency to be more frequently **childless** (Frejka et al. 2010, 585). In yet another manifestation of G-based trending in demographic change, this increase in Japan, Taiwan, Hong Kong, and (as of 1982) South Korea took G' shape, heading toward a crest in the vicinity of 2020. The exception among half a dozen countries occurred in Singapore.[58] What change in the lifestyle or condition of women was shared internationally in this region in such a way as to have a G' impact upon childlessness? Did biological forces generate this much shift, or were women more often childless by choice? The diffusion--via availability and acceptance--of modern contraception, which often took G' shape (Tab. 7.15), is one likely factor in such temporarily elevated celibacy. Changing views about the role of women in society are another. Such shifts in values, such as the secularization of the French Revolution, can come and go somewhat in G' fashion (Ch.5).

METHODS FOR MANAGING FERTILITY

In recent decades, an increasing variety of methods for managing fertility has been utilized in more and more populations worldwide. Choice of family size and means to control it have been diffusing rapidly.

In the vicinity of 1990, for example, married women in Colombia, the Dominican Republic, Kenya, Bangladesh, and Egypt reported having over a third more children than they desired. The proportion in Senegal had reached only more like 20 percent, but perhaps was still rising (Bongaarts 2003, 327). These national proportions peaked then receded abruptly over time[59] as couples quickly began to act upon their desires and control fertility.

The number of children "wanted," however, took C shape from the 1970s through the 1990s in Kenya, Bangladesh, Colombia, Senegal, and Egypt (ibid.; roughly estimated). In the Dominican Republic, the overall path may have been D' instead; but it possibly likewise took C form as far as 1987. In 4 East African countries and Nigeria--as in Bangladesh and perhaps the Dominican Republic--the C trends for desired number of children had zero years between about 1965 and 1985. In 4 West African populations (without Nigeria) and Zimbabwe the C trajectory ran later, targeting 2000 or afterwards--as in Egypt, Colombia, and also Thailand (Cleland 2001, 85; Bongaarts 2001, 265).

Coale's index of **marital fertility control** shows that couples were indeed soon doing something about the discrepancy between wanted and actual numbers of children. In Hong Kong, between 1970 and 1990 '*m*' rose in G' shape toward a crest of approximately 2.1 at about 1996. In Singapore, the index for Chinese couples surged from 1957 through 1980 as if headed for a G' peak near 3.4 about 2010. Then, however, by 1990 it dropped back to 1.7 after a recorded maximum of 2.1 at 1980. In Taiwan, '*m*' leaped from 0.1 at 1957 to 2.7 by 1980, then to 1990 leveled off as if maximizing via G' at about 3.0 in the vicinity of 1992. Among the Chinese of Malaysia, meanwhile, from 1957 to 1980 the trend for the index took the unusual E' path. Then from 1980 through 1990 it seems to have capped out via G' at the comparatively low level of about 1.5 in the vicinity of 1992 (Leete 1996, 155).

Among *Malays* in Peninsular Malaysia, in contrast, marital fertility control was much less frequent--and maximized much sooner. After jumping from 0.17 to 0.49 by 1970, through

1990 the trend took a G’ path that would peak at only about 0.50 near 1966. An insightful exception occurred in the state of Selangor (which contained the more sophisticated capitol region), where from 1957 right through 1990 *m* rose via G’ toward a crest of about 1.1 in the vicinity of 2011. For Malays resident in Singapore, the index--after shifting sharply upward during the 1970s--from 1980 to 1990 followed what could have been a G’ path cresting near 1966 as in Peninsular Malaysia. In maximizing about 1.5, however, the level was 3 times that for Malays on the mainland (Leete 1996, 118).

These patterns--via G’ or in still more abrupt shifts--differ markedly from most trends of *m* previously encountered in Europe and North America (Figs. 5.4, 5.9, 5.10, C.9, 6.7, 6.12; Tabs. 5.4, 5.8). Those have almost universally taken more gradual and persistently upward G shape, from 16th-century European elites to Mormons and U.S. whites in general during the early 20th century. The one exception positively identified[60] has been for revolutionary France, between 1785 and 1805, where an unusual E trend appeared (Fig. 5.1b; possibly E’ for 1765 to 1805--the path found for Chinese in Peninsular Malaysia between 1957 and 1980).

What have been the historical circumstances under which trends more abrupt than gradually decelerating G have occurred in marital fertility control? The simultaneous hardship and philosophical upheaval of later 18th-century France offer one clue. Did the Chinese of postwar Malaysia, who also saw *m* increase in accelerating (E or E’) rather than decelerating fashion, experience anything comparable?

More generally insightful is how several methods for reducing fertility not widely available before World War II, even in developed countries, disseminated internationally quite quickly after the 1950s. More options were known and, most importantly, *accepted* as part of major changes in values--even if sometimes only temporarily. The outstanding feature for Malaysia, for example, is the way that *Malay* advances in fertility control crested after World War II, and then stalled about three-quarters of the way through the 20th century during a period of conservative cultural redefinition in this largely Muslim society. Did postwar shifts in norms bearing on family limitation very generally spread in G' fashion like secularization in 18th- and 19th-century France and Belgium (Figs. C.6, 5.12)? It seems likely, whereas--in contrast--before the later 20th century prevalent G-shape increases in *m* reflect a more gradual spread of long-available practices through populations, as from higher to lower social groups or from one subculture to another, rather than some widespread simultaneous shift in norms (as with the French Revolution or following World War II) or discovery of a new technique.

In the later 20th century, trends both in the use of **contraception in general** and of **particular methods** of fertility control have widely taken G' shape internationally. Such patterning has been encountered in the United States between the 1890s and the Great Depression for the use of condoms, pessaries, and diaphragms, on the one hand, and suppositories and jellies on the other (Fig. 6.11).[61]

The G' path likewise fits the surge of contraception for women 30 through 34 in urban China from 1960 through 1980, then the way this dissemination flattened out between 1975 and 1987--with crest years about 2020 then 2007. Among rural females the G' trend from 1975 through 1987 surged toward a peak at 2011, likewise following even steeper increase since 1965 (Fig. 7.6, Tab. 7.15). Meanwhile, use of the specific control technique abortion increased in G' fashion for rural women from 1965 through 1987, targeting 2027, and for urban females from 1960 through 1987 toward a crest at 2012 (ibid.).

In the later 20th century, abortion rates for Latin America, at 325 per 1,000, were twice a high as those for the Caribbean or for East and Southeast Asia (with Oceania), and almost four times as much as the collective rates for the Middle East and North Africa, or for East Africa (about 90). In West Africa, the proportion was very low, roughly 20, while populations around the Indian Ocean alone rivaled Latin America in employing this technique of fertility control (Frejka and Atkin 1996, 183). Has G' been the recent pattern of adoption in societies with both low and high levels of use?

Table 7.15 compares estimates for all contraception and for particular types of it in other populations with the fitted trends for China. In all, the practice of family limitation since the 1960s in several Asian populations repeatedly has taken the G’ form--like the prewar patterns for the United States. Evidence from Bangladesh, meanwhile, demonstrates how the shift from determining fertility by controlling marriage to family limitation within marriage, whatever the method, has likewise taken G’ shape. There are national variations in timing and in level, but the path of adopting control through contraception is a common one (as G was for family limitation before the 20th century). And it resembles other historical phenomena such as the surges of secularization, extramarital fertility, and treatment of the very young in several parts of modernizing Europe.

In all, various types of data concerning demographic change in later-developing societies of Latin America, Asia, and Africa display the same G-based patterns found in Europe and in European ‘off-shoot’ countries where modernization evolved sooner. Though the record is often frustratingly short, the broader international comparison that is provided both confirms the generality of the recurrent trends and helps to clarify the conditions under which certain types of change in particular demographic variables have occurred. And it makes clear that these are probably universal, or near-universal, patterns of change whose origins must be explored.

NOTES

1. More recent data, through 2010, and projection for 2027, together indicate a C trend for 1988 or sooner through 2027 that targets approximately 2.9 in 2033 (Eastwood and Lipton 2011, 33).

2. Selecting as criterion TFR below 4.5 *or* a decline of 20 percent in TFR, Schmertmann et al. (2010, 363-31) display a diffusion of fertility transition across Brazil between 1960 and 1991--generally from the South to the North. This mapping is compatible with that of Coale and Treadway throughout the many 'provinces' of Europe in the 19th century, notably beginning across France. Those earlier trends, however, took C shape (C. 5), while--in aggregate form at least--for Northeast and Southeast Brazil the modern pattern has been D' instead (Tab 7.1). Did the D' shape characterize *local* Brazilian changes as well, or only their broad regional and national effects? The nature of insight to be had from continuous patterns rather than given thresholds or percentages of decline is once again emphasized.

3. Four other recent estimations indicate D' movement in fertility for China that reaches a minimum in the early 2000s, from 1.35 to 1.6 in level depending on the use of CBR, censuses, surveys, and school enrollments--the lowest being reported TFR, which appears to need adjustment (Goodkind 2011, 295).

4. Fertility trends for Mexican-born and for U.S.-born Mexican females are compared in Ch. 6.

5. Projections (some into the 2020s) are included where marked changes of direction after the date of analysis do not occur (Margolis and Myrskylä 2011, 50; Eastwood and Lipton 2011, 33; Keyfitz and Flieger 1990, 116-65).

6. For Sub-Saharan Africa as a whole, only very slight gain for TFR during the 1950s and 1960s was not trended as G in Figure 7.1.

7. In New Castile (Tab. C.4), the number of children per family shifted from expanding via G to contracting in C fashion about 1700, but reversed then produced a second G-to-C succession around the turn of the century.

8. Useful recent reviews appear in Goldstein et al. 2009 and in Lesthaeghe 2010.

9. A 'cautionary tale' for the United States of America in the early 21st century?

10. Harvard College was almost killed off in infancy by a lack of potential students in the 1660s and 1670s (Harris 1967?, ??).

11. Sharper domestic G' fertility gain from the Depression to 1960 or so would seem to have been shaped by the effect of heavy emigration to Britain and the North American continent in this period. (Keyfitz article?)

12. Presently continuing G movement for the United States (Fig. 6.1) could offer insight as to what may unfold next in at least some other 'developed' societies (especially those with heavy immigration).

13. The cases of Guyana and Bangladesh, on the other hand, perhaps just constitute instances of fertility increase in E fashion that were *not* extensively capitalized upon industrially.

14. Life expectancy at birth rose in E fashion from 1761 through 1831, targeting 1892.

15. In Flanders (Fig. 5.12), rates of early mortality from 1726 through 1786 decline approximately this way via C, though the more exact fit seems to be with two successive G' curves. In New Castile, the crude death rate followed a C trajectory from 1700 through 1770; but childhood mortality ceased declining this way by about 1740 and rose in G fashion thereafter--as Catalonian Igualada and in Bohringen of the Schwartzwald and 4 villages of Oberbayern and Oberhesse (Tabs. C.4, 5.9; Fig. C.10).

16. In Sweden, Finland, and Lombardy two G-shape increases in the population reached successively higher levels with much the same long-term net result as E trends elsewhere (Harris 2001, 148, 190). H-type growth occurred in Norway.

17. Marital fertility increased in Belgium, seemingly via G', to a peak about 1820 (Fig. 4.1a, Tab. 5.2). In the German villages of Knodel collectively, mean fecundability rose in E fashion from 1762 through 1812, while I_g gained slightly during the 1700s (Fig. C.9). In Rust, 4 Waldeck villages, and Öschelbronn, E-shape gain in marital fertility is evident from 1725 into the early 1800s. Decline elsewhere, largely starting only in the late 1700s, depressed the aggregate path for I_g (Tab. C.5). How might the social and economic settings of these different communities have affected which group of European populations their demographic behavior resembled? For example, the large majority of communities (6 of 7) lacking the E path in marital fertility in this period were concentrated in Bavaria (3 of 3) and Baden (3 of 4).

18. From what is known of the historical context, E-shape population growth in Scotland and Ireland, and perhaps northern parts of France, would seem to have involved similar demonomic interactions. In the highland regions of the canton of Zürich, meanwhile, during the later 18th and early 19th centuries population likewise flourished thanks to the expanding production of textiles (Braun 1978).

19. England: GRR t_0 at 1711; I_f, 1712; total age-specific marital fertility, 1728, though I_g flat. New Castile: completed family size, 1688.

20. Though taking different paths, in the Mixteca Alta region of Mexico up through about 1750 the D then G trends for fertility in this era (implied by CBR in Fig. 7.5b) likewise quite directly shaped population size in those same forms rather than serving to curb decelerating G or H demographic growth as in France, Sweden, England and many later European populations (parts B and D, Tab. C.8)--or, by the 1700s, England's American colonies (Tab. 7.5b; Harris 2001, 42).

21. In the best-documented village of Yokouchi, between 1775 and 1780 the ratios of children under 10 to wives age 16 through 50 and of births to wives 21 through 40 fell via C toward t_0's in the 1790s while mortality among children shrank in parallel C fashion from 1685 through 1762 (Hayami and Uchida, 509-10).

22. Though successive trends of G or H shape in Sweden and Finland may have produced net long-term growth comparable to E's elsewhere.

23. And, perhaps, E trends in Belgium--in contrast to these D' changes.

24. Even as their birth rates often first decreased prior to about 1850.

25. More like the early combinations of trends in section A, but without the expansion-generating behavior of falling early mortality and rising fertility.

26. Most flatly in Norway and France, most steeply in Sweden and Bohemia.

27. It would be profitable to compare this international patterning of reversing D' dips in fertility with the relationships of SDT (Second Demographic Transition) values and recent TFR by Lesthaeghe (2010, 232, following Sobotka 2008). The linkages appear similar.

28. Though by the early 2000s the minimum had been passed at least for the time being.

29. From recent English-language journals and a few volumes of collected studies.

30. To compare comparable developments in Europe into the early 20th century, see Tab. C.8 and Ch. 4.

31. For this period, the trajectory of fertility in New Zealand is simply unknown.

32. For Kenya, patterns of both early mortality and fertility are unclear before 1950.

33. China achieved H-type growth via other means.

34. As, following World War II, for infant mortality in the United States and Canada, or fertility in Japan, the Philippines, Sri Lanka, and India (Tab. 7.6)--or, earlier, for young mortality in England and Germany across the later 1700s and fertility in Germany and the Netherlands during the next century (Tab. C.8).

35. Eighteen if movement more like D than D' in fertility for Venezuela and in infant mortality for South Africa and Algeria is included.

36. Argentina based at 1904, China at 1923, the others in the 1940s and 1950s.

37. England was one of a small handful of European peoples to produce at this time the first manifestations on record of the H type of demographic expansion.

38. In England between the 1680s and about 1730, infant mortality had also increased in a G path. Fertility then, however, did follow a comparable G trajectory.

39. Since the first increase may well have begun before the 1920s.

40. Though *G-shape* increase in infant mortality was common during H growth in 19th-century Europe, and Belgium may have had an E type gain in fertility with it between the 1840s and the 1860s (Tab. C.8).

41. As noted in previous chapters for certain periods in the United States, Sweden, and England and Wales (summarized in Tab. 7.9).

42. From recent journals and a few composite studies.

43. Several other societies of Central and South America shared concurrent G-shape increases in literacy and fertility this way during the first half of the 20th century (Tab. 7.10).

44. A C' pattern (G' reversed with respect to time) based about 1730 fits the change in type of protest somewhat longer, from the 1740s through the 1770s.

45. Evidence for the one trend, however, only follows the other after 1970.

46. The proportion of females 10 or more who were literate (Leete 1996, 44).

47. Unless urbanization before 1970 had been taking the E path found thereafter, which would make it run roughly opposite to the current C trend in fertility.

48. In aggregate, however, for the total female population the increase in some education took G rather than E form (Tab. 7.9).

49. The path upward for Korean women 25 to 29 exceptionally took E shape.

50. The timing of the countervailing curves for the United States is vastly different (over 90 years), with very limited further educational improvement occurring relative to current proportional change in agriculture.

51. And possibly Peru, Indonesia, and England and Wales, if what seem to be D-shape movements out of farming estimated from short spans of data, in fact took C form.

52. The decline of the general fertility ratio for Mexico between about 1905 and 1935 (Fig. 7.5a), however, would fit only a considerable flatter C, targeting something like 2010.

53. That is also how the *median* age of first marriage for women rose in the United States from 1955 through 1998, having decreased in C form since 1900 (Dahl 2010, 693). In Frejka et al., average age of *childbearing* is employed, with dates for the birth cohorts of mothers increased by 22 years to approximate mean timing.

54. See the discussion of Fig. 1.5 in Ch. 1.

55. An exceptionally clear recent illustration of this point has been provided by Reher and Sanz-Gimeno (2007, 711) for the Spanish town of Aranjuez between 1873 and 1940.

56. In other parts of Flanders, the birth-to-marriage trends rose via G instead (Harris 2003, 206-07).

57. Like extramarital fertility in many parts of Europe (Ch. 4, Tab. 4.5).

58. With a rough G' targeting more like 1998, or an E from 1980 forward.

59. Shifting more swiftly and raggedly than a G' pattern.

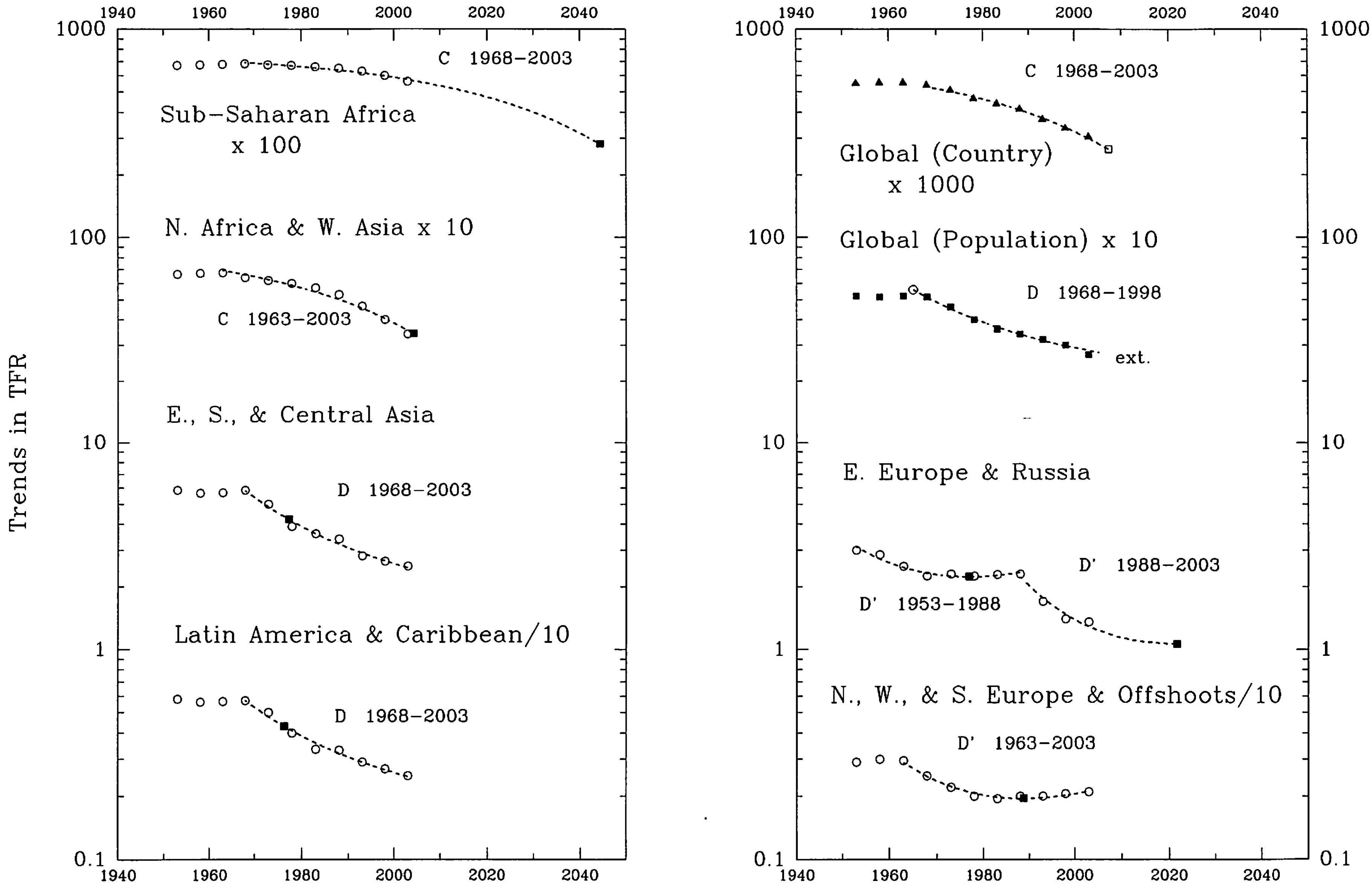
60. Some G patterns, however, have been hypothesized on the basis of just two observations. These--

most frequent in Fig. 5.10--can easily have taken G’ shape instead.

61. For these methods *combined*, the trend from 1894 through 1935 took G shape, though to include some decline to 1944 makes the G’ pattern also more likely for these methods in aggregate.

Figure 7.1

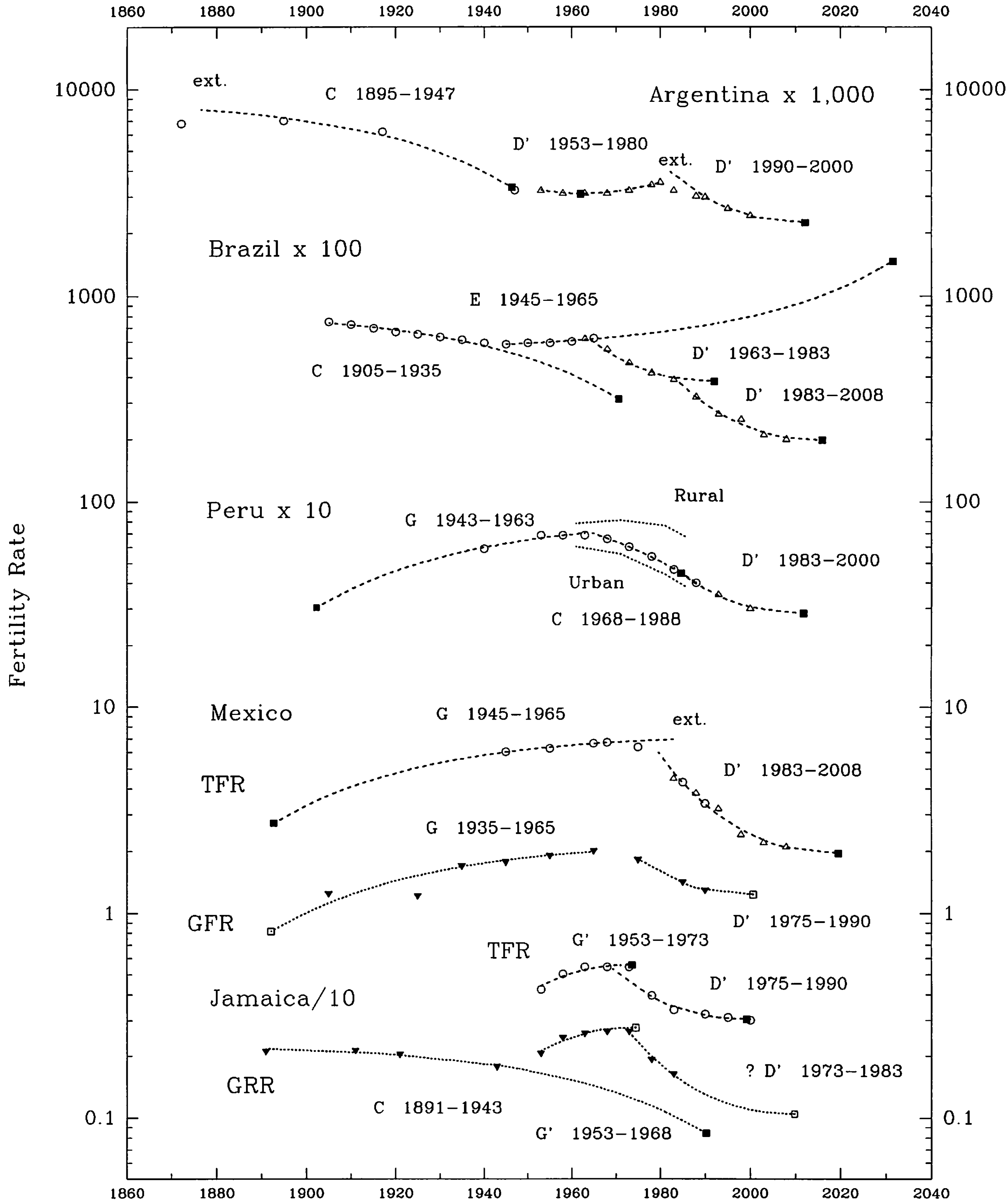
Approximate Regional and Global Trends in Total Fertility Rates



Source: Dorius 2008, 520, 529.

Figure 7.2

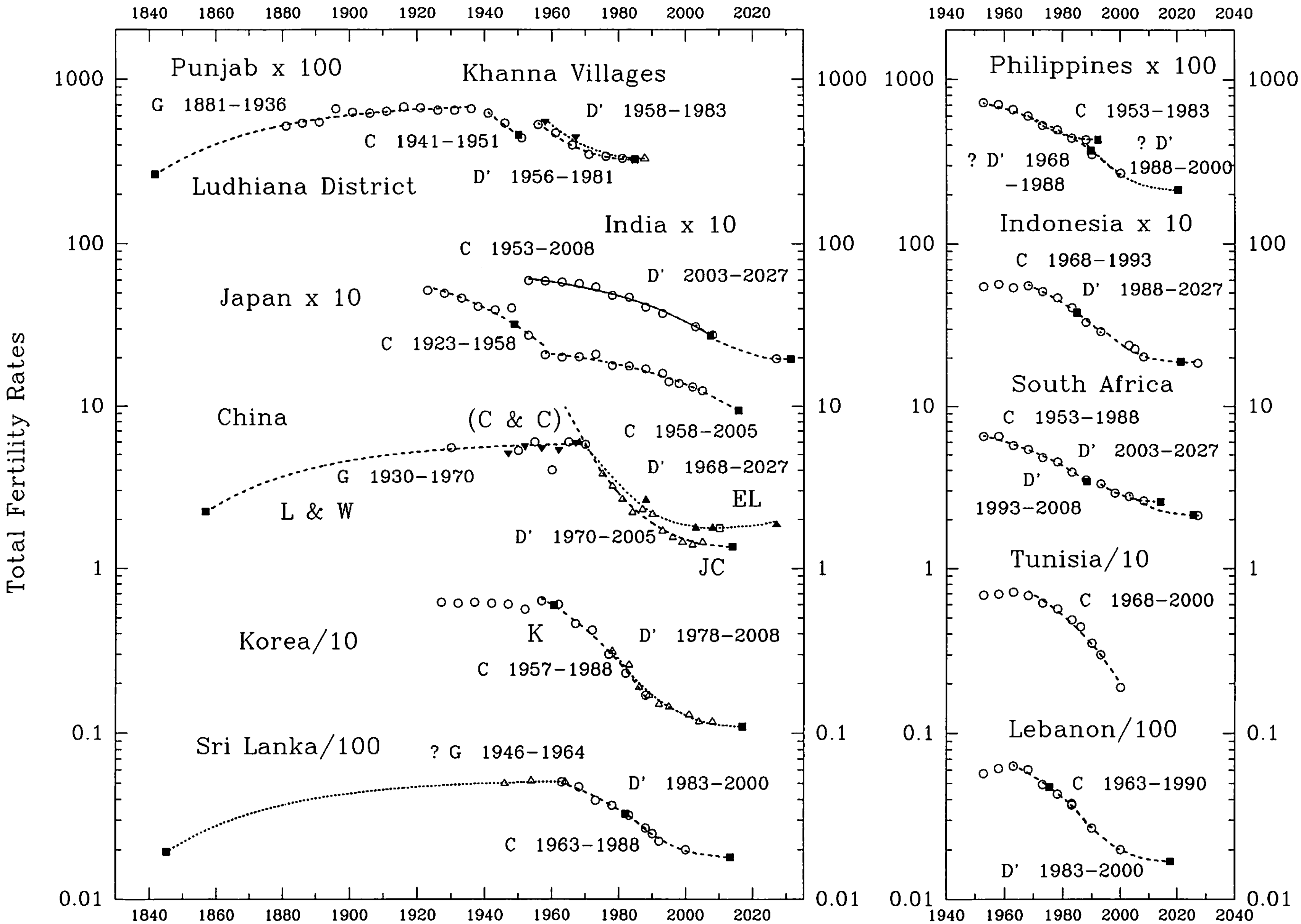
Fertility in Parts of Latin America and the Caribbean



Sources: Chesnais 1992, 537; Pantelides 1996, 348; Magno de Carvallo and Wong 1998 232–33; Lam and Marteleto 2008, 232; Ferrando and Aramburu 1996, 419; Bryant 2007, 109; Feliciano 2000, 611; Roberts 1957, 277–78; Adsera and Menendez 2011, 39.

Figure 7.3

Some 20th-Century Fertility Trends in Asia and Africa

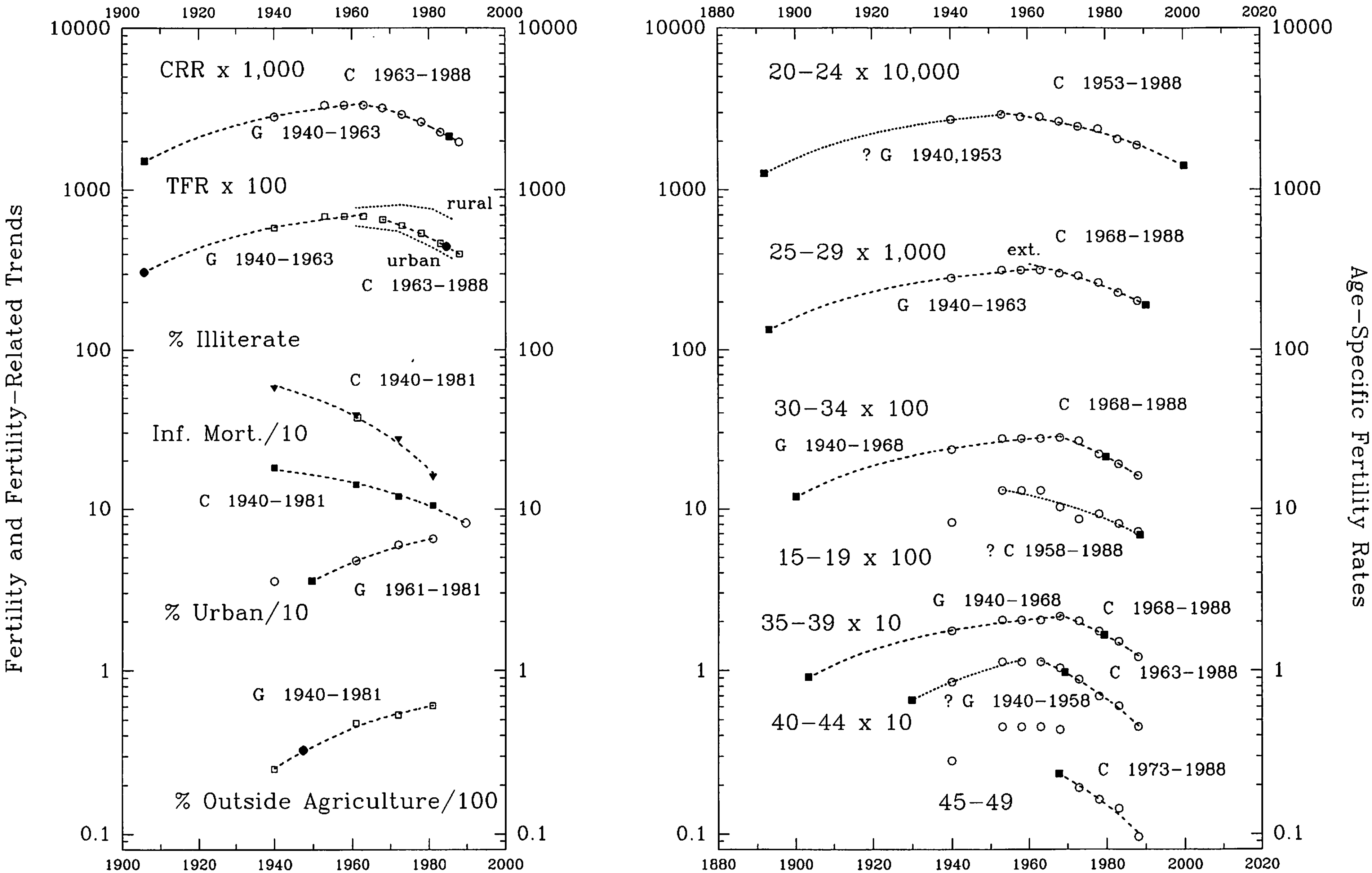


L & W = Lee and Wang; C & C = Coale and Chen; JC = Chen et al. K = Kim; EL = Eastwood and Lipton.

Sources: Das Gupta 2001, 211, 1998, 83; Lee and Wang 1999, 85; Coale and Chen 1987, 25; Chen et al. 2010, 52;; Kim 1992, 52; Langford 2001, 122; Martine 1998, 173; Chesnais 1992, 553-54; Rele and Alam 1993, 20-21; Bryant 2007, 108, 110; Jones 2007, 454; Goldstein et al. 2009, 672.; Margolis and Myrskyla 2011, 50; Eastwood and Lipton, 2011,33.

Figure 7.4

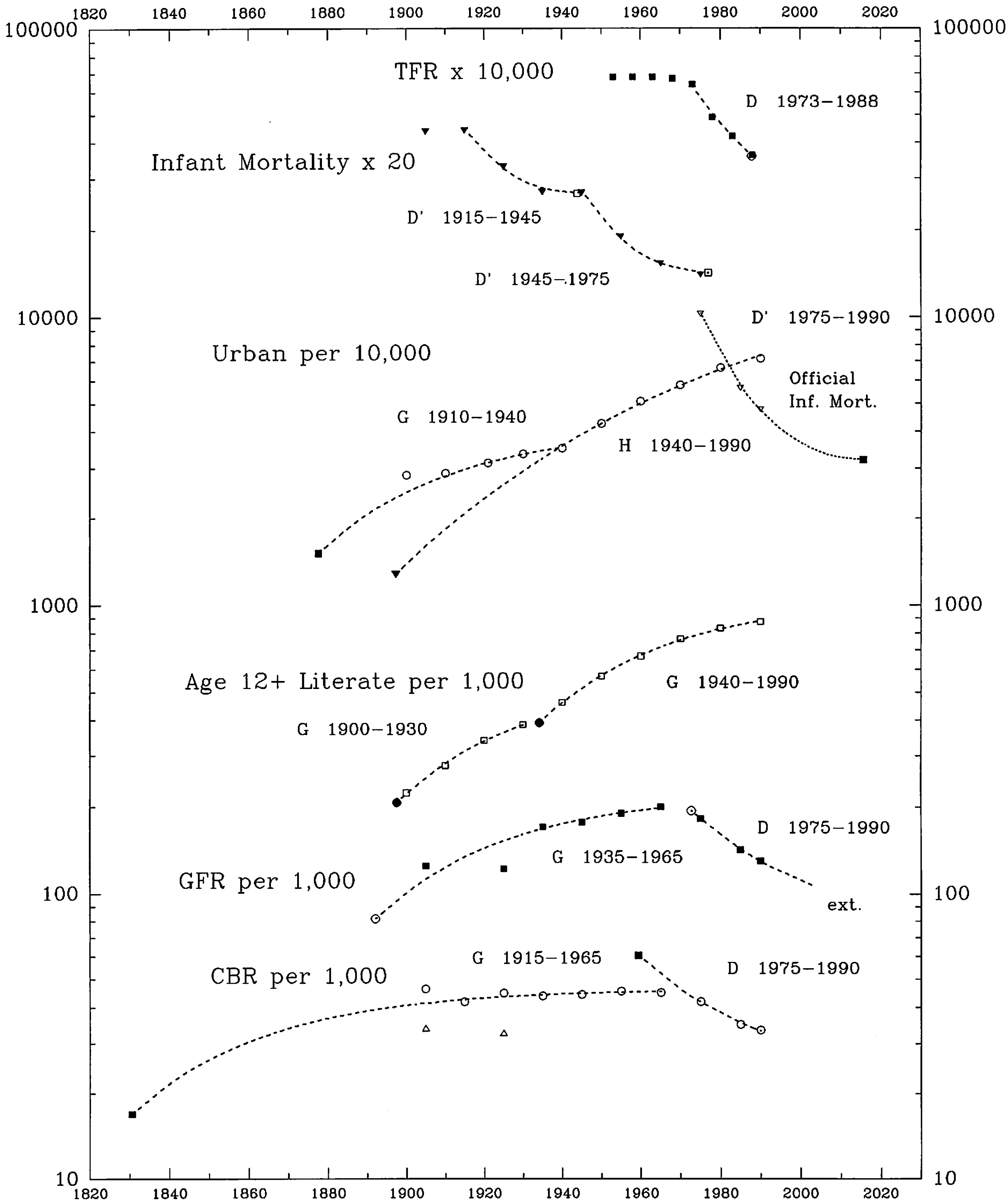
Trends of Fertility and Some Concomitants in Peru 1940–1988



Source: Ferrando and Aramburu 1996, 416, 419.

Figure 7.5a

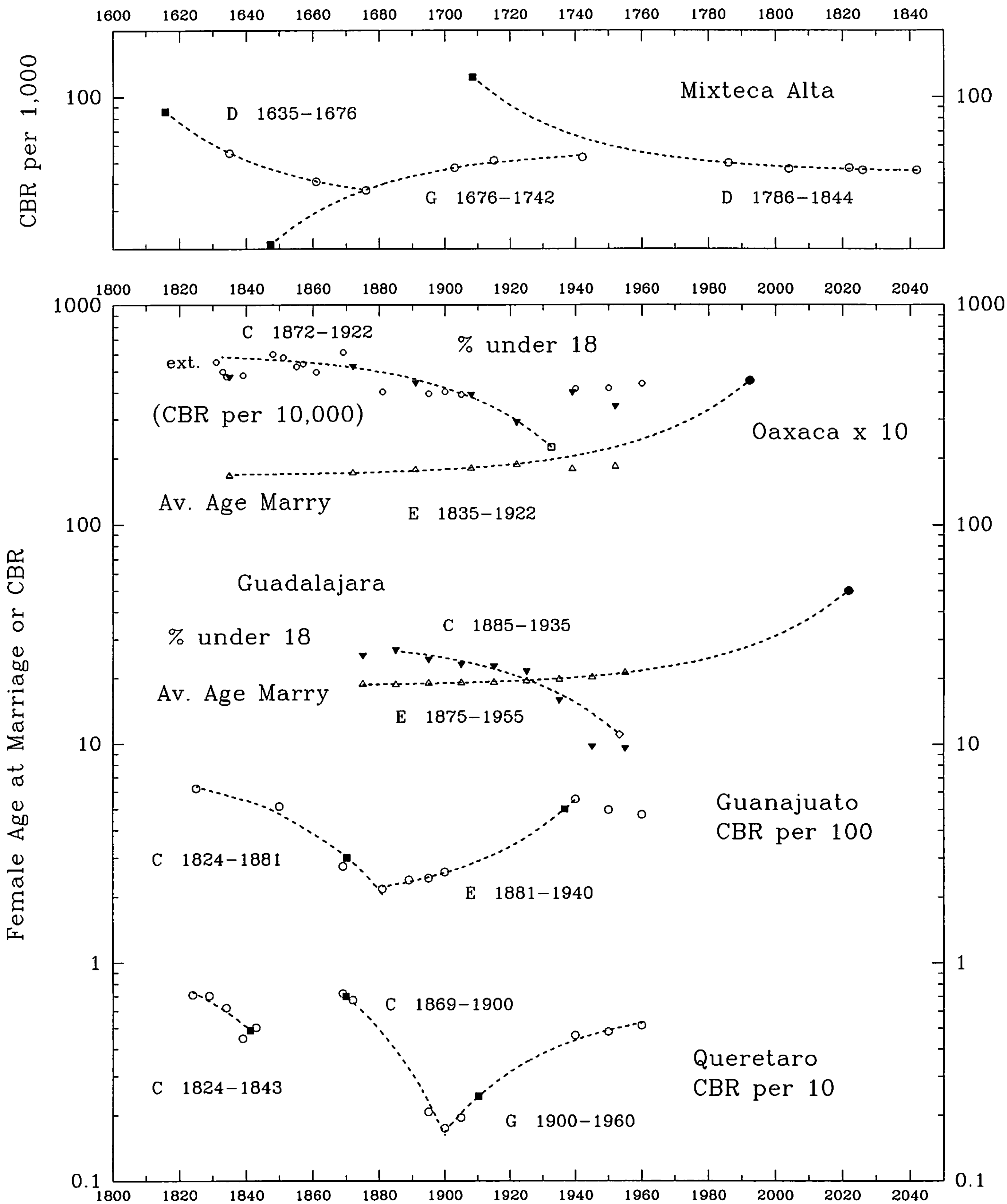
Urbanization, Literacy, and Fertility in Mexico 1900–1990



Sources: Feliciano 2000, 624, 613, 611, 604; Chakiel and Schkolnik 1996, 5.

Figure 7.5b

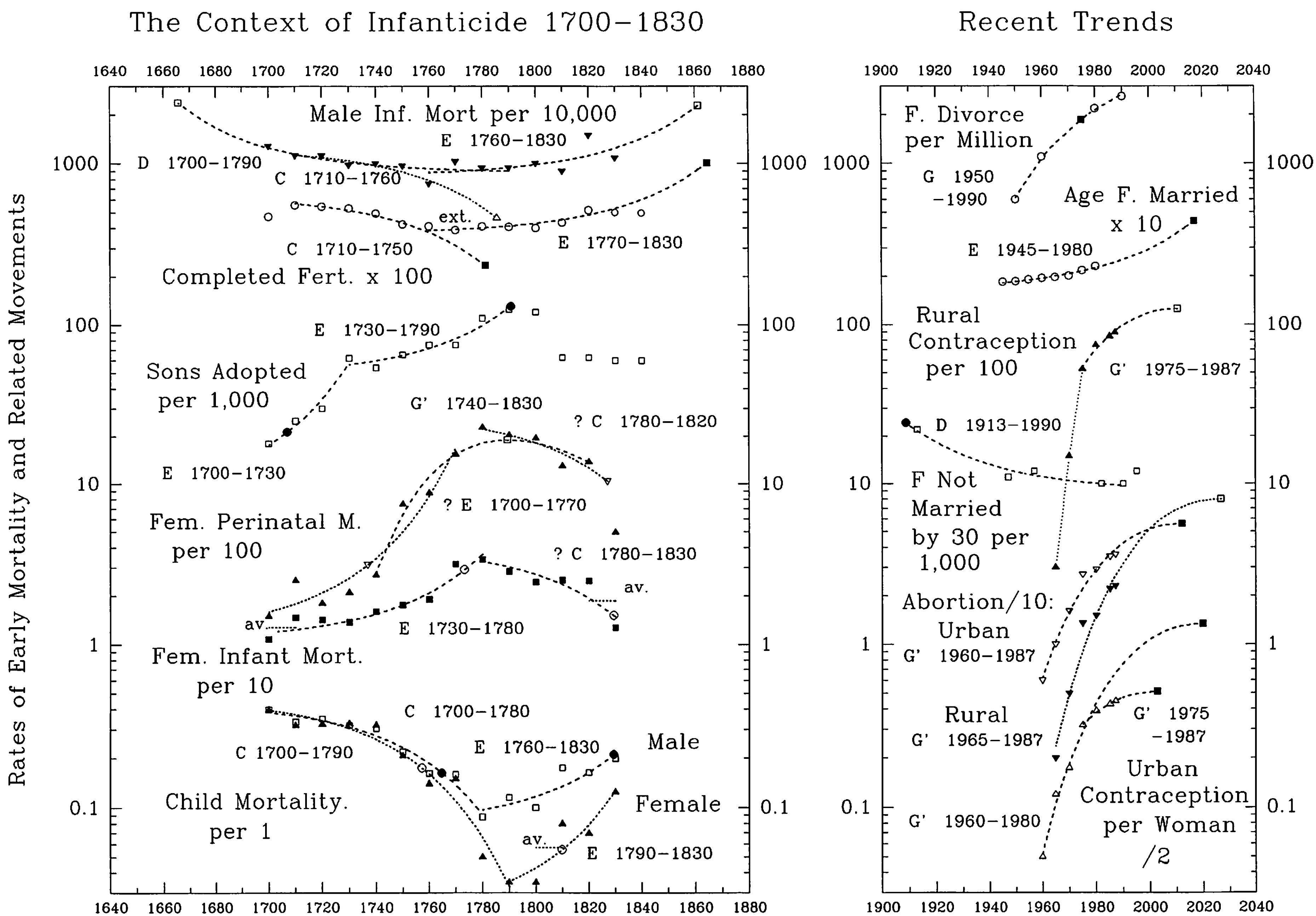
Fertility–Related Trends in Mexico between 1635 and 1960



Sources: Cook and Borah 1974, 2: 289–90, 296, 278–80, 298–99, 304–05, 318, 320.

Figure 7.6

Some Movements Affecting Fertility in China between 1700 and 2000



Sources: Lee and Wang 1999, 46, 110, 50, 142, 94, 68; Peng 1991, 120; Frejka and Ross 2001, 242.

Table 7.1

Comparing Fertility Trends in Latin America and the Caribbean

	1			2			3		
Argentina*	1895-1947	C	1946	1953-1980	D'	1960	1990-2013	D'	2010
Brazil, All*	1905-1935	C	1971	1945-1965	E	2032	1963-1983	D'	1994
" "							1983-2008	D'	2016
" , Southeast[a]	1905-1940	C	1962	1945-1970	C	2018	1980-2005	D'	2015
" , Northeast[a]	1905-1920	C	1966	1920-1945	G	1853			
" "				1940-1970	G	1885	1980-2005	D'	2022
Jamaica, TFR*				1953-1973	G'	1974	1973-2000	D'	2003
" , GRR[b]*	1891-1943	C	1990	1953-1968	G'	1974	1973-1983	D'	2010
Grenada, GRR[b]*	1881-1921	C	1982						
Barbados, GRR[b]*	1911-1947	C	1987						
Trinidad, GRR[b]*	1901-1931	C	1995	1931-1958	G'	1954	1963-1983	D'	1994
LATIN AMERICA & CARIBBEAN				1958-1968	?G	1894	1968-2003	D	1976
Haiti							1985-2000	D'	2010
Cuba							1968-2000	D'	2009
Dominican Republic							1973-1996	D'	2008
Venezuela							1968-2000	D	1967
Panama							1968-2000	D	1975
Chile							1963-2000	D'	1998
Costa Rica				1963-1983	D'	2000	1993-2008	D'	2022
Mexico, TFR*	1945-1965	G	1893				1983-2008	D'	2020
" , GFR*	1935-1965	G	1892				1975-1990	D'	2002
Guatemala				1953-1980	C	2022	1980-2000	D'	2000
Colombia				1953-1963	flat		1963-2000	D'	2001
Ecuador				1978-1998	C	1986	1983-2008	D'	2015
Peru*	1940-1963	G	1906	1968-1988	C	1985	1978-1995	D'	2004
Nicaragua				1953-1995	C	1996	1995,2000	?D'	2034
Uruguay	1953-1973	G	1906	1968-2000	C	2023			
Honduras	1953-1973	?G	1880	1973-2000	C	1995			
Guyana, GRRb*	1891-1953	E	1960	1958-1983	C	1972			
El Salvador	1953-1963	?G	1908	1963-2000	C	1995			
Bolivia				1960-1995	C	2012			
Paraguay				1963-1978	C	1994	1978-2000	C	2027

* Fitted; rest estimated by template. TFR unless otherwise specified.
[a] = from Magno de Carvallo and Wong; [b] = based upon both sexes except for Jamaica 1891-1943.

Sources: Fig. 7.2; Chesnais 1992, 553; Chackiel and Schkolnik 1996, 5; Bryant 2007, 109; Lam and Marteleto 2008, 232; Potter et al. 2010, 298; Adsera and Melendez 2011, 39.

Table 7.2

Fitted and Approximate Trends of Total Fertility in East, Southeast, South, and Central Asia

	1			2			3		
Japan*	1923-1958	C	1949 = 3.2	1958-2005	C	2016 = 0.9			
South Korea*	1927-1953		level	1957-1988	C	1961 = 5.9	1978-2008	D'	2017 = 1.1
China*	1930-1970	G	1857 = 2.3				1970-2005	D'	2014 = 1.35
"							1968-2027	D'	2010 = 1.8
Guangdong							1975-2005	D'	2001 = 1.4
Taiwan				1953-1983	C	1964 = 5.0	1978-2000	D'	2012 = 1.5
Hong Kong				1963-1988	C	1952 = 7.2	1983-2005	D'	2014 = 0.9
Singapore				1953-1963	?C	1960 = 5.4	1963-2008	D'	2014 = 2.4
Viet Nam				1968-1993	C	1980 = 5.4	1988-2008	D'	2020 = 2.0
Thailand				1963-1978	C	1974 = 5.0	1978-2027	D'	2010 = 1.8
Malaysia				1958-1973	C	1990 = 5.5	1973-2005	D'	1998 = 3.8
Indonesia*				1968-2003	C	1994 = 3.0	1993-2027	D'	2021 = 1.8
Philippines*				1953-1983	C	1990 = 3.7	1968-1988	?D'	1992 = 4.3
"							1988-2000	D'	2020 = 2.1
East Timor				1963-1988	C	2025 = 2.6			
Sri Lanka*	1946-1964	G	1845 = 1.95	1963-1988	C	1982 = 3.3	1983-2000	D'	2013 = 1.8
India*				1953-2008	C	2007 = 2.7	2003-2027	D'	2032 = 2.0
Ludhianna, Punjab*	1881-1936	G	1841 = 2.7	1941-1961	?C	1950 = 2.2	1956-1981	D'	1985 = 3.3
Khanna Villages, " *							1958-1993	D'	1988 = 3.3
Bangladesh	1953-1973	E	2006 = 14.0	1973-1983	?C	2000 = 4.0	1983-2000	D'	2022 = 2.2
Pakistan				1963-2000	C	2016 = 3.0			
Nepal				1973-1996	C	2025 = 2.9			
Bhutan				1963-1988	C	2044 = 2.3			
Mongolia				1963-1988	C	2021 = 2.6			

* Fitted; others approximated.

Sources: As in Fig. 7.3; also Bongaarts 2001, 263; McEachran and Diamond 2001, 159; Colombien et al. 2001, 103; Margolis and Myrskylä 2011, 50; Eastwood and Lipton 2011, 33.

Table 7.3

Fitted and Approximate Trends of Total Fertility in North Africa and Western Asia

Tunisia*	1963-1993	C	1983 = 5.0	1988-2023	D'	2022 = 2.0
Algeria	1978-2003	C	1994 = 5.0	2003-2023	D'	2034 = 2.0
Morocco	1968-2003	C	1990 = 4.5	1993-2023	D'	2026 = 3.0
Egypt	1963-1988	D'	1996 = 4.3	1993-2023	D'	2028 = 2.1
Israel	1953-1973	D'	1965 = 3.8	1973-1988	D'	1996 = 3.0
Cyprus	1953-1973	C	1972 = 2.4	1963-1988	D'	1988 = 2.2
"				1988,2005	?D'	?
Lebanon*	1963-1990	C	1975 = 4.8	1983-2000	D'	2018 = 1.7
Kuwait	1963-1988	C	1975 = 1.6			
Bahrain	1963-1988	C	1988 = 4.0			
Turkey	1953-1973	C	2010 = 2.8	1973-2000	D'	2010 = 2.8
United Arab Emirates	1963-1988	C	2004 = 3.2			
Iran	1963-1988	C	2005 = 3.4	1988-2000	D'	2031 = 1.3
Qatar	1963-1988	C	2018 = 3.0			
Jordan	1963-1983	C	2016 = 3.5	1988-2000	D'	2019 = 3.3
Syria	1973-1988	C	2032 = 3.1	1983-2000	?D'	2015 = 3.7
Iraq	1973-1988	C	2024 = 3.1			
Yemen	1953-1988	G	1904 = 3.1	1988-2000	D'	2009 = 6.0
Saudi Arabia	1973-1988	?C	2080 = 2.8	1988,2003	?D'	2024 = 3.2
Democratic Yemen	1963-1988	?C	2096 = 2.6			

* Fitted; others approximated.

Sources: Chesnais 1992, 553-54; Rele and Alam 1993, 21; Bryant 2007, 110; Lutz et al. 2010, 273; Margolis and Myrskylä 2011, 50; Keyfitz and Flieger 1990, 115, 128, 146, 161, 208-46.

Table 7.4

Fitted and Approximate Trends of Total Fertility in Sub-Saharan Africa

	1			2			3		
Mauritius							1968-1983	D'	2000 = 2.4
Réunion							1968-1983	D'	2008 = 1.6
South Africa*				1958-1988	C	1988 = 3.4	1993-2008	D'	2014 = 2.6
" "							2003-2027	D'	2025 = 2.2
Dem. Rep. Congo	1953-1995	E	2030	1995-2027	C	2028 = 3.9			
Zambia	1953-1983	E	2028	1983-2003	C	2050 = 3.1			
Nigeria	1953-1988	E	2060	1988-2027	C	2028 = 3.3			
Kenya	1953-1983	G	1900 = 3.2				1983-2008	D'	2011 = 5.0
Ghana	1953-1968	G	1898 = 2.8	1968-2008	C	2033 = 3.0	2008,2027	?D'	2034 = 3.0
Senegal	1953-1973	G	1890 = 3.7	1973-2013	C	2034 = 2.8			
Uganda	1953-2000	G	1890 = 2.8	2003-2027	C	2027 = 4.0			
Cameroon	1953-1988	G	1889 = 2.3	1988-2027	C	2032 = 3.8			
Côte d'Ivoire	1953-1968	G	1910 = 3.4	1968-2027	C	2025 = 3.1			
Malawi	1953-1988	G	1888 = 2.8	1988-2027	C	2031 = 3.3			
Tanzania	1953-1983	G	1895 = 2.8	1978-2027	C	2028 = 3.0			
Burkina Faso	1953-1988	G	1906 = 2.7	2003-2027	C	2034 = 3.4			
Angola	1953,1968	?G	1894 = 3.0	1968-2003	C	2058 = 2.9			
Congo	1953-1973	G	1885 = 2.3	1973-2013	C	2046 = 2.4			
Chad	1953-1968	G	1900 = 2.5	1968-2003	C	2056 = 2.3			
Niger	1953-1983	G	1885 = 2.7	1988-2013	C	2049 = 3.0			
Sierra Leone	1953-1983	G	1886 = 2.3	1988-2013	C	2038 = 3.0			
Mozambique	1953-1983	G	1886 = 2.5	1988-2027	C	2030 = 3.0			
Benin	1953-1988	G	1874 = 2.7	1993-2013	C	2030 = 3.3			
Mali	1953-1988	G	1866 = 2.5	1988-2003	C	2053 = 2.8			
Central Afr. Rep.	1953-1988	G	1890 = 2.2	1988-2013	C	1890 = 2.2			
Burundi	1958-1983	G	1922 = 2.7	1983-2003	C	2038 = 2.7			
Rwanda	1958-1983	G	1922 = 3.6	1983-2003	C	2028 = 4.0			
Zimbabwe	1953-1968	G	1890 = 3.0	1968-2013	C	2050 = 3.5			
Botswana	1953-1973	G	1906 = 2.8	1973-2003	C	2024 = 3.0			

Ethiopia	1953-1988	flat	1988-2027	C	2027 = 3.4
Sudan	1953-1988	flat	1988-2027	C	2024 = 3.0
Mauretania	1953-1983	flat	1983-2003	C	2055 = 2.7
Togo	1953-1968	flat	1968-2003	C	2052 = 2.4
Lesotho	1953-1983	flat	1983-2013	C	2040 + 2.5
Guinea		-	1953-2013	C	2045 = 2.5

* = Fitted, others approximated.

Sources: Chesnais 1992, 553; Moultrie and Timæus 2003, 266; Bongaarts 2003, 327; Lam and Marteleto 2008, 232; Bryant 2007, 111; Margolis and Myrskylä 2011, 50; Eastwood and Lipton 2011, 33; Romaniuk 2011, 5; Keyfitz and Flieger 1990, 116-65.

Table 7.5a

Early C Trends in Fertility: With Some Associated Movements

	Era	Early Mortality	Crude Birth Rate	Fertility	Marriage	Population
England	A	1580-1640 C 1700	1556-1661 C 1710	1556-1661 C 1711[t]	1556-1651 C 1684[m]	1561-1656 H 1461
				1558-1663 C 1712[f]		
				1612-1662 C 1728[as]		
				flat [g]		
British Peerage	A			1575,1625 ?C 1690[t]		
" "	B			1625-1725 C 1795[t]		
" "	D			1775-1875 C 1888[t]		
New Castile	A	1630-1670 C 1711	1610-1640 C 1684	1600-1640 C 1688[c]	1600-1640 D 1560[m]	1600-1670 C 1750
" "	B	1690-1740 C 1781	1640-1680 G 1595	1700-1750 C 1840[c]	1640-1710 G 1580[m]	1670-1750 E 1710
" "	C	1760-1810 G 1718	1640-1880 G 1595	1790-1810 C 1855[c]	1720-1790 D 1635[m]	1740-1810 G 1710
Geneva Bourgeosie	AB			1625,1675 ?C 1700[t]		
" "	B			1675,1725 ?C 1756[t]		
" "	C			1775-1825 C 1863[t]		
Geneva	B			1662-1714 C 1762[c]		1650-1700 G 1624
"	C			1747-1845 C 1820[c]		
Rouen	B			1655-1715 C 1755[c]		
"	BC			1715-1774 C 1820[c]		
Normandy	B			1700-1730 C 1801[g]		
"	B			1700-1730 C 1792[c]		
"	B			1730-1750 C 1792[c]		
"	C			1750-1790 C 1819[c]		
French Dukes & Peers	B			1675,1750 ?C 1756[c]		
S.E. Paris Basin	B/C			1700-1790 C 1868[g]		
" " "	C			1750-1810 C 1849[c]		
Southwestern France	C			1780-1820 C 1864[g]		
" "	C			1760-1810 C 1875[c]		
France	C	1745-1805 C 1833	1742-1802 C 1859	1755-1817 C 1853[g]	1742-1827 C 1896[m]	1792-1827 E 1896
"	C			1742-1807 C 1855[c]		

2 Friesland Villages	C	1730-1812	C	1830	1725-1812	C	$1870^{g\#}$		
3 Bavarian Villages	C	1775,1812	?C	1874	1775,1812	?C	1877^{g}		
3 Baden Villages^{x}	C	1725-1812	C	1855	1750-1825	C	1898^{g}		
United States	C				1748-1829	C	1864^{Wg}	1680-1850	F
" "	CD				1800-1867	C	1887^{Zt}	1680-1850	F
					1798-1848	C	1876^{Wg}		
" "	D				1841-1865	C	1887^{Hg}		
					1837-1862	C	1887^{Ht}		

A = roughly 1500s to 1650, B = 1650-1750, C = 1750-1825, D = 1825-1875; A/B etc. = overlappimg A and B, etc.

^{t} = total fertility; ^{f} = overall fertility; ^{g} = marital fertility; ^{as} = total age-specific; ^{c} = completed family; # = average estimated; ^{x} = averaged without Rust; ^{W} = Wahl; ^{Z} = Coale and Zelnik; ^{H} = Hacker.

Sources: Figs. 1.4, 1.6; Tabs. 5.1, 5.3, C.4, 5.2, C.5, 6.1.

Table 7.5b

Other Early C trends in Fertility*

Genoa Families	A	1575,1625	?C	1687^{t}
" "	AB	1625,1675	?C	1746^{t}
" "	B	1675,1737	?C	1808^{t}
Milan, Aristocracy	AB	1625,1675	?C	1735^{t}
" "	B	1675,1725	?C	1766^{t}
" "	BC	1725,1775	?C	1823^{t}
Florence, Aristocracy	B	1650,1725	?C	1790^{t}
" "	C	1725,1775	?C	1842^{t}
Florence, Jews (CBR)	B	1681-1763	C	1790
European Rulers	B	1625-1725	C	1775^{t}
Leghorn, Jews (CBR)	C	1713-1788	C	1828
Belgian Aristocracy	C	1715,1790	?C	1854^{t}
Cath. Transdanubia	C	1769,1808	?C	1838^{t}
" "	CD	1808,1836	?C	1868^{t}
Prot. Transdanubia	C	1769,1806	?C	1834^{t}
" "	CD	1806-1873	C	1904^{t}

Mass., R.I., N.Y., N.J.	BC	1726-1774	C	1821^{r}
Mid-Atlantic Quakers	BC	1738-1793	C	1820^{WEm}
Maryland	C	1750,1800	?C	1850^{r}
"	C	1800-1830	C	1856^{r}
R.I., Mass., Conn.	C	1800-1830	C	1856^{r}
Maine, New Hampshire	C	1800-1830	C	1850^{r}
New England	C	1660-1840	C	1864^{Mm}
N.Y., N.J., Pa., Del.	C	1805-1830	C	1860^{r}
Virginia, Kentucky	C	1800-1830	C	1866^{r}
New England & Mid-Atl.	CD	1748-1842	C	1890^{Wm}
No. & So. Carolina, Ga.	CD	1800-1850	C	1880^{r}
Louisiana	CD	1810-1840	C	1844^{r}
Tennessee, Missouri	CD	1800-1850	C	1870^{r}
Ohio	C	1810-1830	C	1853^{r}
"	D	1830-1850	C	1870^{r}
Ind., Ill., Mich.	D	1820-1850	C	1876^{r}
Midwest	D	1829-1853	C	1868^{Wm}
"	D	1853-1892	C	1917^{Wm}
Fla., Ala., Miss., Ark.	D	1830-1860	C	1888^{r}
Iowa	D	1840-1860	?C	1905^{r}

A = roughly 1500s to 1650, B = 1650 to 1750, C = 1750 to 1825, D = 1825 to 1875.

* = CBR employed for Jews of Florence and Leghorn; ^{t} = total fertility; ^{r} = fertility ratio (for whites in U.S.); ^{m} = total marital fertility; ^{WE} = Wells ^{W} = Wahl; ^{M} = Main.

Sources: Tab 5.3; Andorka 1979, 17; Tabs. 6.4, 6.3, 6.1.

Table 7.6

Some Approximate Trends of Infant Mortality Outside Europe

with Accompanying Changes in Fertility and Population Size

United States	Mort.	1902-1922	C	1910	1922-1952	C	1934	1957-1985	C	1967			
	Fert.				1903-1933	C	1940	1963-1978	D'	2000	1983-1998	G	1952
	Pop.	*1850-1930*	*H*	*1854*				*1940-2011*	*H*	*1888*			
Australia	Mort.				1907-1952	C	1937	1952-1985	C	1970			
	Fert.				1908-1938	C	1944	1963-1978	C	1968	1978-2001	C	2045
	Pop.	*1830-1911*	*G*	*1881*	*1911-1947*	*G*	*1904*	*1954-1989*	*G*	*1952*			
New Zealand	Mort.	1907-1917	?C	1904	1917-1932	C	1929	1932-1985	C	1976			
	Fert.							1963-1978	C	1965	1992-2002	C	2031
	Pop.	*1881-1901*	*G*	*1878*	*1901-1945*	*G*	*1901*	*1945-1991*	*G*	*1944*			
Canada	Mort.	1851-1881	C	1925	1891-1951	C	1938	1952-1985	C	1955			
	Fert.				1891-1931	C	1947	1963-1978	D'	2001	1978-2000	C	2033
	Pop.	*1824-1901*	*G*	*1851*	*1901-1941*	*G*	*1903*	*1951-1990*	*G*	*1947*			
Argentina	Mort.	1917-1952	C	1948	1953-1968	C	2003	1973-1993	D'	2004	2003-2023	D'	2025
	Fert.	1895-1947	C	1946	1953-1980	D'	1960	1978-1999	C	2020	1990-2013	D'	2010
	Pop.				*1895-1970*	*H*	*1905*	*1970-2010*	*H*	*1926*			
Uruguay	Mort.	1917-1942	C	1967	1937-1977	D'	1973				1978-2003	D'	2014
	Fert.				1953-1973	G	1906				1968-2000	C	2023
	Pop.	*1908-1950*	*G*	*1909*	*1950-1990*	*G*	*1927*				*1990-2010*	*G*	*1954*
Brazil	Mort.	1907-1957	C	1985	1942-1971	D'	1974	1973-1993	D'	2002			
	Fert.	1905-1935	C	1971	1945-1965	E	2032	1963-1983	D'	1994	1983-2008	D'	2016
	Pop.	*1900-1940*	*H*	*1885*	*1940-2010*	*H*	*1948*						

Mexico	Mort.	1902-1927	C	1928	1915-1945	D'	1944	1945-1975	D'	1978	1975-1990	D'	2016
	Fert.				1945-1965	G	1893				1983-2008	D'	2020
	Pop.	*1873-1910*	*H*	*1819*	*1921-1960*	*E*	*1952*	*1940-1990*	*F*	-			
Peru	Mort.[p]							1940-1981	C	1990	1983-2013	D'	2014
	Fert.				1940-1963	G	1906	1968-1988	C	1985	1978-1995	D'	2004
	Pop.	*1900-1930*	*G*	*1888*	*1920-1961*	*E*	*1962*				*1972-1990*	*F*	-
Chile	Mort.	1907-1937	C	1952				1942-1962	D'	1976	1972-1985	D'	2024
	Fert.										1963-2000	D'	1998
	Pop.	*1907-1930*	*?H*	*1845*	*1940-1960*	*E*	*1967*				*1970-1990*	*G*	*1960*
Venezuela	Mort.				1932-1962	C	1942				1963-1993	D'	1998
	Fert.										1968-2000	D	1975
	Pop.				*1926-1961*	*E*	*1949*	*1961-1976*	*F*	-	*1976-1990*	*G*	*1988*
Costa Rica	Mort.				1932-1942	C	1978	1942-1967	D'	1978	1977-2007	D'	2016
	Fert.							1963-1983	D'	2000	1993-2008	D'	2022
	Pop.				*1920-1963*	*E*	*1946*	*1963-1990*	*G*	*1973*			
Cuba	Mort.				1932-1957	C	1928	1957-1967	?G'	1977	1967-1985	D'	2012
	Fert.										1968-2000	D'	2009
	Pop.				*1899-1943*	*G*	*1913*	*1953-1990*	*G*	*1950*			

Japan	Mort.	1902-1922	E	1964	1917-1967	C	1929				1963-2003	D'	2008
	Fert.				1923-1958	C	1949	1958-2005	C	2016			
	Pop.				*1920-1945*	*G*	*1902*	*1945-1965*	*G*	*1931*	*1965-1990*	*G*	*1939*
Korea	Mort.							1958-1978	C	1964	1978-2023	D'	2011
	Fert.				1927-1953	level		1957-1988	C	1961	1978-2008	D'	2017
	Pop.				*1920-1935*	*E*	*1954*	*1955-1990*	*G*	*1957*			
China	Mort.[kf]							1957-1987	D'	2006	1983-2007	D'	2018
	Fert.				1930-1970	G	1857				1970-2005	D'	2014
	Pop.	*1873-1937*	*H*	*1741*				*1950-1990*	*H*	*1923*			
Taiwan	Mort.				1923-1942	C	1969	1937-1962	D'	1984	1967-1982	D'	2010
	Fert.				1953-1983	C	1964				1978-2000	D'	2012
	Pop.	*1920-1935*	*E*	*1935*	*1935-1971*	*F*	-	*1956-1992*	*G*	*1963*			

Singapore	Mort.	1927-1952	C	1926	1952-1972	D'	1998				1972-2003	D'	2014
	Fert.				1953-1963	?C	1960				1963-2008	D'	2014
	Pop.	*1911-1931*	*G*	*1921*	*1947-1985*	*G*	*1960*						
Malaysia	Mort.				1932-1967	C	1944				1972-1993	D'	2010
	Fert.				1958-1973	C	1990				1973-2005	D'	1998
	Pop.	*1921-1947*	*G*	*1920*	*1955-1980*	*G*	*1960*						
Philippines	Mort.				1927-1952	C	1961	1952-1973	D'	1982	1973-2003	C	1998
	Fert.							1953-1983	C	1990	1988-2000	D'	2020
	Pop.	*1918-1948*	*H*	*1899*	*1939-1960*	*E*	*1956*	*1960-1980*	*F*	-	*1975-1990*	*G*	*1976*
Sri Lanka	Mort.	1912-1942	C	1960	1947-1972	D'	1984				1978-2007	D'	2015
	Fert.				1946-1964	G	1845	1963-1988	C	1982	1983-2000	D'	2013
	Pop.				*1921-1963*	*E*	*1957*	*1963-1990*	*G*	*1956*			
India	Mort.	1902-1951	C	1964				1956-1978	D'	1972	1978-2007	D'	2013
	Fert.							1953-2008	C	2007	2003-2027	D'	2032
	Pop.				*1901-1971*	*E*	*1972*	*1961-1991*	*H*	*1947*			

Mauritius	Mort.	1922-1947	?G	1830	1947-1972	D'	1983				1972-1993	D'	2015
	Fert.										1963-1993	D'	2004
	Pop.	*1862-1931*	*G*	*1810*				*1944-1990*	*G*	*1960*			
South Africa	Mort.							1953-1993	C	1986	1993-2023	D	2010
	Fert.							1958-1998	C	1988	1993-2008	D'	2014
	Pop.							*1960-1990*	*G*	*1970*			
Egypt	Mort.	1922-1937	G	1890	1942-1967	D'	1962	1953-1993	C	2000	1993-2023	C	2021
	Fert.							1963-1988	D'	1996	1983-2000	D'	2028
	Pop.				*1917-1960*	*E*	*1962*	*1960-1990*	*H*	*1956*			
Algeria	Mort.							1953-1993	C	1978	1993-2023	D	2018
	Fert.							1978-2003	C	1994	2003-2023	D'	2034
	Pop.							*1970-1990*	*F*	-			

Senegal	Mort.				1953-1983	D	1976	1983-2003	D	1970
	Fert.				1953-1978	G	1906	1973-2013	C	2034
	Pop.				*1950-1970*	*G*	*1961*	*1970-1990*	*G*	*1981*
Nigeria	Mort.	1953-1968	C	1990	1968-1993	D	1971	1983-2023	C	2018
	Fert.	1953-1988	E	2060				1988-2027	C	2028
	Pop.	*1950-1975*	*E*	*1964*				*1975-2011*	*G*	*1984*
Cameroon	Mort.				1953-1973	C	1978	1973-2023	C	2012
	Fert.				1953-1988	G	1889	1988-2027	C	2027
	Pop.				*1960,1970*	*?E*	*1958*	*1970-1990*	*E*	*1983*
Chad	Mort.				1953-1983	C	2002	1978-2023	C	2012
	Fert.				1953-1968	G	1900	1968-2023	C	2056
	Pop.				*1931-1970*	*G*	*1949*	*1970-1990*	*E*	*1991*
Kenya	Mort.	1953-1983	D	1952	1978-2003	C	2000			
	Fert.	1953-1983	G	1900				1983-2003	D'	2010
	Pop.	*1949-1975*	*H*	*1975*	*1975-1990*	*E*	*1973*			

^{kf} = Keyfitz and Flieger.

Sources: Chesnais 1992, 590-97; Fig. 7.6; Keyfitz and Flieger 1990, 115-64, 208-46; Tabs. 7.1 through 7.4, 7.7; Kuhn 2010, 663; Eastwood and Lipton 2011, 33; Harris 2001, 26-28, 66, 82, 114, 122, 250-51, 280-81.

Table 7.7

Some Other Trends of Infant, Childhood, and Maternal Mortality in Latin America and Asia*

A. Modern Infant and Maternal Mortality

Mexico Infant	1915-1945	D'	1944[f*]	1925-1945	D'	1962[o]
	1945-1975	D'	1978[f*]	1955-1975	D'	1986[o]
				1975-1990	D'	2016[o*]
Peru Infant				1940-1981	C	1990*
Sao Paulo State Infant				1894-1990	C	1968
Brazil Maternal				1980-1988	C	1967
Rural Kerala Infant	1956-1976	D'	1993	1986,1992	?D'	2030
Pen. Malaysia Infant	1957-1980	C	1952[All]	1957-1990	C	1955[Chinese]
	1957-1980	C	1947[Malay]	1957-1990	C	1954[Indian]
China	1930-1981	C	1957			

B. Recent Sex Ratios Reflecting Mortality Differences

	China			India		
Mortality under 1	1974-1995	C	1997	1993-2005	C	2050
Mortality under 5	1974-2000	C	2044	1993-2005	C	2040
Mortality 1-4		?		1993-2005	C	2029
Survival Ratio M/F 0-4	1968-1990	E	2055	1961-2001	E	2069
	1990-2005	G	1954			
	South Korea					
" " " "	1943-1995	E	2048			

C. Early Mortality in Imperial China, 1700-1830

	Male			Female		
Infant*	1710-1760	C	1786	1730-1780	E	1773
	1760-1830	E	1861	1780-1830	?C	1829
Childhood*	1700-1780	C	1765	1700-1790	C	1757
	1760-1830	E	1829	1790-1830	E	1810

Perinatal*	1700-1770	E	1737
	1740-1830	G'	1789
	1780-1820	?C	1827

D. Yokouchi Village, Suwa County, Tokugawa Japan

Mortality 1-10	1685-1762	C	1772

* = fitted, others estimated; [f] = Feliciano estimate; [o] = official figure.

Sources: Figs. 7.5, 7.6; Sastry 2004, 446; Berquó 1998, 397; Krishnan 1998, 50; Leete 1996, 45; Das Gupta et al. 2009, 404; Fig. 7.7; Lee and Wang 1999, 46, 56; Hayami and Uchida 1972, 510.

Table 7.8

Comparing 18th-Century Demographic Change in Asia and Europe

	Population			Early Mortality			Fertility		
Ch'ing Lineage	1675-1734	G	1662[a]	1700-1780	C	1760[b]	1710-1750	C	1781
Yokouchi Village	1720-1790	G	1694	1685-1762	C	1772	1680-1780	C	1795
France	1752-1792	G	1702	1748-1805	C	1833	1742-1807	C	1855
Sweden	1748-1783	G	1706	1753-1823	C	1871	1748-1783	C	1880

[a] = national population; [b] = approximate average for male infants and children and female children.

Sources: Tab. 7.7, Fig. 7.7, Harris 2001, 251; Hayami and Uchida 1972, 509-12; Tab. C.8.

Table 7.9

Some Comparative Trends in Employment, Urbanization, and Education in the Context of Demographic Changes*

	Agriculture			Urbanization			Education		
Mexico				1910-1940	G	1875	1900-1930	G	1896[a]
				1940-1990	G	1935	1940-1990	G	1932[a]
Peru							1900-1930	G	1890[b]
	1961-1981	D	1944	1961-1981	G	1950	1940-2000	G	1934[b]
U.S.A.	1870-1940	C	1932	1850-1920	H	1838	1900-1940	G	1873
	1960-2000	D	1996	1960-1990	C	2003	1940-2000	G	1902
China				1951-1980	?G	1895			
				1980-2008	G	1995			
Malaysia	1945-1965	C	1995[e]						
				1970-1991	E	1980	1957-1991	G	1967[c]
Indonesia	1945-1965	D	1922[e]				1945-1965	E	1933[c]
Thailand	1945-1965	C	2014[e]				1945-1965	?G	1922[c]
Sweden				1870-1940	H	1842			
England & Wales	1870-1910	D	1839	1850,1890	?H	1774	1818-1908	G	1820[d]

* = estimated if not in a figure; [a] = 12+ literate; [b] = ? literate; [c] = females with some education before marriage; [d] = % in primary schooling; [e] = females work in agriculture before marriage; [f] = probability of divorce or separation within 1st 5 years of marriage.

Sources: Tabs. 7.2, 7.3, 7.6, 7.7, C.8, 10.x, 10.y; Fig. 7.7; Rosenfeld 2006, 35; Leete 1996, 28, 44-45; Hirschman and Teerawichitchainan 2003, 226-27, 230-31; Keyfitz and Flieger 1990, 83, 89.

Table 7.9 (cont.)

Some Comparative Trends in Employment, Urbanization, and Education in the Context of Demographic Change*

Divorce			Fertility			Early Mortality			Population		
						1915-1945	D'	1943			
			1945-1965	G	1892	1945-1975	D'	1978	1921-1960	E	1952
			1983-2008	D'	2020	1975-1990	D'	2016	1940-1990	F	-
			1940-1962	G	1906				1920-1961	E	1962
			1968-1988	C	1985	1940-1981	C	1961	1971-1990	F	-
1860-1950	H	1882	1903-1933	C	1940	1922-1952	C	1934	1850-1930	H	1854
1960-1980	E	1953	1963-1978	D'	2000	1957-1985	C	1967	1940-1997	H	1888
1980-2000	C	2035	1988-1998	G	1952						
			1930-1970	G	1857	1930-1981	C	1951	1873-1937	H	1741
1950-1990	G	1975	1970-2005	D'	2014	1967-1987	D'	2006	1950-1990	H	1923
						1987-2003	D'	2020			
1945-1965	D	1967[f]	1958-1973	C	1990	1932-1967	C	1949	1955-1980	G	1960
			1973-1985	D'	1998	1972-1985	D'	2012			
1945-1965	C	1990[f]	1973-1993	C	1982	1960-1985	C	1992	1955-1990	H	1946
			1983-2000	D'	2014						
1945-1965	G'	1946[f]				1953-1970	C	1953	1947-1990	H	1957
			1963-1978	C	1974	1970-1985	C	1972			
			1978-2000	D'	2016						
1855-1923	E	1893	1880-1930	C	1930	1888-1957	C	1932	1848-1943	H	1757
1928-1948	E	1925									
1953-1963	?C	?									
			1881-1931	C	1928	1848-1957	C	1953	1861-1939	H	1794

Table 7.10

Approximate Trends in Literacy, Fertility, and GDP per Capita in Latin America during the 20th Century

	% Literate			Fertility			GDP per Capita		
Mexico I	1900-1930	G	1878	1935-1965	G	1893	1900-1940	G	1877
Honduras I	1900-1940	G	1866	1953-1973	G	1880	1940-2000	G	1920
El Salvador I	1930-1960	G	1927	1953-1963	?G	1908	1920-2000	G	1935
Colombia I	1910-1940	G	1891	1953-1963	flat		1910-1960	G	1922
Uruguay I	1900-1940	G	1870	1953-1973	G	1906	1900-1940	G	1880
Chile I	1900-1950	G	1891	?			1900-1940	G	1894
Ecuador I	1900-1940	G	1880	?			1900-1930	G	1910
Costa Rica II	1900-2000	G	1900	?			1960-2000	G	1952
Peru I	1900-1930	G	1890	1940-1963	G	1906	1900-1930	E	1928

Argentina I	1910-2000	G	1856	1895-1947	C	1946	1900-1940	G	1875
Brazil I	1910-1940	G	1888	1905-1935	C	1971	1900-1930	G	1882
Uruguay II	1940-2000	G	1894	1968-2000	C	2023	1940-2000	G	1935
Ecuador II	1950-2000	G	1937	1978-1998	C	1986	1940-1990	G	1953
Peru II	1940-2000	G	1934	1968-1998	C	1985	1970-2000	flat	
El Salvador II	1960-2000	G	1945	1963-2000	C	1995	1920-2000	G	1935
Honduras II	1960-2000	G	1948	1973-2000	C	1995	1940-2000	G	1920
Guatemala II	1960-2000	G	1954	1953-1980	C	2022	1920-2000	?G	1927
Bolivia II	1950-2000	G	1888	1960-1995	C	2012	1960-2000	G'	1988
Paraguay II	1900-1990	G	1918	1963-1978	C	1994	1960-2000	?G'	1992
Nicaragua II	1960-2000	G	1935	1953-1995	C	1996	1940-1970	E	1958

Sources: Tab. 7.1; Astorga et al. 2005, 790, 788.

Table 7.11

Percentages of Wives Who Married Young:

Southeast Asia and Parts of Mexico

	Malay	*Chinese*	*Indian et al.*
Malaysia 15-19	1957-1980 C 1938	1957-1980 D' 1995	1957-1991 D' 2000
"	1970-1991 D' 2020		
Singapore 15-19	1970-1990 D' 2012	1957-1980 D' 2014	
Brunei 15-19	1970-1991 C 1974		
Indonesia 15-19	1970-1990 C 1979		
Hong Kong 15-19		1961-1991 C 1964	
Taiwan 15-19		1956-1990 C 1962	
Bangladesh 15-19			1975-1994 C 2000
Oaxaca under 18			1872-1922 C 1933
Guadalajara under 18			1885-1935 C 1953

Sources: Leete 1996, 149, 161, 87; McEachran and Diamond 2001, 162; Fig. 7.5b.

Table 7.12

Mean Age of Females at First Marriage

	Malay			Chinese			Indian et al.		
Malaysia	1957-1991	G	1930	1970-1991	E	2036	1957-1981	G	1934
Singapore	1957-1990	G	1934	1957-1990	E	2030			
Brunei	1971-1991	G	1930						
Sabah & Sarawak	1961-1991	G	1925						
Indonesia	1970-1990	G	1923				1970-1985	E	2028
Hong Kong				1961-1991	E	2033			
Taiwan				1956-1990	E	2015			
China				1945-1980	E	2015			
China, Urban				1950-1980	E	2010			
China, Rural				1950-1980	E	2015			
Japan							1947-1990	E	2042*
South Korea							1957-1970	E	2010*
							1979-1992	E	2032*
India							1941-1981	E	2014
Pakistan							1951-1972	G	1916
							1972-1997	E	2032
Mexico							1955-1998	E	2032
U.S.A.							1900-1955	C	2021

* = Estimated from 1st births.

Sources: Leete 1996, 149, 161, 87, 143; Coale and Freedman 1993, 225; Peng 1991, 120; Hakim and Miller 2001, 143; Alam and Leete 1993, 155; Frejka et al. 2010, 587; Fig. 7.5b; Dahl 2010, 693 (median).

Table 7.13

Marriage Age of Females and Fertility

	Females 1st Marry			Fertility		
India	1941-1981	E	2014	1953-1988	C	2009
Pakistan	1972-1997	E	2032	1963-2000	C	2016
Japan	1947-1990	E	2042*	1958-2005	C	2016
Indonesia	1970-1985	E	2028	1973-1993	C	1982
Taiwan	1956-1990	E	2015	1953-1983	C	1964
South Korea	1957-1970	E	2010*	1957-1988	C	1961
	1979-1992	E	2032*			
Hong Kong	1961-1991	E	2033	1963-1988	C	1952
Malaysia	1957-1991	G	1931	1958-1973	C	1990
Singapore	1957-1990	G	1932	1953-1963	?C	1960
China	1945-1980	E	2015	1930-1970	G	1857
England	1615-1675	E	1780	1558-1663	C	1708
	1715-1785	C	1854	1718-1818	E	1857
U.S.A. "B"	1705-1815	E	1864	1748-1829	C	1848 tmfr
"A"	1705,1755	?E	1854	1748-1829	C	1864 tmfrA+B
"B"	1815-1855	C	1911	1798-1838	C	1870
"A"	1805-1825	C	1912	1798-1858	C	1881

* = Estimated from 1st birth; "A" = Wahl data base A; "B" = Wahl data base "B"; tmfr = total marital fertility rate.

Sources: Tabs. 7.2, 7.11, 6.3; Fig. 1.4; Wahl 1986, 401-2.

Table 7.14

Estimated Trends of Age-Specific Fertility in Certain Asian Populations

	China	Sri Lanka	Philippines
TASFR	1970-1992 D 1994	1964-1983 D 1964	1953-1983 C 1987
"		1983-1996 D 1983	
15-19	1953-1980 C 1939 = 170	1953-1974 C 1957 = 62	1960-1975 C 1956 = 95
"		1978-1996 C 2008 = 20	1980-1991 C 1975 = 62
20-24	1971-1980 D 1998 = 77	1963-1978 C 1964 = 220	1960-1975 C 1992 = 138
"		1981-1996 C 1978 = 190	1980-1991 C 1991 = 160
25-29	1971-1980 D 1988 = 160	1953-1996 C 1996 = 135	1965-1991 C 1990 = 190
30-34	1971-1980 D 2025 = 58	1963-1987 C 1973 = 190	1960-1987 C 2003 = 135
35-39	1971-1980 D 2036 = 43	1963-1987 C 1970 = 130	1965-1987 C 1992 = 120
40-44	1971-1980 D 2036 = 27	1963-1996 ?C 1984 = 28	1960-1984 C 2001 = 50
"			1970-1991 C 1970 = 103
45-49	1965-1977 C 1938 = 37	1963-1981 C 1969 = 6	1960-1991 ?C 1970 = 21
"		1984-1996 D 1986 = 2.9	

	Singapore	Pakistan	Bangladesh
TASFR	1957-1977 C 1944	1963-1983 flat	1978-1993 C 1986
15-19	1957-1977 C 1933 = 205	?	1973-1989 E 1984 = 145
20-24	1957-1977 C 1945 = 450	1966-1991 C 2020 = 130	1974-1989 G
25-29	1957-1977 C 1954 = 400	1964-1991 C 2034 = 130	1974-1989 level
30-34	1957-1977 C 1945 = 420	1964-1991 C 2030 = 120	1973-1989 C 1985 = 160
35-39	1957-1977 C 1934 = 530	1964-1991 C 2020 = 90	1974-1989 C 1990 = 92
40-44	1957-1967 C 1937 = 180	1964-1984 G	1974-1989 C 1995 = 40
"	1967-1982 ?D	1984,1991 ?D	
45-49	1957-1967 C 1948 = 16	1964-1991 C 1997 = 35	1973-1989 C 1945 = 120
	1967-1982 ?D		

Sources: Peng 1991, 130; Alam and Leete 1993, 86, 93; Shah and Cleland 1993, 188, 184; Singapore 1983, Table 2.6; U.N. *Demographic Yearbook*, 1992, 1995, 2000.

Table 7.15

Estimated Trends for Adopting Contraception in Certain Populations of Asia

	Sri Lanka	Bangladesh
All Methods	1982-1993 G' 1999 = 66	1975-1994 G' 2030 = 110
Modern Methods	1975-1993 G' 2014 = 56	1975-1994 G' 2034 = 115
Sterilization	1975-1993 G' 2007 = 32	1975-1985 G' 2046 = 300
		1983-1991 G' 2020 = 17
Pill	1975-1993 G' 2022 = 9	1983-1994 G' 2047 = 200
Injection	1975-1993 G' 2038 = 20	
Other Methods	1975-1993 ?G' 2002 = 32	1975-1994 G' 2018 = 12
Safe Period	1982-1993 G' 1996 = 16	1975-1994 G' 2028 = 11

	Pakistan	Khanna Villages of Punjab
All Methods	1975-1991 G' 2015 = 17	1969,1984 ?G' 2004 = 85[a]
"	1991-1998 G' 2044 = 125	1969,1984 ?G' 2004 = 32[b]
Sterilization	1975-1996 G' 2032 = 135	
Modern Temporary	1975-1994 G' 2024 = 14	

	India	Nepal
All Methods	1975-1990 G' 2030 = 65	1976-1991 G' 2042 = 210
Sterilization	1975-1988 G' 2018 = 52	1976-1991 G' 2040 = 140
Modern Temporary	1975-1990 E' 1952 = 3	1976-1996 E' 1936 = 0.3

	China, Rural Women 30-34	China, Urban Women 30-34
All Methods	1975-1987 G' 2011 = 126	1960-1975 G' 2020 = 268
"		1975-1987 G' 2007 = 103
Abortion	1965-1987 G' 2027 = 80	1960-1987 G' 2012 = 56

	North Peninsular Malaysia[c]	East Peninsular Malaysia[c]
All Methods	1970-1990 G' 1992 = 48	1970-1990 G' 2000 = 35
Efficient Methods	1970-1990 G' 2010 = 31	

	South Peninsular Malaysia[c]	Central Peninsular Malaysia[c]
Efficient Methods	1970-1990 G' 2009 = 27	1970-1990 G' 1993 = 22

<u>Bangladesh Fertility Reduction</u>

% from Marriage	1975-1994 /G' 2001 =	13
% from Contraception	1975-1994 G' 2028 =	69

[a] = ages 35-39 ever practiced; [b] = ages 20-24 ever practiced; [c] data reflect when women had been married 15 years.

Sources: Langford 2001, 130; McEachran and Diamond 2001, 167, 164; Hakim and Miller 2001, 146; Das Gupta 1998, 83; Lee and Wang 1999, 94; Leete 1996, 116; Kantner and He 2001, 31.

CHAPTER 8

How G-Related Trends Have Shaped Demographic Replacement and Renewal: Some Characteristics of Human Mortality

What can have generated so many different G-related movements in populations? These have appeared universally in demographic growth and decline (Volume I); in migration, urbanization, and the structure of populations (Volume II); and in fertility, nuptiality, and rates of death (the present volume). The origins of such standardized, repeated G-based curving, it turns out, reside in certain very general characteristics of human life tables. In particular, the way that humans die off with age imprints these G-connected shapes upon many forms of change--demographic, but also cultural and economic.

PATTERNS OF LIFE EXPECTANCY

{Please note that the Figures and Tables referenced in Chapter 8 are not interleafed in the text but appear at the end of the chapter (notes). MSW 31 July 21015}

As for so many aspects of demographic history, the English example has illustrated the way that not just death among the young--which is so important for fertility--but also adult mortality have altered in G-based forms (Tab. 1.5; Figs. 1.9, 1.10. Tab. A.1; Figs. A.1a, A.1b). Ample evidence demonstrates similar movements for other populations in a wide variety of historical circumstances.

Life expectancy **at birth**, which reflects mortality across the whole life cycle, frequently serves as a comprehensive shorthand measure for evaluating human wellbeing. Table 8.1 presents some examples of how (e_0) has changed across time.

Most recently, across the second half of the 20th century (col. 4), all around the world--in developed and in developing countries alike--life expectancies at birth have increased in G fashion with zero years between about 1880 and 1930. Flattest (earliest-based) G trends in England, Denmark, and the United States, and steepest (latest) trajectories in Africa and the Indian state of Kerala,[1] indicate what has been happening since about 1950: Populations with the poorest life expectancies around mid-century have benefited proportionally the most from recent improvements in health and standard of living. Those already enjoying longer life have had less room for further gain, making relative returns from still better medicine and more favorable welfare diminish.

Also intercontinentally, though not in all individual countries, from the later 1800s into the early 1900s appeared accelerating E-shape improvement in e_0 (col. 3). These trends display even more narrowly timed paths of increase, with zero years just between about 1950 and 1975. In the former Soviet Union, the Indian state of Kerala, and the United States (and possibly Africa), the gain took G shape instead. This alternative, decelerating form of increase likewise occurred in Europe, Oceania, and Japan for a while after about 1875 (cols. 1 and 2), and before that (since about 1800) in Europe--notably in France and Sweden, where G-type gain was evident still earlier (during the later 1700s: col. 1). In Paraguay and in villages surrounding the Belgian town of Verviers, for local reasons improvement in G shape appeared even sooner--leading up to 1760. In England and the United States, in contrast, gains across the later 1700s took E form, a pattern with manifestations still somewhat earlier in the town of Verviers itself, and rather later in Sart--another community of eastern Belgium (col. 1).[2] A few trends of other G-related shapes are evident--D or D’ dips in the United States before 1875 and a C decline followed by a G’ surge in England between 1560 and 1620.

In modern times, populations around the world famously have aged as living conditions and life expectancies for **adults** as well as for the young have greatly improved. G-based trends shape this process over and over again, for the future as well as in the past and present. For instance, while life expectancy at birth for females in 5 developed European countries between 1900 and 2000 increased in a G path based about 1872, excluding juvenile mortality the trend retained G shape, but was flatter--with t_0 about 1852. The most significant improvements in this historical rise for e_0 resulted from parallel C-shape reductions (each with base year in the 1920's) in the effects of juvenile and background mortality from 1850 through 1950, particularly during the first half of the 20th century--declines which continued to dwindle approximately log-linearly ($e^{-.03}$) to 2000 (Bongaarts 2006, 611-12). Looking ahead, in an example of projection, forecasts to 2050 for the percentage of voters who will be older than the pension age in Germany, Japan, and the United States take G shape, with zero years near 2000 (Sanderson et al. 2007, 546).

Trends of improving (or deteriorating) prospects at various stages of adulthood that have followed G-related paths are evident back to the middle ages. Life expectancy for young adults, at age 25, in England between 1785 and 1805 (Fig. 1.10) rose via E very much like e_0 from 1731 through 1811, targeting about 1858 compared with 1875 for prospects at birth. Previously, between about 1725 and 1775, the gain took G form instead of the E trend currently followed by e_0.[3] Between roughly 1685 and 1720, though, both swelled together via G'. With the transition from the middle ages to the reign of the Tudors, between the early 1490s and the later 1510s, life expectancy at age 25 for English monks from Durham and Westminster increased in G fashion (Hatcher et al. 2006, 674). Previously, for these men and for monks from a third distinctive location (Canterbury), e_{25} had been declining: twice via C, from about 1427 through 1457, then 1457 through 1487.[4] The annual *death rate* for a group of English creditors, meanwhile, contracted between 1315 and 1492 around an underlying C path that would target about 1454

(Nightingale 2010, 1083). It would be of interest to understand how death rates for creditors improved so closely opposite to decline in life expectancy for monks. Were their living conditions diverging? Were risks for investors above age 25 the determining factor? Figure 1.10, for instance, has displayed some differences in expectancy at successive adult stages of the life cycle in England.

In the current era, expectancy for females at age 65 has increased in some developed countries since 1950 (Meslé and Vallin 2006, 125). First, it tended to improve to about 1980 via E: in the United States, the Netherlands, and possibly France,[5] all targeting about 2018. In Japan, from 1950 to 1970 increase took G form instead. This was then the shape of further gains for all four countries into the first years of the 2000s, flattest in the United States and the Netherlands (t_0 about 1925) and steeper in France and Japan (based in the vicinity of 1950). In Japan, France, and the United States across the second half of the 20th century expectancy at birth increased via somewhat steeper G trends than these for e_{65}--with t_0's about 1922, 1926, and 1893 (Tab. 8.1).[6]

Comparably, *active* life expectancy at 65 in the United States is thought to be increasing currently via G from 1982 through 2022 from a base year around 1948, having accelerated upward in E fashion between 1935 and 1982--targeting about 2008 (Manton et al. 2006, 94; they, too, forecast overall U.S. expectancy at 65 to advance at least through 2022 in G form with zero year in the later 1920s). Life expectancy at 85, meanwhile, increased via G from 1935 through 1999 (t_0 roughly 1926), and now seems to be following another G path through 2022 that is based about 1952. *Active* life expectancy at 85 is projected to take a G trajectory for 40 years following 1982 (based about 1987, or proportionally significantly steeper than the increase for those 65). The number of *disabled* years experienced after 65, meanwhile, first grew in G fashion between 1935 and 1982; but with further medical advances focused upon the elderly it has contracted via D, a trend that is expected to last as far as 2080. At 85, time spent with disability also expanded in G fashion up to the early 1980s before decreasing across the present century--in this case via accelerating C (ibid.). Improvements in care from the 1930s into the

1980s extended life, but at some cost of more years with disabilities. Since then, additional life expectancy has been accompanied by less time disabled. Both changes have taken G-related forms.

So have sex differentials in life expectancy at birth. Data around 1952, 1977, and 2002 suggest that the excess of female over male e_0, always somewhat positive, widely surged in G' fashion among 29 high-income countries (Glei and Horiuchi 2007, 145; limited earlier evidence indicates comparable though weaker swings, up and then back, in Sweden, Denmark, and the Netherlands--peaking around 1840 or 1900--but only gradual, non-reversing increases in Finland and England and Wales: p. 147). The postwar pattern is universal among the nations of this group of 29 which have evidence since 1900: England and Wales, France, the Netherlands, Denmark, Iceland, Norway, Sweden, Finland, Switzerland, and Italy. It is probable in Australia, Belgium, Canada, the Czech Republic, the former West Germany, and New Zealand. In Bulgaria, the former East Germany, Hungary, Japan, Latvia, Lithuania, Russia, Slovakia, Spain, and Ukraine, in contrast, the difference around 2002 was *greater* than it had been 25 years before. Across the 20th century prior to 1977, continual increase prevailed: via G anchored in the early 1900s for Australia, Canada, Finland, Italy, and Spain; probably in E shape for England and Wales, France, Switzerland, Denmark, Norway, and Sweden.

What, following World War II, might have made life expectancy for females in developed countries so generally increase then fall back in something like G' fashion? The adoption of deleterious behavior like smoking or drinking, then its cessation, has been cited. From 1952 to 1977 improvement between ages 60 and 79 universally did most to further advantage the prospects of female at birth. In contrast, narrowing of the lifetime sex differential thereafter, between 1977 and 2002, for many countries, involved not only this age group but others from 0 to 80. Persons over 80 contrarily contributed toward *elevating* the differential. Does, finally, the distinction during decades of the 20th century before 1977 between accelerating E increase in sex differential and its G-type decelerating alternative cast any light upon the dynamics of mortality during this earlier period?

Several factors have been invoked to explain contemporary international variations and historical changes in life expectancy. Notably, in **cross-cultural comparison** at various points in time, countries with higher GDP per capita generally have had longer life expectancies at birth (Preston 1975, 245-47, for 1900s, 1930s, 1960s; Riley 2001, 129-39, for 1900, 1940, 1960, 1997; Soares 2007, 248, for 1960, 1990, 2000). For 1990 and 2000 moreover, among countries with at least $1,000 annual income per capita through the richest with about $20,000, e_0 roughly increased via G with minimal scatter past $8,000. Such an underlying curve is based upon about 26 years of life expectancy for a negative income of approximately -$1,800 (Soares, 248). With better nutrition, meanwhile, above about 1,600 *kcal* per day to over 3,750, the underlying trend for life expectancy as of 2000 improved likewise via G from a base of about 27 years at 1,850 calories (in contrast to the linear path offered by the author). Daily calories, furthermore, rose with annual income from $1,000 to $20,000 also in G fashion, based around 1,000 *kcal* at -$2,200 (ibid., 255).

Table 8.2 estimates changes **over time** in life expectancy at birth in 20 countries of Latin America and the United States. It also relates these to approximate trends in GDP per capita and literacy (Astorga et al. 2005, 791, 788, 790).

From the United States through Ecuador in the table, life expectancy at birth increased in G fashion first across the early decades of the 20th century, then from there to 2000. These gains, with some variation in start and finish and in base year, in each era broadly paralleled contemporary G-shape advances in GDP per capita and literacy. Improvements in material well-being and education fostered health and its impact upon longevity. In the relatively poor countries of Cuba, Haiti, the Dominican Republic, Bolivia, and Paraguay, while G-form advance in literacy again contributed to better life expectancy, concomitant gain in GDP per capita apparently took quite different shape: reversible G’ in Bolivia and Paraguay (cresting about 1990) and accelerating E in the Dominican Republic. The economic trends for Cuba and Haiti are not given.

In Brazil, Chile, Colombia, Nicaragua, and Peru, the first 20th-century improvement in life expectancy took E shape instead, and comparable accelerating increase appeared in wealth as well. Literacy, however, still spread via the G path that is so common in Latin America (in these cases anchored in the 1890s). During the *later* 1900s in all these countries, however, comparable G movements appear simultaneously in e_0, GDP per capita, and literacy.

In the rest of Latin America, during the postwar decades of the 20th century the presence of G-type increases in all three variables likewise prevails, making this a universal experience for the region (except Argentina, Costa Rica, Panama, and Paraguay, where a *single* G trend in literacy lasted the whole century--as in the United States). During the first half of the 1900s, however, Uruguay, Costa Rica, Panama, Venezuela, and perhaps Guatemala also saw life expectancy improve via E rather than G, though no comparable movement occurred in wealth, as it did elsewhere. For some reason, literacy expanded exceptionally via E in Venezuela and Guatemala. What policies or practices might have made that happen?

How did so much uniformity of change, especially following World War II, pertain throughout Latin America, particularly in the diffusion of literacy but also in improving life expectancy and GDP per capita? In the principal variation, in Brazil, Chile, Colombia, Nicaragua, and Peru E-shape increase in mean wealth seems to have imprinted this type of trend upon life expectancy during the earlier decades of the 20th century. In Uruguay, Costa Rica, Panama, Venezuela, and perhaps Guatemala, however, e_0 lengthened via E without such support from prosperity. How did that occur? What, finally, would one expect to find in developing countries of Asia or Africa: the same relationships among the three variables of Table 8.2 as better health, livelihood, and education have diffused across the modern world; or different connections, perhaps because those other countries have lacked the uniform Catholicism of Latin

America? This regional example, in spite of the questions it still raises, has taught us more about how life expectancy has improved historically.

Life expectancy **by age** has likewise taken G-related shapes throughout the historical record. Table 8.3 illustrates this point with several examples from national populations of the 20th century.

Across most of the life span, life expectancy by age falls in C form. A few modern illustrations appear in Figure 8.1a. From age 1 or 5 forward, e_x quickly converges with the C path from above. Then late in the life cycle it diverges back above the C trajectory. In France as of 1926, this departure in old age was negligible (Fig. 8.1a, left panel). In 1911 Australia, even more so in 1981 China, after age 70 more marked divergence appears. Estimations for Sweden (both sexes) in 1903 and 1953, Greece in 1928, those districts of Canada that had adequate registration in 1921, Argentina in 1964, El Salvador in the 1960s, and Madagascar in 1966 provide other examples (Tab. 8.3) of historical populations in which C-shape decline characterized reduction in life expectancy from age 20 or before into the 70s, with still little departure from that basic path by 85.

The *righthand* panel of Figure 8.1a, however, illustrates cases in which after about 65 a readily perceptible new trend lifts e_x systematically above the C path for the remainder of the life span. These curves in 1960 Tunisia, 1962 Trinidad and Tobago, and 1950 El Salvador take C' rather than C shape. C' is the first derivative of C. Second movements of this shape are similarly estimated in Table 8.3 for 1961 Sarawak, Honduras in the 1960s, 1975 Fiji, 1998 Sweden, China at three points between 1964 and 2000, and men and women of the United States in the1990s who currently smoked two packs or more of cigarettes per day (Fig. 8.1c).

Figure 8.1b and Table 8.4 demonstrate how both such successions of C then C' patterns in life expectancy and C paths without any significant C' follow-up have been common earlier in human history--for males as well as females. The exceptionally high-quality early historical data from Breslau for the two sexes together with which Edmund Halley worked in the late 17th century, for example, declines from age 25 through 75 along a C trajectory that also just barely runs below the rate for age 80 (Fig. 8.1b: Halley 1693, in Smith and Keyfitz 1977, 24, 5). John Graunt's calculations for London in 1662 and Johan de Wit's Dutch computations of 1671, in contrast, are estimated--in Table 8.4--to follow C form to about age 40, then C' shape thereafter (Smith and Keyfitz 1977, 5). What later-17th-century European conditions might have distinguished the experience of these two populations from that of Breslau? A largely comparable two-stage pattern, but with very steep, early-based C' decline across the 40's, characterizes what may have been the life expectancy conclusions made by Ulpian for Romans in 225 CE--though just what his calculations represented continues to be debated (ibid., 7-9; Figure 8.1b).

Similar two-step patterning--C through 50, C' from there through age 80--seems, Table 8.4 shows, to fit change with age for life expectancy in Norman Crulai around 1700 (Gautier and Henry 1958, as represented by Smith and Keyfitz 1977, 5). In the Chinese imperial lineage (Campbell 1997, 196-97), however, the succession of trend shapes was different. For males born between 1644 and 1739, and also from 1740 and 1839, for some reason C-type decline in life expectancy with age from 5 into the 40s was followed not by new C' movement but by second, less sharply bending trends of C shape (Fig. 8.2b) Among females born between 1644 and 1739, somehow the familiar order of patterns was reversed, with C' decline occurring up to about age 50 and C decrease thereafter. For more ordinary females in Daoyi and Gaizhou during the first half of the 19th century, however, the more familiar C then C' succession of trends in e_x appears. How Chinese attitudes about the sexes and about aging, or differences between elites and more ordinary people, might have generated distinct shapes of change in life expectancy seems worth considering.

Several sets of data from the 17th and 18th centuries in North America, meanwhile, indicate mostly C-type declines in life expectancy with age followed by C' trends later in life.

The shift of pattern appears earlier in the life cycle among colonial residents of Maryland and Virginia than in contemporary populations of New England. Eighteenth-century evidence from the Northeast, furthermore--with just C patterns for Wigglesworth's Massachusetts life table of 1789, for married Yale graduates of 1701 through 1805, for Andover females born in the first quarter of the 1700s, and in elite families of Philadelphia before 1800[7]--presages what 19th-century studies in the United States have found. There, C trends alone suffice to pattern data from the Philadelphia elite of 1800 to 1850, Salem, Boston, several New York counties, the city of Schenectady, and some counties of Pennsylvania--as they do for females in all registration areas of the United States in 1900 and Canada as of 1921 (Tabs. 8.4 and 8.3; Preston et al. 1972, 726). Just a lone C trend also characterizes Buffon's 1772 evidence on life expectancy by age for Paris and its surroundings, the data evoked somewhat later by Thomas Jefferson (D. S. Smith 1999, 596).

In parts of western Mexico studied by Cook and Borah (2: 1974, 384, 388, 393, 397), however, secondary, C'-shape decline appears in life expectancy by age for the long period between about 1880 and 1960. That is not the case for early 20th-century Peking (Beijing). Instead, for both males and females of the First Demonstration Health Station there from 1929 through 1933, e_x tapered off between childhood and about 70 in simple C fashion (Campbell 1997, 198).

A further insightful perspective on change in life expectancy with age appears in Figure 8.1c and at the bottom of Table 8.3. In a recent study of Americans of 'average' socioeconomic standing and health condition from 1991 through 1997 (Rogers et al. 2005, 283, 285), females and males who currently smoked two or more packs of cigarettes a day surrendered further time to live across the life cycle, first via C and then in C' fashion, not unlike people in general in many countries of the 20th century (Tab. 8.3)--or in western Mexico between 1880 and 1960 (Tab. 8.4) and 17th- and 18th-century New England, Philadelphia, the Chesapeake, London, Holland, and Normandy, or China between 1644 and 1867.

At the other extreme of the international evidence, American men and women in the 1990s who had *never* smoked experienced dwindling life expectancy with increasing age not only at higher levels than their compatriots but also, rather than C, via the more slowly bending H trend reversed with respect to time, H_r (as C is the chronological reverse of G, or G_r). Does this indicate--absent negative actions like the use of nicotine, alcohol, and other drugs or risky behaviors such as unprotected sex--that the ‘natural’ path for decline in life expectancy under optimum conditions is H reversed in time? As the human organism ages with the support of best medical practice, eliminating or controlling many historically all-too-familiar sources of mortality (including malnutrition when young), does life expectancy erode with additional years in this only slowly decelerating reversed H fashion? How might that hypothesis be tested; and what would its confirmation imply?

TRENDS IN OTHER PROPERTIES OF THE HUMAN LIFE TABLE: SURVIVORSHIP (l_x)

Life expectancy by age, or e_x, is one dimension of a **life table**. Life tables are based upon observed rates of death for persons of certain ages in populations. Often they distinguish males and females, who make significantly different contributions to demographic processes. Upon this evidence from actual populations are built tables of survivorship and life expectancy and related measures of how successive cohorts would die off and dwindle in relative numerical significance given these age-specific death rates.

Though the Roman calculations of Ulpian (ca. 225 C.E.) may have constituted such an effort (Trennery 1926, as excerpted in Smith and Keyfitz 1977, 7-9), the modern development of life tables was pioneered in England by John Graunt in 1662, working with London evidence, and Edmund Halley, in 1693, using high-quality data from the Silesian city of Breslau (now Polish Wroclaw). Other noteworthy early but helpfully accumulating contributions toward constructing life tables were presented by Johan de Wit (1671), Antoine Deparcieux (1746), Daniel Bernoulli (1766), and Émmanuel Étienne Duvillard (1806) (Smith and Keyfitz 1977, 1-5).

From the start, the desire to compute more accurate risks and pricing for annuities did much to motivate advances in calculating deaths among humans. This interest bred attempts to model in a general way how mortality changed across the life cycle, in survivorship to particular ages or in age-specific rates of mortality. Analyses of this sort by Benjamin Gompertz (1825) and William M. Makeham (1867) laid the foundation for periodic modern re-explorations, which continue today. These two early treatments are still thought to retain much value in outlining the behavior of current evidence, though various other patterns of change, including logistic approaches, are advanced to account rather better, it is argued, for movements over the whole adult life span, including the very young and the very old (for example, Bongaarts 2005, 24).

It is proposed here, however, that modeling life table values by means of the G-based forms that appear in them during successive stages of aging depicts repeated change across most of the human life span--especially during its most consequential years of reproduction and support for population--more accurately, more generally, and more insightfully than these recent interpretations as well as the original historical insights upon which it is based. Most centrally, our novel, G-related approach captures in a precise, parsimonious, and very general way how in population after population--across the years of reproduction, household formation, child-rearing, education, most lifetime production and consumption, and also increasingly more years of young or old dependency--cohorts die off and are replaced by new members of society. Regardless of some obvious departures from the basic C trend among the very young and the very old, in other words, thanks to the long, crucial segment of the total life cycle that it occupies, this single pattern in mortality by age dominates the renewal process and has vital implications for how all sorts of change pass through populations. That is why G-related forms are so ubiquitous not only in demographic development but in social, cultural, and economic trends as well.

The measure l_x calculates how many of an original birth cohort (frequently 100,000, sometimes a base of 1,000 or 100 or 1 is used instead) would survive to particular ages given the age-specific schedule of death rates that is observed in a population. Since the pervasive C-to-C' succession of paths deals with the course of survivorship only from some point in childhood or adolescence forward, these movements are labeled "second" and "third" trends within the life cycle. Generally, though, a shift in advanced ages from C-shape decline to atrophy in C' form is more evident here than in e_x. Indeed, all 16 fits of l_x for modern populations and all 36 estimations of it that are added to them for broader comparison in Table 8.5 display this succession of curves.

Fits of l_x for England and Wales, Japan, Chile, and New Zealand (Figs. 8.2a through 8.2d) show how, after an ever-shorter initial period of heavy infant and early childhood mortality, through a century or so of demographic change into the 1980s the C trend of survivorship with age up to later adulthood (on average, about age 50) historically both shifted upward and flattened out, to have a much later zero year as well as a higher level through adolescence, young adulthood, and middle age. Least change occurred in New Zealand, where survivorship was by comparison already high in the 1880s, most in Chile--where as of 1909 some 40 percent of live births expired by age 10. Comparable shifting is estimated for the United States between 1900 and 1985 and Italy between 1881 and 1983, while approximated trending for Mauritius at 1966 and 1980 and for Taiwan at 1920 and 1966,[8] demonstrates how change in this manner continued well through the 20th century (Tab. 8.5).

The ubiquitous third-stage decline of l_x in more abrupt C' fashion, likewise shifted outward as well as upward over time in these national populations. It did not, however, generally displace the preceding C trend any earlier, which the starting ages for C' trends in Table 8.5 indicate (mean of 47.5, standard deviation of 6.88, including the *first* C' trend of West Cameroon). Such stability in transition suggests that the aggregate increase in mortality from various causes which generates the C' trend in survivorship during later years of life is particularly sensitive to biological age, and is not altered all that easily. The relatively tight range of *zero years* for this form of change--mostly between 35 and 50 with mean of 42.3 and standard deviation of 6.3 (evident in the right side of Table 8.5) signals the same. The implication is that mortality between about 5 and 50, like earlier death in infancy and childhood (which determines the level where C-shape decline *begins*), has been more malleable to modern health-related practices than losses later in life. This is hardly a novel proposition; but identification of repeated C-to-C' transitions of curve in one population after another offers a simpler and more general way of making comparisons and contrasts across populations, and of exploring causation.

During the first decade or so of life, however, the general *level* from which such sequential C-then-C'changes in l_x will subsequently unfold is established by the strength of infant and childhood mortality, which together decline in some decelerating fashion. Illustrations in populations covered in Table 8.5 and its related figures 8.2a through 8.2h involve such early losses for females by age 5 or 10 that entail: 42.4 percent of total births in 1881 Italy, 40.8 percent in 1920 Taiwan, and 37.7 percent in 1909 Chile; more moderate depletions of between about 24 and 30 percent in 1964 West Cameroon, 1966 Madagascar, 1861 England and Wales, the 'colored' population of South Africa in 1941, and 1899 Japan; and very limited casualties (by historical perspective) in the 1980s for countries such as New Zealand, England and Wales, Chile, and Japan, with only slightly greater early attrition for 1981 China and 1966 Kuwait. These losses through infancy and childhood crucially establish the level where the second or C phase of decline in life expectancy with age begins.

The height at which the *third* or C' phase for shrinking l_x starts to depart from its predecessor in turn depends upon the target or zero year for the preceding C-shape decline. This determines how much such a curve will have reduced life expectancy since childhood before the C' trend takes over. While the typical age of transition from C to C' has been relatively stable in modern times, the new trend can begin at quite varying points along the succeeding C' curve itself. In England and Wales as of 1985, for example, the C' path takes over near its own zero year around age 49; in 1861, for the same population the C' trajectory appears only after about age 65, some 35 years following its t_0, where survival is decreasing very steeply. Along with the tendency for zero years in C' patterns in all populations of Table 8.5 since 1940 to cluster around the lower 40s,[9] this suggests a fairly common way in which modern medicine and living conditions, though they extend life, do in the end confront limits with age.

Some earlier, often more local, evidence on patterns of survivorship from the late 16th century into the early 20th (Figs. 8.3a and 8.3b; Tab. 8.6) helps--in conjunction with these more recent national patterns--to clarify similarities and differences among populations across various eras and cultural settings, and to identify likely reasons for them. To begin, among all these data one particularly notable and insightful exception stands out: mid-17th-century London .

In Graunt's calculation for that dangerous metropolis (males and females together), no less than 75 percent of those born had died by age 26. The London losses contrast with only something like 40 percent, just over half as much, in the smaller Silesian city of Breslau a generation later--as of 1693. The worst modern attrition among the national illustrations of Table 8.5 amount to around 50 percent over a comparable segment of the life span (by age 25) in 1881 Italy, 1909 Chile, and 1920 Taiwan (Preston et al. 1972, 224, 226; 384, 386, 144, 146, 700, 702).

Based on 1662, Graunt's analysis does *not* reflect the plague of 1665 and the great fire of 1666. The middle 1660s, however, marked the peak of London's deficit of births relative to deaths, a broad 17th-century G' surge in population loss that was not due simply to those two famous shocks to the city (Harris 2003, 187--based on Wrigley and Schofield 1981, 167-69). Simply put, the demographic history of this huge central place for its time, notorious for its destruction of lives during the period, does not properly compare with the experiences of diverse national peoples or local, often quite rural populations during more ordinary epochs. Though clearly unusual, Graunt's calculation's may be significantly accurate.

For contemporary 1625-through-1699 Colyton, in rural Devon, the pattern of survivorship is available only from age 25 forward (Tab. 8.6, "Western Communities").

Automatically, therefore, all levels for subsequent C-and C'-shape attrition in l_x will run higher (by the extent of losses prior to 25). The *timing* (and therefore the slope) of the C' trend between about 40 and 70 for the seventy-five years around 1662 is, however, very similar to that for contemporary London (t_0 around age 24 vs. 20). In contrast, the C decline for younger, middle-aged adults is much flatter than the London pattern (based around an historically common age of 48 rather than the extremely low 23 of the metropolis). The implication is that while 'senescence' affected survivorship approximately the same way after about age 50 in city and countryside, preceding 'background' losses from metropolitan health conditions were comparatively devastating (reducing survivorship from 25 to just 10 percent of the original birth cohort, even after an extreme prior pruning of children and adolescents).[10] This fits the historical narrative for 17th-century London (Wrigley 1967; Harris 2003, 187). Young adults, who predominate among metropolitan in-migrants, are famously vulnerable historically to the health threats of big cities.

On the other hand, the Colyton data also reflect not only rural advantages over London but the high adult as well as young mortality of the 17th century that affected England as a whole, not just the metropolis (Figs. 1.1, 1.9, A.1a, A.1b, 1.8a, 1.8b). For 1538 through 1624 and then 1700 through 1774, largely 'background' mortality up through middle age reduced survivorship markedly less acutely than during the intervening period of 1625-1699, with t_0's of 70 and 66 for l_x from age 25 through 50 or 60 as opposed to just 48. Though less different, trends in Colyton of third-stage or heavily 'senescent' mortality after age 40 in both earlier and later eras likewise cut downward somewhat later in life--with zero years of 28 and 30 as opposed to London's 24 for the period around 1662.

The modern national pattern in Table 8.5 most comparable to Graunt's London is that for Taiwanese females as of 1920. There, however, the base year for the C curve came only at age 44 in contrast to the 23 of London, and l_x sank just from 49 to 31 percent between ages 25 and 45 (or lost 37 percent of the number surviving at 25 in contrast to the 60 percent in 1662 London over the comparable span). Even among females in the Qing imperial lineage between 1640 and 1739 (midpoint about 1691), the zero year of the C trend for survival to age 40 under conditions primarily of post-childhood ‘background’ mortality came only at age 36 compared with London’s 23 (Tab. 8.6, “China and Japan”). For these females, the C’ or *third* trend--reflecting an increasingly dominant effect of ‘senescent’ mortality--was likewise based at a later age than in London, about 33, though for Qing *males* (in this era as in two later ones) the early zero year for the metropolis (at about 20) was matched in all three eras reported. In all, the London experience of the 1660s was more exceptional in the pre-adult and the intermediate, mostly ‘background’ C phases than in the C’ stage, which is dominated by the dwindling survivorship of old age.[11]

Among other western *cities* in Table 8.6, attrition by about age 26 in 1693 Breslau and in 1750 Hamburg amounted to about 44 percent in contrast to the huge 75 percent for London in 1662. By 1903-06 in Schenectady, New York, the loss over this portion of the life cycle had been reduced yet further: to 29 percent. First-stage or childhood and adolescent mortality apparently improved markedly with time. (In Peking around 1930, however, the attrition in survivorship for females by age 25 was still 40 percent for males, 46 percent for females.) Urban l_x comparably improved historically during the second phase. The exceptionally steep C trend for London (t_0 = age 23) leveled out to zero years of 52 and 56 for Breslau and Hamburg in the vicinity of 1720, then to about 88 years for Schenectady in the early 1900s (the point for males in 1930 Peking, though for females it was only 68). Before the 20th century, though, historical change in the third or largely ‘senescent’ phase of attrition may have had more to do with the size and nature of the city involved. Hamburg, a booming entrepôt for northern Europe in the 18th century, displays a C’ trend more like that of London ninety years before than the one for contemporary Breslau (curves based at 18, 20, and 29, respectively). Schenectady, however, does share a zero point that resembles those for several national populations in the early 1900s (the United States, Sweden, Chile, Japan--Tabs. 8.5 and 8.6) and Peking about 1930.

Among the substantial, diverse and aggregated, populations of Western nations and their regions--and also in smaller local populations--second, C stages of decline in survivorship with age display base years that range considerably, mostly from 60 to 80 (overall, from 48 to 97). Steepness does not simply reflect chronology. Asian trends before 1930 are by comparison consistently steep, for Japan and Taiwan as well as for the Qing imperial lineage between 1644 and 1890 (whose females suffered exceptionally sharp decline in second-phase survivorship). By 1899, however, the C-shaped trend of l_x for females in Japan already extended to age 60 with a target year as late as 70 (contrasting to from 44 to 53 for the three groups of Qing males). By about 1930, this more mortality-resistant type of pattern was also attained by females in the First Demonstration Health Station of Peking while even later and flatter contraction of survival with age (t_0 only coming at 88) characterized males there. Did significant improvement in survivorship after childhood, already present in Japan, come to at least parts of China in the 1920s? To what extent did big cities like Peking now take the lead in improving health rather than being especially dangerous for survival?

Together, evidence from Europe and North America indicates C-shape decline in survival between childhood and old age that repeatedly foreshadows later developments in Asia. In Silesian Breslau as of 1693, the trend for males and females together already resembles those for males in the Qing lineage born from 1740 though 1899 and Taiwanese women as of 1920. Among females, the Japanese trend at 1899 is much like that for England and Wales and several New York counties four decades before, around 1860, and this pattern in timing (at a lower level) still characterized the experience of Peking residents a generation later, around 1930, though survivorship for males there now tapered off more flatly (as among females in Schenectady during the first years of the 20th century). In all, as improvements in l_x during the first years of life (before the 20s) advanced with time since the 17th century--with the West leading the East and Japan preceding China, but parts of Europe and the United States moving closely with each other--likewise, much the same temporal and cross-cultural relationships applied among trends of the subsequent stage of survival from childhood through middle age. Everywhere, however, this ‘background’ pattern by age, unlike its predecessor, always took a single, C, shape--which has been found for many modern populations in Table 8.5.

The C’ trends that repeatedly characterized the third-phase, heavily ‘senescent’ decline in survivorship for older adults improved noticeably over the years among western nations and their regions, though not among smaller populations before 1900. For Graunt’s London population of 1662, and for Qing males born in the three periods of 1644 through 1739, 1740 through 1839, and 1840 through 1899, though the starting point moved higher because of the way that the C phase of l_x grew flatter with time, the C’ pattern according to which survivorship dropped off through older ages still tended to be based near 20. In 1693 Breslau and in several New York counties and also England and Wales in the middle of the 19th century (much as in Italy at 1881), and in Taiwan as late as 1920, the zero year of the C’curve was appreciably delayed: into the later 20s.[12] In Schenectady, the registration states of the United States, and Japan in the vicinity of 1900, and in Peking around 1930, on the other hand, the t_0 for the C’ trend came only in the middle to later 30s, much as in Chile at 1909 or several populations that still well into the 20th century were modernizing rather more tardily, such as Portugal at 1920 or Madagascar, Indonesia, the Indian and Pakistani females of Malaysia, and the inhabitants of Guyana in the 1960s (Tab. 8.5).

In all, curtailment of survival in C’ shape during the later years of life not only was common among populations from the 17th through the 20th centuries. It also tended to shift outward gradually over time as health and welfare for the elderly improved. The patterns for local populations before 1900 in Table 8.6, for instance, have a mean zero year at 24.5 compared with 36.7 for Schenectady and Peking in the early 1900s, and 42.3 for the several dozen national populations of Table 8.5. The latter include earlier cases such as 1861 England and Wales, 1881 Italy, 1899 Japan, and 1920 Taiwan as well as later populations living in ‘less developed’ conditions like those of West Cameroon, Madagascar, and Indonesia in the 1960s--instances whose C’ trends paralleled those of Schenectady and Peking early in the 20th century. What is it about the kinds of mortality that cull older persons this way that collectively takes C’ rather than C form with increasing age and has maintained this shape over three centuries as survivorship has widely been improved by better living conditions and practices?

In short, historical changes or comparisons in survival are best understood through viewing l_x across the life cycle in three phases. Each of these repeatedly displays its own characteristic pattern of reduction. The C path between childhood and old age lasts longest. It is followed by C’ erosion in survivorship through the remainder of life. The brief opening phase of decline in l_x with infant and childhood mortality does not pattern as specifically as the other two, though certain characteristics, repeated in changes or comparisons, can be identified. Historically, this earliest stage of mortality has had the most powerful impact on overall life expectancy through time or cross-culturally, setting the level for all that follows. Its impact, however, has dwindled markedly with time, and it now does much less to distinguish populations from each other.

Among those born from 1644 through 1739 for example, attrition in the Qing lineage eliminated 45 percent of males and 48 percent of females during the first decade of life.[13] To make a big-city-to-big-city comparison (Peking), this loss resembles approximately 52 percent attrition by age 10 for the overall population (both sexes) of London in 1662.[14] The Chinese imperial family, needless to say, experienced better living conditions than the large majority of residents in Restoration London, and the mid-point year for *births* in this urban group arrived three decades later than in London, only in 1692. One implication of the comparison is that Graunt’s very early contemporary computations are not wildly inaccurate. Another is that the largest cities, whether East or West, have historically suffered comparable levels of infant and childhood mortality. In contrast, casualties during the first decade of life in Breslau, even for the population as a whole, amounted to only 34 percent, an appreciably healthier record that for even the elite in contemporary Peking. Was the good record-keeping that attracted Halley to employ these data for his analysis reflective of superior management of public health in that Silesian city? Or, did Breslau's smaller scale simply make it a safer place, with less congestion and less life-threatening poverty?

Among the males of the Chinese imperial lineage born later, from 1740 through 1899, the degree of childhood loss shrank to about 30 percent. For one area of Peking (served by the First Demonstration Health Station: Campbell 1997, 198) in the much later period 1929 to 1933, however, attrition by age 10 for both males and females of the *general* population was still a little higher (36 percent) than found among the male Qing lineage members born from 1740 through 1899--and greater than what was found for Breslau already by the 1690s, more than two centuries before.

These early-20th-century losses in Peking by age 10 represent some improvement relative to the 41 percent for all females on occupied Taiwan as of 1920, but remain appreciably more than the less than 26 percent already prevailing among homeland Japanese girls in 1899. This last Asian historical example of attrition during the first decade of life approximately equaled loss by age 10 for females in seven New York counties 1850-1865 and bettered the 28 percent for girls in England and Wales as of 1861 (even more, the 42 percent for Italy in 1881). While in the 1880s some 32 percent of children died during their first decade in the middle-sized New York city of Schenectady, by the early 1900s the percentage attrition there had contracted to the low 20's, as in all states of the United States which had registration and in seven Pennsylvania counties examined by Haines. By about 1930, this early pruning of lives in Schenectady shrank to 10 percent, on its way down to the mere 1.1 percent characteristic of the United States and of England and Wales in the 1980s (Wells 1995, 420; Haines 1976, Appendix).

An overview of childhood survivorship historically, furthermore, indicates (from graphing that is not shown) a recurrent reduction over time for female attrition during the first decade of life. The amount of erosion in l_x by age 10--in England and Wales from 1861 through 1960, the United States from 1900 or sooner through 1950,[15] and Italy between 1881 and 1985--in each case declines according to a C trend targeting about 1920. This is the shape of change through time found widely in preceding chapters for death rates in general, and for infant and childhood mortality in particular, during the transition to modern demographic regimes. Somewhere between 1908 and 1940 Japanese losses similarly assumed contemporary C-shape reduction as far as 1970, while Taiwanese girls died off in parallel contracting fashion from 1920 through 1965. In New Zealand across the first half of the 20th century (1901 to 1950), the proportion for young female losses came down in C form somewhat more tardily, with t_0 the middle 1930s. Still later C-type decline between 1920 and 1970 in Chile had its zero year only near 1950.[16] How much these improvements during early life have come from rising living standards as opposed to better public health and sanitation, an ongoing debate in the literature (for instance, Campbell 1997, 181-82), has to be left to detailed studies of particular populations and their environments. But betterment over time consistently took C form.

Though those with more generous resources (like those in the Qing lineage) fared better than other members of their society, and residence in a major city could generally increase the risk, the historical tendency since the 17th century has been for infant and childhood survivorship, for instance by age 10, to improve as losses at the beginning of the life cycle ameliorated. This decelerating initial decrease of survival across childhood determines the point from which subsequent C and C' trends during the life cycle begin, thus doing so much to generate overall levels of mortality for a population. In one possible insight as to how the trend for early l_x has been shaped, the extremely deep and lasting decline of survivorship up to age 16 in Graunt's London may have taken D' form (Fig. 8.3a; alternatively, D through age 26). This suggests that this G-based decelerating path of erosion is a possible upper limit for the consequences of heavy, sustained early mortality. As fewer losses are digested in other populations, the bend of deceleration--here, exceptionally *not* fixed by the $e^{-.03}$ rate or speeding up with its derivative--becomes sharper and sharper. The path of survivorship during childhood, the first of three phases of decline during the life cycle, not only drops less but fails to last as long before background C-type contraction appears (Figs. 8.3a and 8.3b).

HOW TRENDS OF DECLINING HEALTH AND CAPABILITY WHILE AGING RESEMBLE PATTERNS OF SURVIVORSHIP

Physical properties of living humans, not just records of death but characteristics of the unhealthy and even measurements of the healthy, have provided bases for fruitful insights with which to compare populations and to follow change in them over time. Most of these chronological perspectives, too, take G-based trends.

Records of **height**, most frequently kept by armies for young adult males or by those in charge of other unfree persons (slaves, bound or contract servants, convicts, controlled migrants), have for a generation now been used effectively to distinguish levels of wellbeing among various types of populations and to reveal trends in welfare. Historical changes of just a few centimeters (around averages of mostly 160 to 170 cm. for men, for example) do not, however, meaningfully follow G-related patterns to scale. Proportionally, they are extremely flat, curving almost imperceptibly (even more so than movements in the age of first marriage around averages in the low 20s, which have been discussed in preceding chapters). Nonetheless, if the series are re-stated as variations in excess of a base level that is set a centimeter or two below their actual minima, proportional changes in them follow trends that accelerate or decelerate in familiar ways as they rise or fall. Even though they take G-related trajectories which are still affected somewhat by the base level chosen and by the degree of spread in the evidence above this point, the curves of these paths (upward or downward, accelerating or decelerating) facilitate some insightful comparison with the unadjusted G-based patterns of other variables.

In this somewhat arbitrary fashion, Table 8.7 culls from some historical studies of heights patterns of change in this indicator of human wellbeing. Most of the trends are for male caucasian military recruits. The exceptions are noted. During certain time periods there has been considerable sharing of patterns of change in height. Some insightful differences have also occurred.

Among those born from the middle of the 18th century into the early years of the 19th, military recruits across Europe--in Sweden, Lombardy (Northern Italy), Hungary, Bohemia, France, England, and possibly Bavaria[17]--became shorter in something like D manner (Komlos and Baten 2004, 194, 198; A'Hearn 2003, 272). That is, differences from the base levels of height first declined relatively quickly then progressively leveled out following the ubiquitous minus .03 rate of decline in proportional change. Losses during these trends ranged from about 2.2 cm. in England and Bohemia, where D-shape decrease in height lasted for 40 and 25 years, to more like 5.5 in Lombardy and Hungary, where it persisted for 90 and 75 years respectively. Actual levels for those born at the beginning of decline, in the middle of the 1700s, ranged from about 169.5 cm. in Sweden to around 167.5 cm. in England. At the end of this phase of D-shape decrease, the resulting spread was roughly from 164.0 cm. in Lombardy to more like 167.0 in Sweden. The height of soldiers in Lombardy and Hungary, where loss lasted longest, fell most: by about 5.5 cm.. Loss of stature was least in England, Bohemia, and Sweden: on average around 2.3 cm.

Such particulars about absolute starting and ending levels and amount of change are of course evident more precisely from the tables and figures of the various studies that produced the data than hey are in the trending of Table 8.7. Unnoticed in the prolific international analysis so far, however, is just how similar in shape these historical changes were. That is, not only did declines occur in many populations during this era, a fact that has been well noted; they all also very generally followed the D path. What was at work after about 1740 that so widely across Europe reduced stature in this decelerating pattern, first faster then slower? Did the decline reflect a widespread change in European health; or did the international, even intercontinental, wars of the later 1700s and early 1800s force military recruiters and conscriptors to scrape the barrel? Comparing equivalent trends for *females* and for men outside the military would greatly clarify the answer.

In North America, for example, during this same period the height of native-born white males, in contrast, *increased* about a centimeter--in G fashion--for those born between 1765 and 1830 (Haines 2000b, 171). Most change occurred among those who, while children during the revolt, attained military age in what was peacetime for North America (between the Peace of Paris and the War of 1812). More selective peacetime recruitment seems more likely to account for greater height than healthier up-bringing during the Revolution.

What did decline via D in the colonies between about 1740 and 1790, however, was the height of male *slaves*--from about 174.0 to more like 172.5 cm. (Komlos and Baten 2004, 194). Consciously picked mostly for heavy physical labor, these men were about 5.0 cm. taller than contemporary Swedish soldiers whose decrease in height their shortening paralleled in D manner for a few decades beginning with those born about 1740, or in their 20s only beginning in the 1760s. The Atlantic slave trade attained its peak during this period--especially for North America, which was a marginal market for even just the British segment of the international business (Harris 2003, 97; 102, 163-64). Slavers had to penetrate further into the interior, and both westward and southeastward along the African coast, to obtain supply (ibid., 107-09, 143-46). Between about 1730 and 1780, as imports to North America surged to a crest (102), the proportion of males within the British trade declined and more women and children were included (trends associated with scarcity that characterized other shippers as well; 362, 366). Meanwhile, as prices rose--in the New World (notably in South Carolina, starting in the 1740s, especially once the Caribbean islands ceded by France in 1763 had to be stocked with labor) and in Africa--shippers invested more in keeping their valuable cargoes alive and losses on the voyage declined (374-75; 379-87; 394-96). Decreasing stature for slaves in the later 1700s, in short, reflects supply and demand in this particular labor market rather than living conditions in North America.

Similarly, the stature of *servants* in England receded in D shape for those born between about 1755 and 1815 (Komlos and Baten 2004, 197). Seeking men about 20 years old between 1775 and 1835, employers of this group were competing not only with the British military for manpower but with the entrepreneurs of the industrial revolution. Urban wages, for example, gained significantly against rural ones into the 1830s, especially in the North and Midlands, as the fastest shift of workers from agriculture into manufacturing occurred between 1800 and 1835, though real wages and living conditions generally declined up to about 1815 in spite of the new form of economic growth (Ch. 10? Figs. 12-11, -4, -1; G Clark, wages and labor force). For English servants born between about 1755 and 1815, both deteriorating conditions during childhood and competition in the labor market as adults worked to reduce stature.

For native white American males, increase in height that took G shape had also appeared earlier, first of all among those born between about 1710 and 1765. It seems reasonable to encounter across the majority of the 18th century some gain in wellbeing among such boys and young men. The colonial economy, for example, matured during these years to the point where its leaders could seek to be more independent from the homeland. Prices for colonial products flourished (Harris 1996, 473-74). Similar G-shape gains in stature for French soldiers born between the 1675 and 1750 likewise may have begun with improving standards of living up to that point (Komlos and Baten 2004, 198; Wrigley 1985b, xxx) As noted, stature subsequently diminished in D fashion for French army recruits born between 1755 and 1785. These men were boys during the degeneration of French life that fostered revolution. They were then of potential military age during a quarter of a century of sustained conflict between 1792 and 1815, when more and more were asked to serve first the defense, then the European hegemony, of France--an immense draining of national manpower. The institutional and socioeconomic changes of French life that were inspired by revolutionary values can readily be expected to have improved the living conditions for those born between the 1780s and the 1820s, while the shift to peacetime military recruitment among men who were turning 20 between 1805 and 1845 no longer pressed so close to the margin. Perhaps most importantly, how much did the young during this era benefit from the industrial development of France, much in a distinctive national way which relied less on large concentrated factory production than in England, more on relatively small, relatively local firms (Habakkuk). In England, meanwhile, the first half of the 19th century began to witness some fruits of the new economy accrue to workers--in G-shape trends (Ch. 10? food puzzle Fig. 12-7).

When the advantages for England of an early lead in industrial development began to dwindle as other nations started to compete successfully, living conditions for those likely to become military recruits (aggravated by several international epidemics that damaged the young as well as killing them off) apparently deteriorated during the second half of the 19th century, lowering average height (Tab. 8.7). In England, for some reason the trend took C shape between 1841 and 1881. In a few of the communities of eastern Belgium that have been studied (in the province of Liège; most clearly Limbourg and Verviers, where urban conditions worsened (Alter et al. 2004, 238), in the Netherlands, and in the United States, D-shape decline, which starts more swiftly then levels out rather than accelerating, appeared instead--beginning among men aged 20 between about 1825 and 1865, or rather earlier than in England (Haines 2004, 250-52; 2000b, 171). The decline in the United States, meanwhile, was greater among ordinary northern military personnel than among West Point cadets and free African Americans; most among the sons of farmers but least among boys from the middle class (Komlos and Baten 2004, 200-01). The drop was not an American “puzzle,” however, but an international phenomenon.

Then, from the late 19th century[18] into the 20th, in the Low Countries and the United States boys who would serve in the military began to mature to greater heights (Haines 2004, 250, 252) as public health improved, the benefits of industrialization spread across the population, and generally peaceful conditions did not make recruitment desperate. By World

War I, G-shape increase in stature was also under way in several areas of northwestern Argentina (Salvatore 2004, 208).

In several historical instances, finally, change in height seems instead to have taken the more short-term, reversible G' shape. In Europe, this pattern appears in 18th-century Bavaria and in several communities of eastern Belgium during the 19th century (Tab. 8.7; G' rather than G is most likely in Belgian Seraing and Tilleur). In the Bavarian instance, the upward surge may largely reflect the competitive nature of military recruiting in the 18th century. In the 19th-century Belgian province of Liège, economic change is more likely to have been the driving factor. Did young men in certain rural communities rather abruptly find other than military employment hard to obtain?

The G' pattern also fits heights of male and female indentured emigrants from northern India (modern Uttar Pradesh and Bihar) through Calcutta who were born between 1845 and 1892--or of age most likely to relocate between about 1870 and 1917 (Brennan et al. 1994, 280). The flow and ebb of migrations has been shown repeatedly to take G' form. The greatest height for those age about 25 came in the later 1890s. A G'-shape surge that would summarize the flow of indentured migrant workers to Fiji (where these northern Indians traveled through Calcutta) together with Queensland peaked in the first years of the 20th century--though the most numerous decade was actually the 1880s, while the emigration of all indentured Indians who went to British colonies quite clearly crested in G' fashion to maximize in the 1890s before receding (Harris 2003, 84). Stature, in other words, rose as the outflow became popular, but diminished as the demand began to outrun the supply. This happened for women a decade earlier than for men as this particular historical migration followed the pattern of so many others: families were significant in the build-up toward a maximum, but then more and more were replaced by single men as the best opportunity offered by relocation was used up (for instance, Wokeck 1999). Very recently, among North Korean refugees between 1997 and 2007 the tallest had been born in the vicinity of 1971 (Pak et al. 2011, 147). In a migration that ran its course within just a decade, this up-then-down pattern suggests that conditions during childhood were the determinant of stature rather than changes over time in the appeal of leaving.

Whether shaped by the health environment for growing up or determined through a competitive market for manpower that lowered or lifted standards of selection or the desire to participate in the sub-population studied, recorded historical trends in height have repeatedly taken G-based forms. Though the evidence has to be re-stated somewhat arbitrarily relatively to a typical local threshold, the familiar accelerating and decelerating G-related trajectories--all bending via .03--appear, both in rough approximations and where observations have been precise and frequent. Simply, this is the way that changes in height, a *physical attribute* of mankind, have diffused through populations in the same manner as alterations in many types of demographic and other *behavior.*

Both between childhood and old age and then within the later years of life, furthermore, indicators of objective or self-perceived **physical capacity** for the persons who remain alive after the culling of mortality have tended to erode with age in the same types of C then C' paths that are evident for sheer survival itself (Tab. 8.8; Tabs. 8.5, 8.6). Degradation of the human body, whether fatal or not, progresses across the life cycle in these same two stages and via the same two shapes of trajectory.

For four groups of British men active during various periods between 1750 and 1985 (Riley 1991, 181), actual working years between age 21 and 55 dwindled in C fashion much like life expectancy for the same segment of their life span (${}_{50}e_{21}$ also between 21 and 55). In each case, the curve for working life declined in C shape through a zero point only 1 or 2 years of age earlier than life expectancy, making the trend just slightly steeper.

If one can assume that the physical capacity and the mind set required to risk and to carry out crime to a considerable extent require the vigor and the outlook of youth, another indicator for decreasing vitality with age becomes available. Among U.S. males born to native parents during the early 1900s, age-specific crime rates between 32 and 75 declined in C fashion, also with t_0's in the 30s. For major crimes, the decrease was noticeably steeper ($t_0 \approx 30$) than the C-shape declines of British working life across the past two-and-a-half centuries. For minor crimes, however, the steepness ($t_0 \approx 37$) clearly fell within the range of those curves (Moehling and Piehl 2011, 814). Violent crime in particular can be expected to be more of a youthful undertaking.[19]

"Sickness Expectation" refers to the amount of time likely to be sick during the remaining years of expected occupational activity (Riley 1991, 180-81). With fewer working years left as the life cycle progresses, less absolute time should be consumed by sickness. As noted, across four groups of British men, remaining working time altered little over 250 years. Between 1750 and 1897, however, their sickness time did not contract as much while their working lives advanced as would be the case for their successors of the 1980s. By that latest period, thanks to modern medicine and public health, expected sickness time shrank proportionally along a C trend based about age 50 in contrast to 85 to 98, or much closer to remaining working time (whose zero year came about 33).

Among men who joined the Hampshire Friendly Society in the Connecticut valley between 1851 and 1911, having endured 8 or more years of sickness before the age of 50 significantly speeded up within the life cycle the curve of senescent mortality relative to that for individuals who had experienced 1 year or less of illness by that point (Gorsky et al. 2006, 589). The C' shape persisted; but it shifted 5 years from a base of about 1.1 in the vicinity of 43 for men 57 through 77 to more like 1.1 about age 43 for those 52 through 72. The main consequence of illness, in other words, was to speed up the age at which the senescent phase of mortality began without altering its pattern of decline.

When Americans born between 1911 and 1960 evaluated their own health, the composite result for various ages in successive surveys conducted between 1972 and 2002 was proportional decline in the rating between ages 25 and 64 that decreased via C with age before flattening out for the remainder of life (Easterlin n.d., Fig. 1). This curve, with its zero year at approximately

104, largely parallels the decline of survivorship with age in the society (with t_0 near 120 for ages 1 through 60 in 1985: Tab. 8.5).

In studies of what happens to human physical capacity with age (Burke et al. 1953 and Lynch et al. 1999; as cited in Burnette 2006, 707), strength of grip, arm, and leg similarly decline in C fashion between ages 20 and 80. With target years in the early 90s, these trends resemble those for background survivorship in many national populations of the middle or later 20th century (Tab. 8.5, “Second Trend”). In other words, in modern conditions both physical weakening and merely staying alive deteriorate in parallel C form until the point where senescent mortality dominates survivorship. Historically, furthermore, employers have recognized something like this pattern of deteriorating capacity with age. Average wages for male farm laborers in Derbyshire and Gloucetershire in 1833, for example, between age 35 and 65 fell in C manner with t_0 in the vicinity of 94. This compares with about 91 to 94 for three measures of strength in modern men (Burnette 2006, 702).

In two models advanced to represent survivorship for high-mortality populations, however--one based on Taiwan for East Asia, the other employing early 20th-century Chile for “Southern Europe” (Woods 2007, 379-80)--for ages 5 through 65 l_x decreased via C toward zero years in the vicinity of 50. While this decimation unfolded appreciably more steeply than the approximate trends for actual modern measures of physical strength (all in the low 90s), it was more gradual than either background survivorship or working life for Britons between 1850 and 1895 (C-shape decreases with t_0’s in the 30s). The model trends do resemble, however, background or ‘second stage’ losses by age in Breslau and Colyton in the 17th century, Hamburg and Hungarian Sárpilis in the 18th, or Madagascar in the 1960s--and the experience of males through age 45 in the Qing lineage, especially between 1740 and 1890 (Tab. 8.6). The similarity of the trend for sickness expectation among British men of the 1980s seems to be coincidental, perhaps a consequence of reliance on self-assessment for this one of four samples (Riley 1991, 180).

For the subsequent, predominantly ‘senescent’ stage of decline in survivorship, on the other hand, C’ decreases for the two models of modern ‘high mortality’ populations--with zero years in the vicinity of 26--are more like other historical trends (Tab. 8.6; also 1861 England and Wales and 1881 Italy in Tab. 8.5). While from 1982 to 1994 U.S. women died off considerably more flatly (t_0 about age 40 for a C’ trend that began only in the 80s), the pattern for men was not far different from those modeled for ‘high mortality’ contexts (Manton and Land 2000, 261-62; Woods 2007, 379-80). The same was true for the major crime rate of U.S. men with native-born parents, which contracted from 55 through 75 based about age 24. An alternative trending for minor crime rates among the same men ages 27 through 75, furthermore, shrank via a C’ curve based about 25--while major crimes among men 42 through 65 who had foreign-born parents contracted in C’ manner from a zero year around 34 (Moehling and Piehl 2011, 814).

The wage that Derbyshire and Gloucestershire farmers in 1833 on average paid increasingly older male farm laborers between 50 and 75, in contrast--their estimate of work value with age--shrank via a C’ trend based in the vicinity of 46. This is later than the t_0’s in the 30s for life expectancy and working life for British men in the 1800s, but declines more abruptly than modern physical strength, which apparently deteriorate more slowly: via C all the way to age 80 rather than dropping off via C’.[20] Did 19th-century employers, like many present-day ones, discount capacity with age more aggressively than workers’ abilities actually deteriorated--while not acknowledging experience and loyalty in wages? Or did physical capacity with age after 50 improve this much between the mid-19th- and mid-20th centuries?

If before the Civil War African slaves are estimated to have reached U.S. soil on average about age 25, they died off between age 35 and 75 along a C’ path anchored at 26 (based on Fogel and Engerman 1974, 2: 32). This decline closely resembles senescent survivorship for many other populations. The senescent stage, however, began for slaves very early by comparison, by about 35--matched only in China (evident by 40 in the imperial lineage throughout and perhaps Peking as a whole as late as 1930) and in Colyton and a few German communities during the 17th and 18th centuries. Even adults in Graunt's London of 1661 entered the senescent phase a little later in life. That slaves "wore out" this way, that the dynamics of old age arrived early for them, was apparently well recognized by owners. In the Old South as of 1850, *prices* paid for male and for female slaves between age 30 and age 60 or 70 fell in C' fashion based respectively around age 14 and age 6. These zero ages for the curves in male and female prices are young relative to the 26 for survivorship because purchasing planters paid for *anticipated lifetime returns* on investment. *Earnings*, too, are calculated to have declined in C' shape: for slave men between 40 and 70 with zero year about age 20; for females between 30 and 70 via C' from a zero point around 14 (ibid. 1: 76; 2: 82). And, though it must be remembered that the calculations are rough, a *C* (not C') trend all the way from 20 though 70 with zero year in the vicinity of 53 broadly represents the underlying ratio of female to male prices by age, a matter of some interest in the literature. (This ratio could be said to have decreased between 20 and just the 60s along a C path anchored at more like 46.)

In all, quite different measures or indicators of health, strength, and capability each attest that the second and third stages of survivorship--the C-shape phase in which 'background'mortality is proportionally its strongest and then the third or predominantly 'senescent' one of C' form--reflect universal underlying paths across the life cycle according to which the human organism weakens or erodes. These tendencies shape not only patterns of death but the loss of capacity that precedes death as people advance through the span of life. Such fundamental trends of deterioration, culminating in expiration with age, shape all dimensions of the human life table, the age structure of populations, and a wide range of processes that with time pass through the life table and age structures. And they repeatedly imprint G-related patterns upon them.

MORTALITY BY AGE: HOW ATTRITION RATES ACROSS THE LIFE CYCLE SHAPE SURVIVORSHIP

The empirical basis of human life tables is ${}_nM_x$, or the observed age-specific death rate at successive points in the life cycle (typically, in 5-year steps following age 5). All other properties, including e_x, and l_x, are constructed directly or indirectly from it.[21] This measure can be quite volatile across the life span. Figures 8.2a through 8.2h, however, demonstrate the way that ubiquitous E' trends have appeared in age-specific mortality rates for 16 relatively modern historical populations, and show how l_x reflects these movements. The figures also display alternative underlying patterns of the often very similar E shape to represent movements of ${}_nM_x$ during successive phases of the life cycle following childhood. Those possible trends of E form, the integral of E', are labeled in parentheses and plotted with lighter lines. The curvatures of the E' and E trajectories a couple of decades past their zero years are similar enough to make choosing a preference for representing the course of observed rates difficult, and not always very consequential. E, of course, is the vertical reciprocal of C, the pervasive form of trend in survivorship across the bulk of the life cycle. E' is the comparable opposite of C', which has been shown to appear repeatedly in third-stage l_x historically.

In general, upwardly accelerating increases of E' (possibly E) shape trim away survivorship in phases that are likely to produce the C then C' declines in l_x that have been noted. With each year of life, the observed age-specific mortality rate progressively carves proportionally larger and larger slices off the remaining population, giving l_x its diminishing pattern from age to age. Like l_x, ${}_nM_x$ follows distinct successive paths of acceleration--in its case upward--first through middle age then during old age. The impact of age-specific mortality on survivorship is not, however, a matter of neatly reciprocal trends in rates of death and continuing life, even though E' and C' or E and C are offsetting trajectories. The effect is more indirect. The age-range for phase movements in l_x and ${}_nM_x$ and even the number of stages evident for each variable, do not automatically match. The successive juxtaposition of trends in the two life table dimensions is nonetheless both significant and insightful.

The first tendency after birth, however, is for age-specific mortality (the solid squares in Figs. 8.2a through 8.2h) to drop very steeply from high levels in the first year of life to a minimum in the vicinity of age 10. This plunge in ${}_nM_x$ generates the typical initially sharp but quickly decelerating decline in l_x during early childhood that is observed particularly in populations before the late 20th century[22] and sets the *base level* for initially flatter but progressively accelerating subsequent increases in mortality rates through successive stages of the life cycle.

Following this early decrease in childhood, for most populations some equilibrating “bounce” back up in mortality rates has occurred during the next few years of aging. In most observed cases this has been quite an abrupt shift, and has been completed by age 15 or 20. A G-shape trend for ages 15 through 45 in England as of 1861 (Fig. 8.2a), however, provides one possible exception. Comparable tendencies for this decelerating G type of increase in mortality rate to emerge through early adulthood (not plotted in the graphs) also may appear in 1881 New Zealand and in some late-developing countries in the middle of the 1900s. Nonetheless, upwardly accelerating trends mostly take over by the 20s.

From this point in life forward, Figures 8.2a through 8.2h display two or three phases of increase in age-specific mortality that repeatedly take E’ (sometimes possibly E) shape.[23] Among these 16 graphed populations and 7 others[24] for which estimated trends are added in Tables 8.9a and 8.9b, the more modern cases begin with an E’ pattern in adult mortality that starts from a very low level relative to the past. This phenomenon occurs either in the form of a supplementary, opening E’ trend that was not evident before (England and Wales, Italy, the United States, and China) or as just a downward and backward shift in the kind of longer first E’ pattern observed in a prior period (New Zealand, Japan, and Chile) without adding a new phase (Tab. 8.9b vs. Tab. 8.9a).

All 7 populations of the 1980s (Tab. 8.9b) display such early, low-level E’ movements from age 20 or sooner into or through middle age. So do Mexico, Ecuador, and Fiji in the

1960s--and also Kuwait and West Cameroon, though the E' trajectories start there only by age 25 or 30. The average projected base year for these 12 E' trends during early adulthood in 23 populations would fall about 3.2 years before birth. In contrast, all 8 populations before the 1960s (Tab. 8.9a), along with Tunisia and Madagascar and the Malay sub-population of West Malaysia in the 1960s, lack an early E' pattern of $_nM_x$ with this timing.[25]

Because these initial, proportionally plotted E' paths for $_nM_x$ during early adult life rise from a very low base, they reduce survivorship very little in absolute terms for the time being. In England and Wales, for instance, the potential E' curve for mortality rates during early adulthood for 1985 starts from a level that is only 1/58 as high as the first movement of that shape in 1861. At low modern levels of overall mortality, even sharp *proportional* increases (particularly trends with E' form, which at first rise only very slowly), do little to curb survivorship until appreciably later in life.[26] Since ultimately 100 percent of a birth cohort always dies, this modern improvement in mortality for children and young adults makes further increases through middle and old age notably steeper than before (as in England and Wales between 1861 and 1985, Japan between 1899 and 1980, Chile between 1909 and 1980, and New Zealand between 1881 and 1985: Figs. 8.2a through 8.2d). But those greater later increases still generally take E' shape and create C and then C' declines in l_x.

Whether early or not, *all* 23 initial E' movements of age-specific mortality that appear in Tables 8.9a and 8.9b clearly started only several years *after* a C-shape decline in l_x had begun. This is because l_x records the *cumulative* impact of $_nM_x$. Its C trajectory is the integral of the reciprocal (C') of the E' type of path taken by $_nM_x$. Even before the first E' movement in age-specific mortality appears, l_x has aggregated the effects of the last years of declining mortality in childhood and the impact of the "bounce" of the death rate back up during adolescence to initiate a long-running C-shape decline. What could make l_x lead and $_nM_x$ follow like this? What is it that pushes survivorship into C shape so early in life? The ultimate basis for such shaping of demographic and related change by universal characteristics of human life tables is the topic of the next chapter.

No less than 21 of 23 populations in Tables 8.9a and 8.9b then display a second or first E' pattern of increase in age-specific mortality from middle age into old age. The two exceptions come from the females of West Cameroon and Fiji, whose opening E' patterns seem to continue right through this middle phase of adult death. The estimated average base age for these mid-life E' trends is about 14.6 years. These later, virtually ubiquitous, E' movements in adult age-specific mortality tend, not surprisingly, to unfold rather later in life where an early initial E' pattern has already appeared.

A final (most often second, less frequently third, occasionally even fourth) group of E' trends appear during the waning years of life--from the 60s or 70s onward--in 15 or 16 of the 23 illustrations. The one exception before the 1960s is for Italy in 1881 (though Chile in 1909 is questionable). As of that decade, Tunisia, Fiji, and Kuwait also lack such a secondary E' trend. The presence of a late, further steep rise in age-specific mortality through the 70s or 80s in New Zealand, Chile, and Japan in the 1980s (or Mexico in the 1960s) suggests how the E' pattern might appear still again during extreme old age in modern populations.[27] The estimated paths in Tables 8.9a and 8.9b for mortality rates during advanced adulthood (not including out through the 90s) collectively imply an average zero age for this late trend at about 29.8 compared with 14.6 with the mid-life phase when it comes first and -3.2 where extra E' increases through early adulthood appear.

Figures 8.4a and 8.4b provide a few examples of adult age-specific mortality rates that extend insight from the West and from China back further in time than the evidence of Figures 8.2a through 8.2h. Table 8.10 compares the particulars of these trends with estimated patterns of ${}_nM_x$ in 19th-century Britain and Sweden, Sweden in 2000, and recently developing nations of modern Asia

Among monks in the northern English county of Durham between the end of the 14th century and the early 16th, a single E trend from age 25 through age 80 might broadly approximate the rise of mortality rates across the adult life cycle (Fig. 8.4a). A more accurate representation, however, is provided by two successive E' trends, from 25 to 60 then from 60 to 80 (Hatcher et al. 2006, 681). For later England, in the 19th century, William Makeham's 1867 revisions of calculations by Gompertz generate for adult females[28] rates of age-specific death between 30 and 70 that, Figure 8.4a shows, accelerated upward in E' fashion (Smith and Keyfitz 1977, 285). This trend resembles closely what modern analysis indicates for England and Wales as of 1861 for ages 30 through 70, the next plot in the figure demonstrates. Much the same patterning likewise appears in estimates for both urban and rural British Foresters, for Odd Fellows (partially), and for contemporary mid-19th-century Swedes (Tab. 8.10). For roughly the same period, meanwhile, ${}_nM_x$ for women in several New York counties rose in E' form successively between ages 30 and 60, then from 60 to 80 (Haines 1976, Appendix). The New York data between about 10 and 30, on the other hand, seem to provide one more example of G-type decelerating increase in mortality rate from later childhood into middle age to accompany 1861 England from 15 to 45. So do Swedes between 25 and 50 in 1850 and rural mid-19th-century English Odd Fellows aged 22 through 47 (Tab. 8.10).

Figure 8.4b plots age-specific death rates for certain Chinese populations, all of which dwelt in Peking. In the elite Qing imperial lineage, males and females together who had been born between 1644 and 1739 from 30 to 65 saw their mortality increase in E' form. With base year around 20, the timing of this pattern closely resembles those for the first E' curves among 15th-century Durham monks between 30 and 65, English women 30 to 70 at 1861, and females 30 through 60 in 7 New York counties between 1850 and 1865 (Tab. 8.10). The difference is that mortality per 1,000 during the first two decades of life was so much heavier in the imperial elite of Peking that as of about age 20 the rate began its initial E' upward movement at twice the level for these western and less predominantly urban populations. For Qing males starting life between 1740 and 1839, a comparable resemblance in timing but contrast in level for E' increase appears between the ages of 40 and 65. Among those born in each era, furthermore, a late E' gain between 65 and 80 is once more timed like the English data (Tab. 8.10; Fig. 8.4a) though the *level* of the trend is more than twice as high.

For the two groups of Qing males born after 1740, however, an additional, even earlier E' segment appears up to age 40 or 45. With an average base year projected somewhat before birth and an average death rate of about 7.5 per 1,000 estimated for that point, these trends resemble in *timing* early E' patterns of ${}_nM_x$ for populations of the 1980s in England and Wales, Italy, New Zealand, the United States, Japan, China, and Chile, though they entail considerably higher rates throughout (Tabs. 8.9, 8.10). The later E' movements in these quite recent national populations likewise resemble patterns of that shape found during advanced years for members of the Qing lineage, for more ordinary residents of Peking about 1930, and for the early English and American examples in Figure 8.4a.

In all, evidence from the 15th through the 20th century indicates a patterning of successive E' increases in age-specific death rates, first into middle age then once or twice more across the remainder of life.

The basis of the human life table, and of the way the life table imprints itself upon many aspects of demographic and many other kinds of change, is this tendency between childhood and the most advanced years for aggregate age-specific mortality rates, from all causes, to rise repeatedly in E' fashion. Across the largest and most active portion of the life span, between childhood and old age, in both modern and much earlier populations this continual whittling away at those still alive in shavings that grow proportionally larger in E' form with age produces long C-shape trends in survivorship.

As noted, C is the integral of C', which is the vertical reciprocal of E'. At times, in other words--when the base years for the C in l_x and the E' in ${}_nM_x$ are approximately the same and the levels are comparable--the instantaneous slices of ${}_nM_x$ would mathematically tend to produce a reciprocal cumulative contraction of l_x in C form.

While such a straightforward mathematical effect may be consequential here and there in the populations studied, the dynamics of mortality are usually more complicated than that. First, C trends in survivorship typically begin at clearly earlier ages than contemporary E' patterns in age-specific mortality--by evening out the abrupt swings in death rate that are typical during childhood and adolescence. Second, during the long age spans of the C movements that consistently appear in l_x frequently more than one E' rise in ${}_nM_x$ occurs--or part of another one. Somehow the effects of both trends of death rate *together* generate a single, continuing C path for survivorship. Finally, during very old age the typical trend for l_x takes C' rather than C shape. This suggests that the instantaneous impact rather than the accumulative consequence of the age-specific death rate now determines the path of survivorship. During advanced years, that is, the decimated residual population still left from the original birth cohort no longer contains much stabilizing momentum and becomes increasingly sensitive to just the pattern of current rather than cumulative losses. During this late phase, once more the timings within the life span for C' decline in l_x and for E' increase in ${}_nM_x$ do not neatly coincide, again adjusting how observed age-specific mortality patterns ultimately result in the observed movements of survivorship.

Something is at work that smoothes out the variations in the typically E'-shape movements of ${}_nM_x$ from simple reciprocation in such a way as to produce the smoother, longer-lasting, and more similarly repeated C then C' patterns of l_x. The chief suspect is the way change passes through an age structure (the topic of Ch. 9).

Modern analysis, like the path-breaking efforts of Gompertz in the 1820s and Makeham in the 1860s, has focused upon identifying a single formula that would trend mortality rates or 'the force of mortality' all the way through adult life (Bongaarts 2005, 24-25, presents a useful review). Seeking a single formula for all of adult life, however, may not be the most empirically accurate and analytically fruitful approach toward understanding how mortality comes to bear at successive ages. Instead, it may be more insightful to recognize the prevalence of *repeated* E' tendencies in aggregate death rates during the adult life span within and among populations (not a different trend for every population) and to explore what might produce them. That approach requires a fresh exploration of just how a population erodes over time, including a rethinking of the much-used concepts of ‘background’ and ‘senescent’ mortality. For such an endeavor, it is essential to review how certain *types* of death have actually inflicted casualties on persons of successive ages.

THE INROADS BY AGE OF PARTICULAR TYPES OF MORTALITY

Though it can be done only imprecisely, because of vagueness and inconsistency in historical definition and recording, it is possible to follow the impact of certain crudely categorized causes of death on populations during successive stages of the life cycle. Table 8.11 presents approximate trends of age-specific death rates among females for 8 broad groups of disorders in 10 historical populations: 3 from the 1960s and 7 from between 1861 and 1941 (Preston et al. 1972, where pp. 41-42 discuss some of the problems of identification and bias in the classifications employed). Fitted G-related paths for England and Wales at 1861 then at 1964 in Figures 8.5a and 8.5b illustrate the types of movements that repeatedly appear.

The figures also show how modern medicine, public health, and living conditions have altered the patterns characteristic of earlier times as overall mortality has on the whole improved substantially. Among the 10 populations analyzed, the death rate from all causes was reduced on average by about 60 percent from before World War II to the 1960s. Some types of mortality have lessened; but others now take a heavier toll. Crude death rates from each category, regardless of age, demonstrate how the overall effects of different disorders have generally waxed or waned.

The next thing to note is that for 7 of 8 more significant categories of morality (and also for violence, which is included in the graphing for England) death rates have continually risen with age--in both pre-1950 and post-1950 populations. This happened both in disorders that became less deadly over time and in those for which mortality rates on average remained about the same (neoplasms and degenerative maladies) or grew significantly more severe (cardiovascular diseases).

For four broad types of casualty--diarrheal diseases; influenza, pneumonia, and bronchitis; various infections and parasites; and other or unknown causes--increases across successive portions of the life span primarily took accelerating E' shape, especially during the middle, typically longest, phase of adult life (36 of 40 of these trends). Among successive movements in mortality with age for neoplasms (cancer etc.) and degenerative disorders, *de*celerating G' forms of increase prevailed instead. The later the phase, furthermore, the more completely this was the case: 5 of 8 trends in early adulthood, 17 of 19 through the middle of life, and 11 of 11 in old age. The age-specific death rate from cardiovascular diseases likewise rose more often in G' form as the life cycle progressed (2/9, 3/9, then 7/10). Because of the heavy presence of E'-type increase in stages before old age, however, that path (rather than G') was followed by no less than 16 of 28 distinct upward cardiovascular trends found in 10 populations.

The one exception to otherwise universal increase of disease-specific death rates with age is provided by respiratory tuberculosis, which before the middle of the 20th century took its heaviest toll among those in their 20s and 30s, and universally declined thereafter. Its impact dropped off with age almost always in accelerating C' form. By the 1960s, however, death rates from tuberculosis instead increased in E' fashion after about age 35 because it had become a disappearing disorder.[29] The casualties were now those who had had the disease for years.

Gompertz theorized in the 1820s that overall mortality rates, which he called 'the force of mortality,' rose across adult life in simple exponential form: $m(x) = ae^{bx}$, where x is age, a is the level for a given population where adult aging begins, and b is the exponential slope with age.

Makeham in the 1860s improved the fit of this model by adding a constant *c* to what a Gompertz slope produced for any age: $m(x) = ae^{bx} + c$. The interpretation of this constant has been that some level of 'background' mortality affects persons of all age quite similarly. Death shaped by advancing years, 'senescent' mortality, takes place above that level. The total 'force of mortality' (age-specific mortality at any given age) is the combination of these two components. Modern analysts have since improved the *slope* in Makeham's model by making it logistic in form (asymmetrically 'S'-shaped rather than log-linear): $m(x) = (ae^{bx}/(1 + ae^{bx})) + c$. That first or slope term on the right side of this equation is said to represent the 'senescent' force of mortality with age. The constant *c* portrays a 'background' element supposedly shared at all adult ages in addition to the effect of the slope. Summing the two yields the overall age-specific mortality rate or total force of mortality by age (Bongaarts 2005, 24-27).

Table 8.11 indicates, however, that among various identifiable major types of disorders only respiratory tuberculosis before the middle on the 20th century, while cresting and beginning to decline, produced death rates that for much of the life span were comparatively level (at least for about ages 15 through 60), the kind of movement called for by the 'background' concept (ibid., 27). While as of the 1960s, female loss rates from diarrheal diseases, other infections and parasites, and motor vehicle accidents do seem to run level from childhood to about age 40 (along with influenza, pneumonia, and bronchitis just to age 30), during early adulthood their impact on overall death rates is insignificant, at extremely low rates of .00003 or less (frequently under .00001). In pre-1950 circumstances, moreover, even this minimal evidence of a level 'background' contribution to overall mortality, which current theory expects, is absent--except in respiratory tuberculosis and (at a very low level, to just age 30) in death by violence. Any tendency toward flatness early in adulthood for types of disorders or just a slow rise in age-specific rates for fatalities as a whole, to the contrary, derives not from dangers to which adults of all ages are equally susceptible but from the way that E' patterns, which eventually rise very steeply and substantially into old age, *begin* quite gradually. This dominance during early adulthood of E' increase rather than level 'background' rates, the two examples from England and Wales a century apart illustrate (Figs. 8.5a, 8.5b), is even more characteristic of populations before the middle of the 20th century than among later ones. Current theory expects just the opposite: 'background' mortality early in history is considered *more* powerful relative to 'senescent' death than under modern conditions (Bongaarts 2005, 27).

What significance does 'background' mortality then retain when most major disorders from the beginning of adulthood instead increase strongly with age via E' or G'? Any *relatively* flatter early movement in age-specific mortality through early adulthood seems due instead to factors other than some 'background' constant. That *c* parameter, unchanging across adulthood, lingers on in contemporary analysis because it is mathematically necessary adjustment to make a logistic path fit the actual behavior of the data. In reality, these empirical observations instead rise with age in successive E' movements, everywhere in overall age-specific adult mortality rates (Tabs. 8.9a, 8.9b, 8.10) and in death rates for most types of fatalities (Tab. 8.11).

There is a minimum level, for age-specific mortality as a whole and for particular disorders, below which rates do not drop once adulthood begins.[30] This residual remaining after the reduction of mortality during childhood constitutes a base above which casualties sensitive to age subsequently rise. In one sense, this level might be thought to capture what 'background' mortality has signified--without introducing an extra, constant parameter to represent an unchanging 'background' component of mortality, for which empirical evidence is lacking. In this thinking, the concept of a constant 'background' ('*c*'), introduced by Makeham and retained in modern studies to accompany a different form of slope in logistic approaches, reduces to just the initial level ('*a*') in the first E' trend, and one less parameter is needed to portray the curving.

On the other hand, actual death rates usually follow more than one E' trend with age, generating the succession of increases across the life cycle that appears in Tables 8.9a, 8.9b, and 8.10 for age-specific mortality as a whole and in Table 8.11 for particular causes of death. In this sense, one might think that in most populations around a certain age a new threshold or ‘background’ level is for some reason introduced, from which increase in E’ fashion starts over again. One could in these terms say that a ‘background’ shift takes place. The same shape of slope operates, but from a new level and with a new base or zero age. What might cause such a shift? Fruitful insight into this issue can come from examining just how a rise of age-specific mortality in E’ fashion unfolds.

The type of error and potential misinterpretation embedded in a logistic approach that attempts to model all adult mortality with one formula, including a constant ‘background’ parameter, is illustrated by an application of the technique to Swedish women as of 2000 (Bongaarts 2005, 25). Though over the whole adult life span the data and the fitted trend do rise rather closely together, the actual death rates swing repeatedly and systematically back and forth across the proposed model. They clearly run low in the 30s, high in the 40s and early 50s, consistently low from the early 60s through the early 80s, then high again after about 90. In contrast, the E’ patterning estimated for this population in Table 8.10, eliminates most of this visible error of the logistic solution.

The logistic method does still fit rates across *all* adulthood quite well with a single formula. But it requires a new slope (‘*b*’ parameter) for each population examined. The G-based representation estimated in Table 8.11 employs three E’ trends between ages 27 and 92, rather than just one formula, and ignores (for the time being) subsequently decelerating increase for mortality rates in very old age. But it uses the *same* slope parameter (.03) for successive phases of aging within particular populations and across all kinds of populations at all recorded times, dispenses with the need for a constant ‘*c*’ parameter, and represents the actual bending of the data better.

The most fruitful decision seems to be: Does one *learn* more about demographic processes by generating, one population at a time, quite a good single fit to adult mortality all the way from adolescence to death;[31] or is it more insightful to abandon the ambition to derive a single solution for all adult ages and to recognize a repeated curving of the one, identical E’ type in all (or almost all) populations? The recent effort to simplify and consolidate representations of adult mortality as a whole in individual populations by means of a 'shifting logistic' model is a step toward grasping the greater generality of the patterning of change with age in populations. In the 'shifting logistic' approach, slopes with age are assumed to remain constant over time *within a given population,* but to slide historically forward or backward across the adult ages of the life cycle (Bongaarts 2005, 27-30, including references to prior efforts of this type). The analysis, it should be noted, is based upon 14 populations of Western Europe and North America over the period between 1950 and 2000, all of them residing in developed societies during the period after major changes in medicine and public health emerged out of World War II. The proposed shift with time seems analogous to the way that t_0 for E' curving alters historically. It is suggested, though, that to recognize the invariant bend of the E' curve for all populations as well as for all times is a far more general and insightful step for understanding human mortality and aspects of life and society that it affects.

For instance, total age-specific mortality rates rise relatively gradually during early adulthood predominantly because among the various contributing types of deaths themselves most, though not all, become more frequent with age in slow-starting but accelerating E' fashion. Four broad classes of threat--diseases of the chest and lungs (influenza, pneumonia, bronchitis); diarrheal disorders; various other infections and parasites; and unclassified or unknown causes of death--overwhelmingly have increased with age in E' movements. Among the varied cases estimated in Table 8.11, before World War II these types of casualties accounted a little under 3/4 of all mortality. In the three populations of the 1960s, slightly under 1/2 of the total were due to them. Age-specific death rates from cardiovascular diseases in the 10 sample populations also rose in predominantly E' form--at least until quite old age. No less than 13 of 18 trends in this type of fatality during either the early or the middle, principal stage of adult life followed such a path (Tab. 8.11). All 5 of the exceptional early increases for heart disease that instead took G' shape, moreover, occurred in populations before 1950. As cardiovascular deaths became more significant, both in number and as a proportion of all mortality, the E’ pattern before quite old age became universal (at least for the sample of populations explored). If cardiovascular casualties are added to the other 4 types of death which overwhelmingly display E’ increase by age in death rates, as many as 5/6 of all fatalities occurred from causes whose mortality rates rose in E’ fashion--both in populations before 1950 and, separately, in those of the 1960s.

It has, moreover, been specifically from weaknesses likely to be inherited--neoplasms and degenerative diseases throughout adulthood, cardiovascular problems after about 60 in modern populations and sometimes earlier in life before 1950--that increases in mortality rates have leveled out via G’, decelerating with age rather than accelerating like the prevalent E’ movements observed.

The G’ pattern is simply the inverse of E’. It is, in other words, E’ both upside down and reversed with respect to age. Regulating the rate of change in both trends is the universal .03 constant of the G family of curves. Whichever way the death rate rises, .03 determines how fast the rate of increase speeds up or slows down. In particular, to understand how this universality of bending occurs opens up far richer and more widely embracing insight into demographic processes than fitting logistic ‘senescent’ and level ‘background’ models that require a new slope for every population studied, one that ‘shifts’ even in the same population over time.

The G’ pattern for death rates across a portion of the life cycle implies that further vulnerability to this particular type of weakness is in effect being exhausted as older ages are reached. For instance, those with propensities to cancer are progressively weeded out of a population, leaving a lower proportion of survivors who are susceptible to this kind of threat. Do *successive* G’ movements in a population then reflect the damage of, say, different kinds of cancers that tend to appear at different stages in life? By very advanced age, moreover, death rates as a whole seem to rise a little further in G’ form (not shown in Tab. 8.11). Now only the hardy are left. Roughly approximated G’ paths for Swedish women project from about age 88 through 99 to reach 100 percent in the vicinity of 122 years old as of the middle of the 19th century and, as of 2000, across the 90s toward 100 percent near age 134 (from graphed data in Bongaarts 2005, 25). This final, decelerating phase of increase in overall age-specific mortality--the counterpart of the late bend of the ‘S’ in logistic models--occurs, however, only very late in life (Tabs. 8.9a and 8.9b indicate beginnings mostly around 75 to 85).

The E’ form, meanwhile, suggests that, given an environment in which a disease exists, older persons become vulnerable to it more and more rapidly with age. *Sequential* E’ patterns imply, on the other hand, that accelerating ravages from this disorder for some reason tend to be curbed at a certain stage in life (the relatively flat trajectory early in the E’ curve replaces a much later stage in a previous E’ movement, which has become steeper and steeper) only to begin to accelerate upward again. What might break the prior E’ trend and cause such a restart of E’-shape increase?

In the exceptional C’ decreases with age for death from respiratory tuberculosis in populations before about 1950, the pattern reflects the concentration of casualties within a relatively few years of early adulthood. After the early 20s, with each additional year the mortality rate drops faster, once again governed at bottom by the .03 rate (in derivative manifestation).

THE IMPACT OF SPECIFIC SOURCES OF MORTALITY OVER TIME

Table 8.12, taking a different perspective, demonstrates how death rates for particular types of disorders changed *over time* in G-related paths as well as from age to age within a population at any given date. The proposed trendings from the later 1800s to the 1960s are again only approximated, not fitted. They clearly indicate, nonetheless, quite different shapes of historical change for particular kinds of fatalities. These patterns should conform to what is known about risk and prevention or treatment for certain disorders in various societies, and should extend our understanding of the effects of such developments.

Simply, mortality rates from respiratory tuberculosis, from other infections and parasites, from influenza, pneumonia, and bronchitis, and from various diarrheal diseases all declined in C' manner. This was particularly true for the years between about 1910 and 1950 (excepting only a G increase in Chile and a C decrease in the United States for diarrheal disease). Earlier C'-shape declines in death rates are also evident here and there: in England and Wales, New Zealand, and Italy for influenza, pneumonia, and bronchitis; in New Zealand, Chile, and Italy for deaths from other infections and parasites; in New Zealand, Sweden, and Japan for respiratory tuberculosis--while more gradual C-type contractions appear at this stage for tuberculosis in England and Wales, Chile, and the United States, for other infections and parasites in England and Wales and the United States. Following about 1940, finally, some mortality rates visibly began to "bottom out" in decelerating D' fashion: particularly for deaths from other infections and parasites and diarrheal diseases and in the same 5 societies (England and Wales, New Zealand, Sweden, Chile, and the United States). This late development begins to explain how D and D' declines in aggregate crude death rate were observed in Chapter 2. The D' pattern would seem to represent how prevention and treatment improved in proportionally less and less effective steps as they approached the minimum limit of a D-type contraction in population. The C' form, in contrast, depicts through its derivative nature the marginal rate of progress in, for the time being, a C-shape pattern of *accelerating* improvement in curbing demographic loss.

Death rates due to miscellaneous or unknown causes altered through time much like mortality for the four more clearly determined classes of disorders considered. Of some special interest, however, is what the early D' reduction in uncertain deaths before 1940 in England and Wales, the United States, and Italy signify. Do they indicate that, early in the 20th century, the classification of the cause of death was generally handled differently in these three countries?

Unlike the five other major disease categories examined, whose rates fell markedly with the arrival of modern medicine and public health, death rates from cardiovascular causes, neoplasms, and degenerative disorders mostly increased over time--and did so primarily along

G’ paths. Exceptions to G’ for the years after World War I include 5 mid-century D’ dips plus 1 G-shape advance in the United States for degenerative disorders and 1 E-form gain for cardiovascular mortality (in Italy). The most variation from the common G’ pattern of change during this era appeared in death from neoplasms (3 G trends and 2 or 3 E patterns). Earlier, during the late 19th century and first years of the 20th, though there was only 1 extra trend (a G’) for degenerative disorders among the 8 populations examined, for cardiovascular issues and neoplasms a mix of 4 G, 3 E, and 1 D’ trend accompanied the 6 G’ movements that are likely. As was the case for the receding causes of mortality between the late 1800s and the 1960s, these chronological patterns for types of death that became *more* common should assist in understanding the impact of changing exposure, prevention, and treatment in various historical circumstances.

The G’ pattern, moreover, has been characteristic of the onset then decline of historical mortality and disease since records begin. Along with the international death patterns from the 1860s to the 1960s for cancer, heart disease, and degenerative disorders just discussed (Tab.8.12), it characterizes--probably since the 14th century--the historical trends for a wide array of disorders from the plague, smallpox, malaria, and murder to present-day threats such as HIV-AIDS, fatalities from smoking, and obesity.

The bold trend line across the middle of Figure 8.6a depicts the ratio of estimated cases of **plague** (Chenais from Biraben)[32] to the population of Europe Livi Bacci 2000, 8-9) from 1550 through 1850 for 50-year spans centered from 1575 through 1825). A maximum of about 0.2 seems to have been reached at 1601.

If fatalities from the Black Death are assumed to have dominated mortality patterns in medieval Europe over at least a few decades from the middle of the 1300s forward, then plague deaths centuries earlier also, after the initial sudden shock, probably quickly took G’ form. G’, that is, constitutes the derivative of G, the vertical mirror image of D, the path of contraction carved out of the populations of England and many European locales mostly by mortality in this devastating period (Harris 2001, 173, 337, 360; 354-55, 363-65; 2003, 258). The D-type decay of the population of Egypt between about the 1330s and 1420 could likewise reflect significant impact of the plague (ibid., 285, 287).

The pervasive 17th-century D-shape declines of national and local populations across many parts of Europe and individual communities therein (Harris 2001, Ch.'s 5, 6, 8) reflected warfare, famine, and other disease as well as plague. Though the majority of national D-type declines became apparent only later in the 1600s, the base years for these trends lay in the late 1500s and in their timing the contractions diffused outward from the Mediterranean--with earliest trends evident in Spain (1589) and Italy (1625 or sooner). This geographically resembles the way plague spread as it reappeared in Europe during this era. A role of plague in the D-shape demographic contraction of China between 1578 and the 1620s or later seems worth exploring (ibid., 243-44). In the 17th century as in the 14th, the disease was an international phenomenon.

Another devastating global menace has been **smallpox**. It, too--while lingering, particularly in urban populations--has surged periodically in G' fashion. In Geneva the death rate crested approximately this way three times between 1585 and 1805 (Fig. 8.6a, Tab. 8.13), receding over time from a peak near 100 per 1,000 in the vicinity of 1616 to a maximum of more like 60 around 1768 (Perrenoud 1997, 314).[33] In London, the death rate from smallpox between 1660 and 1740 mostly followed a comparably timed G' path, with the same turn-of-the-century dip as observed in Geneva, cresting at more like 103 per 1,000 than 80 (ibid.).[34] Thereafter, from the 1740s into the 1780s the trend took new G' shape with maximum at about 102 near 1768 compared with Geneva's 60 at 1768 (ibid. and Oxley 2003, 636).[35] If later death rates for London's population (Oxley 2003, 636) are added to this series, however, it appears that mortality from smallpox in the metropolis may actually have shrunk from the 1780s to the 1840s in C' form (based at about 99 per 1,000 around 1783) as inoculation was introduced between 1778 and 1798 in southern England (Razzell 2011, 1319). Then it fell further in D' manner to a minimum level of merely 1.1 per 1,000 in the vicinity of 1880 as the disease was largely eliminated.[36] These shifting patterns for death from smallpox throw light upon how other threats to life, such as those covered in Table 8.12, may first have spread then come under control historically. What kinds of attempts to control a threat and what types of circumstances in which the challenge must be met do G’, C’, and D’ patterns of decline in mortality tend to reflect?

In addition, the proportional presence of pock marks on local male convicts under 40 (Oxley 2003, 636), if shifted earlier by 30 years, paralleled for at least six decades the second G’ path for the death rate from the disease in London (Fig, 8.6a). In Sweden, meanwhile, the percentage of all deaths that were due to smallpox from the 1750s though the first years of the 19th century (Sköld 1997, 6) declined in G’ form closely parallel with current G’ trend of rates for smallpox deaths in Geneva and London. The surge in the disease during this period was apparently widespread across Europe.

While it is sometimes hard to distinguish the disease from measles, which also devastated hitherto unexposed New World populations, with the Spanish invasion small pox similarly diffused within just a few years (from 1518 to 1527 or so) across the Caribbean and Central and South America (Livi Bacci 2006, 214-15). It in the least contributed significantly to the many notorious D-shape collapses observed in regional and local populations (Harris 2001, 101-09). Most early demographic declines of this D shape in Latin America, from Hispaniola to Peru, had zero years between 1561 and 1578 (ibid., 104). As previously introduced with regard to European and Egyptian plague in the 14th and 15th centuries, an overall death rate that took G’ shape (the derivative of G, the opposite of D) based in the vicinity of 1570 would carve out the population of Latin America this way. Smallpox mortality rates in the New World thus quite probably surged and then slowed down this way, via G’, as they did in 16th-, 17th-, 18th-, and 19th-century Europe. Again as in Europe, secondary D-shape contractions in populations imply later, successive waves of deaths in G’ form, in which recurrent smallpox is likely to have played a significant part (ibid., 102, 104-06).

The remaining plot of Figure 8.6a trends (at the top) one type of *intentional* death at human hands: **neonaticides** (murders of babies within their first month) in the European-American population of New England (Roth 2001, 109). Starting at about 52 per 100,000 live births in the 1630s, the rate declined across the 17th century to less than 10 in what may have been a G' path based near 1600--a time of hardship including minimal real wages in England before colonial settlement (Ch. 10; Wrigley and Schofield 1980, 642-44). Several more G' movements seem to have followed, at successively lower levels until the middle of the 1800s. Sometimes these trends coincided with patterns of this shape in other rates of mortality, sometimes not (Tab. 8.13). The *recorded* incidence of this type of death, at least, was fortunately always relatively low; it tended to rise and fall, however, like more frequent fatalities inflicted by nature upon humans, not consciously generated by them.

So did death rates from **homicide** (Fig. 8.6b). Probably four such underlying G' tendencies in murder rates appeared in New York City between 1800 and 2000. Up until World War II estimated homicides there swung back and forth mostly between about 3 and 10 per 100,000 population annually. The recent G' surge into the 1990s, however, elevated the maximum to more like 30. The homicide rate for Los Angeles, on the other hand, began high--near 20 per 100,000, in the 1890s--but then declined to more like 3 by the 1950s before surging parallel to the New York G' trend across the remainder of the 20th century (Monkonnen 2001, 63). In Chicago, the closest fit between 1887 and 1912 is a G' path aimed to peak at about 10 per 100,000 around 1927 (Adler 2001, 30). Much-dramatized turbulent years for the city following World War I, however, continued to lift the rate along an $e^{.03}$ log-linear path through 1924 (or later) abandoning the tendency of the G' pattern to slow and level out below that slope after about 1910 (Fig. 8.6b, bottom). The average homicide rate for 2 or 3 cities, meanwhile, between 1880 and 1950 peaked in the vicinity of 1905, rather earlier than for New York and Chicago because of the higher and differently timed G' curve for estimates from Los Angeles.

The remaining plot on Figure 8.6b, at the top, returns to examine the exogenous impact of disease over time. It estimates trends for deaths from **malaria** for Punjab in northwestern colonial India between 1868 and 1940 (Zurbrigg 1997, 32). Oct.-Dec. fever deaths per 1,000 per year, which varied widely, are given an approximate underlying G' pattern by eye and template. This trend maximizes at about 9 per 1,000 in the early 1890s. Table 8.13 compares the timing of these deaths with other forms of mortality in other places.

It is insightful to contrast this course of malaria in a region of South Asia with the underlying tendencies of the death rate from **typhoid** in North Africa and Europe during much of the same period. Here--in British-controlled Egypt, and in Algeria and Tunisia with their colonial power, France (Curtin 1995, 38-39)--instead of tapering off in G' fashion the mortality rate was reduced in C' form. Between 1885 and 1900 in the Egyptian military the underlying C' trend fell from a base of about 12 per 1,000 in the vicinity of 1856. Between 1897 and 1911 in the armed forces of Algeria and Tunisia it shrank in that form from roughly 9 near 1864. Between 1882 and 1906 in France the death rate from typhoid likewise diminished via C', but from approximately only 6.6 around 1847. Previously it had risen since 1862 (as in Algeria and Tunisia) in what could well have been G' form. By 1900, however, in Egypt and France C' mortality trends were replaced by D' movements to 1912 as control of the disease approached maximization--at least for the time being.

These successive patterns of G', C', then D' increase then decline in historical mortality rates from typhoid resemble the movements of deaths from several groups of disorders surveyed internationally in Table 8.12. They indicate stages of control or approximate elimination as modern prevention and treatment were brought to bear on the threat of typhoid, results not achieved for malaria in northern India before 1940.

The 20th-century reduction of **fetal death** rates per 1,000 live births, likewise, has unfolded like rates for several types of diseases that have significantly come under control since the 19th century (Costa 2004, 1066; Tab. 8.12). For whites in the United States, reduction from

1915 through 1940 took C' based at about 1912, followed by D' drops between 1935 and 1970 then 1970 and 1995 (aimed to minimize in the vicinity of 1973 then 2008). For U.S. women of other types, the rate fell via C' from 1915 through 1955--virtually simultaneous with that for whites (base year estimated around 1914 compared with 1912). D'-shape declines from 1950 through 1965 then 1965 to 1995 preceded comparable trends for whites by just a few years (zero dates about 1968 vs. 1973, 2000 vs. 2008). In all, for both categories of women the decreases were closely similar, though the level for non-whites was 2 to 3 times as high as for whites throughout. Identical forces seem to have shaped the change--first in C' manner, then in repeated D' paths as further improvement in fetal health with currently available resources became more difficult.

Already decades earlier--between 1839 and 1884, minimizing in the vicinity of 1875--in government-assisted **immigrant voyages** from Britain to Australia the death rate per month at sea fell in first rapid then 'bottoming out' D' manner (McDonald and Shlomowitz 1990, 89). As in the control of typhoid for various militaries (where D' movement began to appear around 1900, official policy played a crucial role in this improvement. The most likely reason for a D' shape in the Australian rate, however, is that--given cargoes of mostly poor, frequently urban people who had been exposed to a variety of 19th-century disorders--by the third quarter of the 19th century attempts to reduce mortality any further exhausted methods of control available at the time and economic resources made available. In contrast, death rates in the **slave trade** between the 1640s and the 1840s rose and fell repeatedly in G' fashion predominantly for reasons of profit. At certain times, inexperienced merchants and captains were drawn into the trade and the promise of gain tempted all slavers to give less care to cargoes. Such repeated G' surges in fatalities were not shared by ships' crews (Harris 2003, 394, 396). Mortality on the voyage for bound servants and contract laborers of non-European origin, meanwhile, for the most part in aggregate seems to have improved along a single underlying C path across the 18th and 19th centuries, much like rates for free and convict Europeans as a whole, though at an appreciably higher level (ibid., 496). Long-term improvements in how to transport people at sea in general shaped the death rate on voyages not shorter-term vicissitudes of the business, as in slaving.

Not just remote historical incursions of mortality but contemporary, current and future scourges rise and fall in these G-related forms through time. Figure 8.6c presents some recent estimates of the diffusion of **HIV-AIDS** (Bongaarts et al. 2008, 210, 205). Prior to the 1990s, the numbers are likely to be seriously incomplete (e.g., McNeil 2011a, *New York Times*, Oct. 18, review of Pépin). Nonetheless, recent trends and informed projections for net accumulated infections in persons 15 through 49 characteristically taper off along G' paths. Worldwide, the indication is that current infections for this age group peaked in the vicinity of 2003 at a little more than 4.5 per 1,000 total population: about 27 million cases among 5.83 billion persons of all ages as of 2000; 28.5 million at 2010 in a global population of somewhat under 7 billion or about 4.3 per 1,000 (Bongaarts et al. 2008, 210; Harris 2001, 385, which projected 6.65 billion for 2010 compared with an accepted estimate of 7.00 billion in October 2011). The proportion of infection among all 15-49 just in Sub-Saharan Africa (the earliest and most seriously affected part of the globe), meanwhile, between 2000 and 2020 declined along a G' path from a projected peak of 6.8 percent or 68 per 1,000 in the vicinity of 1978 (Bongaarts et al., 205). As a fraction of population expected for all of Africa (Harris 2001, 385), current infections of Sub-Saharan residents 15 through 49 are expected to decline from 2010 to 2050 also in G' fashion, but later and at a lower level (from somewhat under 38 per 1,000 in the vicinity of 1996). This is a less precise calculation, but one that offers insight a generation further ahead.

The rate of *new* HIV-AIDS cases among adults relative to the size of worldwide population, in contrast, has been contracting in decelerating D' fashion since about 1995, as recognition and acknowledgement of the threat have spread internationally and first steps have been taken to control the epidemic (Bongaarts et al. 2008, 210).[37] As of about 2020, the projections even imply that with more awareness and better methods of prevention and treatment the rate of new cases will henceforth fall in accelerating C' manner--the way that mortality from diseases like respiratory tuberculosis, diarrheal disorders, influenza, pneumonia, and bronchitis, and other infections and parasites was reduced in many countries during the late 1800s and the first two-thirds of the 1900s (Tab. 8.12).

In the control of these previous historical threats, however, reduction in D' manner *followed* substantial curbing in C' form (ibid). One possibility is that the early D' pattern appears in HIV-AIDS globally because of the way certain countries attacked the problem quickly and energetically, capitalizing upon advanced medical and public health systems and awareness already developed to fight previous historical threats--efforts which had for some time been reducing the toll of other disorders toward minima in D' paths. Pointing to a different explanation, though, it is especially in Africa (Sub-Saharan cases 15-49/all African population) that D' reduction in the rate of new infections from 1990 through 2010 (t_0 about 2022) *precedes* projected C' further decline from 2010 through 2050 (t_0 near 2015). Some development (perhaps simply public awareness, perhaps some rudimentary step to manage the epidemic?) lowered the African rate in the 1990s, then lost its impact. Serious investment in control, it is implied, is now making continuing, ever-faster C' improvement possible. The D' trends currently evident in mortality from other diseases (Tab. 8.12), in contrast, reflect using the tools of modern medicine and public health to squeeze the last benefits out of historic change.

Simply to project G' trends for the rates of all or just new infections in Figure 8.6c backward calls for too many cases. For example, 70 years before 2003--at 1933--there were not some 39,000 infections in a global population of about 1.35 billion (or 0.029 per 1,000). The disease had just jumped from chimpanzees to a few African hunters in the 1920s. Ironically and tragically, however, during the 1930s, 1940s, and 1950s a series of often well-intended 'amplifiers' aggressively multiplied the transmission of HIV in less developed societies before it was adequately recognized. These notably included accessible firearms for hunting larger monkeys, a widespread use of vaccination in French and Belgian colonies to fight leprosy, sleeping sickness, and other diseases (a medical procedure which benefited from new, cheaper, machine-made syringes), profitable blood plasma processors, mass prostitution in exploding metropolises, and centers for sex holidays (McNeil citing Pépin). Magnified this way, infection exploded internationally. It will require further research to determine at just what point in time such ‘amplifiers’ elevated the infection rate to levels that would be projected backward from Figure 8.6c: that is, where G’ patterns of rise then fall actually began.

Two other contemporary scourges are lung cancer and obesity. The rate of **lung cancer** mortality among U.S. males 15 and older between 1957 and 1994 (Pampel 2003, 56) surged then began to taper off in G’ form with peak at about 79 per 100,000 at 1988 (Fig, 8.6d, left panel). For women, by the 1970s what had been increase in accelerating E fashion since the mid-1950s or sooner likewise settled into a G’ path. This, however, lagged behind the comparable trend for men, aiming to crest only in the vicinity of 2006. The rate for females was lower as well as later, heading for a maximum at that date of only about 21 per 100,000 not 79. In Israel, meanwhile, the proportion of all deaths for Jewish men that was due to lung cancer rose from 1952 through 1996 in G’ fashion with crest about 1992, just 4 years later than the death rate from this cause among U.S. males. Among Jewish women in Israel, evidence around 1974 and 1996 would fit a proportional G’ pattern maximizing in the vicinity of 2008 compared with 2006 for the U.S. death rate from lung cancer for females, while data at 1952 and 1974 would suit an E trend with zero year about 1963 compared with 1966 (Staetsky 2011, 235; Tab. 8.13). For *all* deaths attributed to smoking (including other cancers, COPD, and various other causes), for Israeli Jewish men the percentage rises roughly via G’ maximizing near 1984; for women an E trend pivoting approximately in 1962 followed by a G’ cresting near 1999 are possible. The indication is that the patterns observed for just lung cancer rates in the United States (Tab. 8.13) apply to other developed societies, and to consequences of smoking besides lung cancer.

Predictions for long cancer mortality rates relative to the diffusion of cigarettes take rather different curvilinear form. For comparison with the actual historical trends, the maximum for men, 4 decades into cigarette diffusion, is set at 1987--about the peak of the G' trend for current deaths. From the equivalent dates of 1941 to 1987, the mortality rate for long cancer among males rises via G rather than G'. Then from 1987 through 2007 it seems to recede in C' shape rather than G'. For women, the first trend once again takes E form. If the zero year for this pattern in current deaths is employed to peg the comparable point in the trend of that shape relative to cigarette diffusion, the rate rises this way from a low of about 6 per 100,000 about 1929 to 18 at 1776. Thereafter, a G rather than a G' movement is likely into the mid-1990s or later. To probe how G' patterns appear in current mortality rates for lung cancer but not relative to cigarette diffusion may throw some further light upon the relationship of the two phenomena. In any case, however, lung cancer seems to be yet another threat to human life that has risen and fallen in G' fashion--and continues to do so.

The same is true of **obesity**, the implications of which have only recently received significant attention. Among adults 20 through 75 in the United States, three measures of excessive weight for three sub-groups of the population (Jolliffe 2004, 312) have all increased in G' manner since the late 1970s or the 1980s (the right panel of Fig. 8.6d; for each group, the scale rises toward 100 for prevalence, toward or above 10 for severity and depth respectively).

'Prevalence', the proportion of the population that is overweight, has increased least but most uniformly (with t_0's from 2007 to 2010) among non-hispanic whites (38 percent), blacks (25 percent), and hispanics (33 percent). The gains have started and ended lower among whites than among others. In terms of 'depth' and 'severity' (defined ibid., 306) overweight status for hispanics has swollen less than for whites and blacks whose maxima are projected to arrive visibly later, with measures doubling or more between 1978 and 2000, projected to multiply 3 to 4 times before maximizing in the years ahead.

How obesity shapes mortality rates is a matter of current debate. There may be less connection now than previously, thanks in large part to the control of heart disease (Mehta and Chang 2011, 447-49). The underlying frequency of being overweight, or of being dangerously overweight, however, seems to be following familiar G-related paths as it increasingly threatens modern life.

Rates for particular sources of morbidity and mortality, in short, have since the middle ages tended to surge and recede--often repeatedly--in G' form. That is how populations hit by particularly severe crises of health have over and over again contracted in D shape (Harris 2001). Knowing how losses might rise then taper off this way, as opposed to also familiar decreases in the alternative C' and D' shapes that are sometimes observed, should help in understanding how threats spread and are controlled or lose impact on their own, insight that should be of value for living in our future as well as for comprehending our past.

MAN, MONKEYS, AND OTHERS: A BIOLOGICAL BASIS FOR THE PATTERNS OF SURVIVORSHIP?

The examples used so far to illustrate the permeation of life tables by G-related trends all involve societies with written histories and various degrees of early modern or quite recent socio-economic development.[38] If the phenomenon is, as suspected, rooted in the biological nature of mankind, however, similar patterns should also occur in much more primitive societies of *homo sapiens*. There is evidence that it does.

Figures 8.7a and 8.7b trend survivorship (l_x) for selected populations of hunter-gatherers, forager-agriculturalists, and acculturated hunter-gatherers (Gurven and Kaplan 2007, 328). These are described collectively as "the most complete set of preindustrial populations available" that have adequate demographic particulars. Acculturated hunter-gatherers have “either recently started horticulture and/or have been exposed to medicines, markets, and other modern amenities” (323).

Among the sufficiently documented *hunter-gatherers*, the Dobe !Kung live in the Kalahari desert of Botswana and Namibia, the Hazda in Tanzania, the Agta in the Philippines, the Ache in Paraguay, and the Hiwi in Venezuela. Of the *forager-agriculturalists*, the Tsimane reside in forest areas of the Bolivian lowlands, the Yanomamo Mucaj in the Parima highlands of Brazil, the Yanomamo in Venezuelan Amazonia, and the Gainj in the central highland forests of Papua New Guinea. Aborigines of Australia’s Northern Territories are included among *acculturated hunter-gatherers* along with later populations of the !Kung, Agta, Ache, and Hiwi. Further details on these peoples, assessments of the quality of the data available, and the periods and conditions in which their demography was recorded are available (ibid., 324, 354-59).

All 15 groups display, except in the very last years of life for transitional Agta in (Fig. 8.7b), the same sequence of three distinctive trends that has been found in modern and pre-modern historical populations (Figs. 8.2a through 8.2h, 8.3a, 8.3b: Tabs. 8.5, 8.6). A sharp, but decelerating, drop into mid- or later childhood is followed by a long span during which l_x contracts in C shape. Then, through the last years of life, survivorship erodes away more abruptly in C’ fashion.

Table 8.14 estimates particulars for the second and third trends of this lifetime patterning, and provides some comparisons with historical populations previously examined. The cases from 1661 London downward in the table are ordered primarily by the base ages for their C curves in survivorship, beginning at 22.6 and flattening out all the way to 120.7 for China as of 1981.

For the 20th-century Yanomamo and the Hiwi, the zero year of the C trend falls between those for the general population of 17th-century London and elite Qing females of 17th-century Beijing. The t_0 for the Yanomamo Mocaj, on the other hand, resembles those for Qing males born between 1644 and 1739 and for Taiwanese women in 1920. All of these C trends yield to replacements of C' shape quite early, by about age 40 or 45. Their levels at the zero year range from 27.3 to 39.3 per 100 births, averaging 32.6. That makes them resemble in this respect all the populations from 1661 London downward in the table as far as the 20th century (ranging from 20.8 to 39.3, with a mean of 30.7). In all, that is, in this group of populations across three centuries and from totally preindustrial conditions down to quite modern ones, the base age for the C trend has increased substantially with little variation in the proportion still surviving at that zero point. Just an advance of the C path later into the life cycle has occurred. This finding resembles one insight of the 'shifting logistic' conceptualization of adult survivorship (Bongaarts, 2005, 29-30).

In this broad historical progression, for the forager-agricultural Gainj and the hunter-gatherer !Kung and for the acculturated Hiwi after 1960, the C trends for survivorship were comparable in zero age to those for Qing males born between 1740 and 1890, the population of Silesian Breslau in the 1690s, and women in 1909 Chile and 1966 Madagascar. The t_0's for C in l_x for most other preindustrial populations analyzed by Gurven and Kaplan, in contrast, arrived about a decade later in life (in the 60s rather than the 50s)--like those for Swedes in the middle of the 18th century or for females in Peking around 1930 or in 1899 Japan. As in those same three instances, furthermore, the C path now mostly lasted longer, close to age 60. For the acculturated Aborigines of Australia's Northern Territories, finally, the C pattern through 65 would reach its zero point only at age 84, even later than was the case in several western countries during the later 19th and early 20th centuries, or in Indonesia as late as 1961--but sooner than in rural Taiwan in 1966, not to mention the populations of the 1980s characterized in Table 8.5.[39] The settled Ache and the acculturated !Kung after 1963, nonetheless, have estimated zero years for their C trends comparable to the populations of many developing or developed countries of the later 20th century (the bottom of Tab. 8.14).

Among the third-phase C' trends from London down in Table 8.14, less variation is evident in the zero age projected than for the preceding C movements (13.8 to 51.9 in place of 22.6 to 120.7). But more spread is found in the *height* of the survivorship curve at that point (from 14.7 to 90.0 as opposed to 20.8 to 39.3). This zero level depends upon the timing (and therefore the slope) of the preceding, second-stage C trend, from which it takes over. As a consequence, diversity in projected *age* for the C stage creates variation in *level* for the C' phase that follows.

Within the relatively compact distribution of zero base ages for the C' declines in l_x, the Gainj, the !Kung, and the peasant Agta display the earliest points of all (13.8, 15.3, 18.9). These do not much precede the t_0's for 1661 Londoners (20.0) or for Qing males during three different eras (20.2, 18.9, 22.1). The other 11 detectable C' curves for the preindustrial populations of Gurven and Kaplan fall in a range from 25.9 to 51.9, a span that embraces the zero years for all of the undeveloped or developing populations illustrated. For the most part, in short, the *timing* of C' contraction in survivorship during later life, like the *level* for the C trend preceding it has in modern societies resembled what is found among recent or older preindustrial populations

Patterns of survivorship for historical *homo sapiens*, furthermore, look familiar in even broader biological perspective (Fig. 8.7c). For a group of a dozen **prehistoric human** populations, between ages 1 and 20 l_x declines in C fashion with a percentage of approximately 39 near age 29 (Tab. 8.14; Gage 1998, 202, from O'Connor 1995).[40] The level for this trend at the zero year (38.6) falls near the top of the range for all historical populations from 17th-century London downward in Table 8.14. The base age (28.5) resembles that found for C in 1661 London, among the Yanomamo and the Hiwi, and in Qing females born from 1644 through 1739. The C' trend that follows from ages 30 through 60 for prehistoric humans, in contrast, projects to more than 110 "survivors" (of 100) at something like 11 years before birth. This represents an unusually steep drop. Was the hypothesized sharp fall-off after the late 20s inherent in the nature of prehistoric human life; or does it somehow originate from the way such data must be derived? The early-based (age 4), abrupt C' decline after about 40 for *life expectancy* in Rome at 225 CE (Fig. 8.1b, Tab. 8.4), at an intermediate stage of historical socioeconomic development, may support the former interpretation of long-term demographic shift with the evolution of human life.

The comparison extends beyond prehistoric humans to **primates** (Fig. 8.7c). For three captive populations of *Pan troglodytes* (the common chimpanzee, Man's closest present neighbor on the evolutionary tree: Gage 1998, 202, from Dyke et al. 1995), the C phase of decline in survivorship runs into the 40s (right panel of figure)--as among the early historical and preindustrial populations in the top half of Table 8.14. The timing of the base year for this curve (age 35), meanwhile, resembles that for the Yanomamo and the Hiwi, and for Qing females born from 1644 through 1739. With 43 survivors at t_0 out of an original 100, the level is just a little higher than is typical for the human populations (Tabs. 8.10, 8.6, 8.5). Among these *captive* chimpanzees, the C' decline that follows from ages 50 through 65 is also timed much like that for prehistoric humans (about -6 compared with -11). The projected level at t_0, however, is more than twice as high (273 vs. 111). Human care lengthens the C trend of *wild* chimpanzees (Gage 204; involving Gombe animals from Mode 1988) so that this phase of decline in survivorship begins earlier and lasts longer than it does for captive *Pan* (age 5 to 45 vs. 10 to 35). The starting level for C is raised by reducing losses during immaturity. In addition, the zero age for C is extended from about 12 to 35, flattening the slope. Human assistance--in feeding, shelter, protection, and medical treatment--however, does *not* significantly alter the t_0 of the C'-shape decline that follows (about -2 compared with -6). But, thanks to the flatter and longer C preceding, it takes effect much later in life and falls from a much higher base level--at about 250 rather than 40 per 100. Improvements from human intervention still collide with, and give in to, the ultimate aging pattern for chimpanzees even if captive care postpones the C-to-C' transition for about a decade of life.

In England and Wales, Japan, Chile, and New Zealand, across a century or so of change between the 1860s and the 1980s comparable developments in survivorship occur (Tabs. 8.5, 8.9; Fig. 8.2a to 8.2d), namely:

a) an earlier beginning and later extension of C;

b) much more increase in the base timing for C than in the height of the trend at its zero year (from age 69 to a projected 138 rather than just from 32 to 37 per 100);

c)more increase in the zero level for C' than in its base age (from 60 to 96 per 100 vs. just 37 to 49).

These changes and continuities in patterns of survivorship are found not just in four societies over a fairly recent 100 years. They appear very much across the whole historical record (Tab. 8.14). The patterns shift this way with time in a variety of populations since the 17th century or sooner, and--regardless of era--from the least 'developed' societies to the most. Improved treatment and conditions for humans, in short, produce results similar to human care for chimpanzees relative to their wild experience where:

a) the C phase expands from 10-35 to 5-45;

b) the zero level for C rises only from 36 to 43 per 100, while the zero age advances from just 12 to 35 ;

c) for the C' phase, in contrast, the base age shifts only from -2 to -6, actually falling back a little, while the level for l_x at that point jumps from 40 per 100 to a projected 250 for captive animals.

The crucial change in adult survivorship with better care consists of the way that the zero year for the C phase of erosion pushes outward into older ages. That makes the slope of decline during this stage flatter as less severe losses are suffered year after year during aging. The C trend also lasts somewhat longer, holding off for a while the inevitable encounter with a C'-type of trend during advanced years. The latter, for Man and for monkeys, reflects what might be called a 'natural' pattern of deterioration with age. It is characteristic of non-fatal deterioration as well as death, a previous section has demonstrated. The zero age for this C' trend may advance to the 40s in the most developed societies from the 10s and 20s found in preindustrial and early historical populations (or among poorly treated slaves) and the negative bases for captive and wild chimpanzees (Tabs. 8.5, 8.6, 8.8, 8.14). Nevertheless, a cut-off of survivorship in this more abrupt C' shape awaits older adults. Such a terminal decline with age "finishes off" the old in all populations no matter how long preceding flatter C-type decrease has postponed the encounter with C' decline or what proportion of the population has survived to that point.

Old world monkeys represent a mixed group without chimpanzees. (Gage 1998, 202; from Gage and Dyke 1988 and 1993). The sample blends life tables from several populations. Most are macaques (some rhesus, some Japanese), including one wild and two provisioned groups among six. The two others are mixed *Papio* ssp (mostly yellow baboons).

Compared with wild chimpanzees, the C trend for old world monkeys begins earlier and higher, but does not last as long. The C' pattern takes over by age 20 rather than about 30 for prehistoric humans and wild chimpanzees, and as late as 50 for captive *Pan* (Fig 8-7c). Their mean age of reproduction and generation length are about half that for both wild and captive chimpanzees (12.2 and 11.4 vs. 21.3-23.5 and 21.5-22.8), whose values are somewhat lower than those for prehistoric humans--both at 27.1 (Gage 1998, 212).

New world monkeys are represented by a blend of life tables for four species of captives. These include the common marmoset, the golden lion tamarind, the saddleback tamarind, and the cotton-top tamarind (Gage 1998, 201; from Dyke et al. 1993). For these primates, mean reproduction and generation length come earlier still--about 5.4 and 5.7 years of age. No C phase is evident in survivorship. The C' trend appears already by the end of the first year, and advances as if based at -62.5 rather than the -29.5 for old world monkeys. For *Pan* and for both old world and new world monkeys, meanwhile, in general death rates appear to have climbed in two or more successive E' movements as observed in a variety of human populations (Gage 1998, 212; Figs. 8.2a through 8.2h, 8.4a, 8.4b; Tabs. 8.9, 8.10).[41]

In all, humans and chimpanzees--relatively close biological cousins--display similar C then C' patterns of l_x across their life spans. Survival with age for other primates is clearly more different. Unlike a rough similarity between prehistoric humans and closely related chimpanzees, however, with life expectancies in the 80s modern *homo sapiens* characteristically survives approximately twice as long as the old world monkeys illustrated, and almost four times as long as the new world primates. For example, less than .005 of a birth cohort of prehistoric humans, *Pan*, or wild chimpanzees is typically left by age 65, but the comparable proportion for old world monkeys is reached by 45, while new world monkeys erode that much by 20 (Fig. 8.7c). The average breeding age and generation shift comparably (Gage 1998, 212). If the length of life is made more similar, however, a rather different impression of a likely C then C' sequence emerges for these two groups of monkeys that are more unlike humans than chimpanzees--and also for much more diverse types of fauna beyond primates.

Figure 8.8 and Table 8.15 crudely adjust the life spans of several species to the 70-to-85 years experienced by humans from prehistoric to modern times. (The basic evidence comes from Figure 8.7c and from Deevey 1977 [1947], 62-72). These plottings are very rough: over half are estimated from graphs; adjustment to fall within the range of a historically increasing human life span is approximated by simple multiples and the true natural life of a species to which the multiple is applied is often difficult to identify. In the cases of the snowshoe rabbit, the herring gull, and the song sparrow the original data are given not as calendar units but as multiples of the mean length of life. Nevertheless, the figure and Table 8.15, which compares its results with some of the primate findings in Figure 8.7c and Table 8.14, should provide some useful insight and inspire further investigation as to what is common and what varies in survivorship for fauna, and why.

When populations are framed hypothetically to have comparable life spans, the indications are that:

1) Not just for humans, but for mammals more generally, the C-then-C' sequence of survival characterizes survivorship during younger then older ages.

2) The need to extend a particular life span for comparison with humans, however, implies that the rate of acceleration downward in both C and C’ for the species is higher in real life. It would be something like .06 where old world monkeys live half as long as humans, who display a repeated .03 constant; more in the vicinity of .18 for new world monkeys, whose life span is about 1/3.6 as long as that for modern mankind. The structure of the formulas remains the same. Just the exponential constant for shorter-lived animals differs.

For chimpanzees, our closest relative, the .03 exponential coefficient of C and C’ is shared since no significant adjustment of the lifespan is necessary. Furthermore, both the level and the timing of the two curves for *Pan* falls within the range found for historic or prehistoric humans. For the two other groups of primates, once the specified adjustments are made, only the timing of the C trend for new world monkeys stands out as being much different from human populations. Yet in this form (Fig. 8.8), as opposed to unadjusted survivorship (Fig. 8.7c), a definite C phase does occur.

For mountain sheep, whales, and snowshoe rabbits (Fig. 8.8 and Tab. 8.15)--the other mammals illustrated--different (not .03) exponential constants for their equivalents of C and C’ trends in real circumstances are required, because length of life must be extended considerably to compare with that for humans. Each species, moreover, displays distinctive timings and/or levels for these patterns when these are artificially adjusted for longevity similar to that of humans--more divergence than is evident just among primates. Still, the scaled equivalent of C-then-C’ succession persists across these very different species. Is such trending in survivorship universal for all mammals? And how might that be?

For birds and for invertebrates, however, the C-then-C’ generalization seems not to apply (Tab. 8.15). Instead, survivorship from early in life onward erodes via a succession of only C’ movements without any C phase. The appropriate multiples in life span for *birds* relative to humans have to be about three times greater than for primates more removed from humans than chimpanzees and for the other mammals illustrated. For the two *invertebrate* species, barnacles and *floscularia*, the required adjustment in longevity is much larger still. The exponential constant for C' must increase accordingly; but the characteristic fixed C'-type curvature with age for each species is retained.

Among the birds examined, which require life-span multiples of about 8 to resemble humans, for some reason the last C' stage for l_x seems quite comparable both in base age and in level at that base point. In timing, furthermore, this final C' trend resembles that for the mammals in Table 8.15, though the height of the pattern at t_0 is much lower, following previous losses in C' rather than C fashion. Do warm-blooded creatures in general encounter similar acceleration of attrition in their last years of life?

While during the initial 'adult' phase ("second trend" in Tab. 8.15) survivorship for birds always takes C' shape rather than the mammalian C, these patterns are less similar than at the end of life. In particular, the level at which this first C' decline is based varies (unlike the narrow range in level among C movements during this phase for mammals but more variation in timing)

One implication is that from species to species how young birds and mammals are nurtured, trained, and make a successful transition into mature life varies more than how adults wear out, particularly the largely common timing of the late C' tendency. For the two kinds of invertebrates, just the opposite is suggested. The heavily adjusted examples are very similar to each other during the first C' decline, less so thereafter. What about their growth and aging might cause this different result?

Even with just these few crude, artificially adjusted comparisons, such similarities and differences in survivorship patterns among primates, other mammals, birds, and invertebrates should offer some fruitful insight for population biologists and geneticists. G-type patterns, with exponential coefficients distinctive from the .03 for humans can be found imbedded in the development of other species of fauna and perhaps also flora. This is indicated, for instance, by the way that they improve upon logistic trending long offered for expanding populations of fruit flies and bacteria, on the one hand, and the growth of individual sunflowers and rats, on the other (Lotka 1925, 69-74; unpublished investigation that probed the nature of the G trajectory in demographic increase for Volume I of this study).

Humans, in short, are not the only beings which experience the types of G-related trends for survival and other components crucial in shaping many types of demographic and related change through time. That this property is shared with other organisms--closely with some, with others only given modified timing, level, and/or succession of C or C' patterns--indicates a biological foundation for the patterning. Humans die off in a distinctive way as a 'biological brake' built upon the -.03 exponential constant progressively slows life to a stop.

THE IMPACT OF SURVORSHIP: HOW MORTALITY SHAPES DEMOGRAPHIC REPLACEMENT AND CHANGE IN REPEATED G-RELATED WAYS

Human life expectancy (Figs. 8.1a through 8.1c; Tabs. 8.3, 8.4) and survivorship (Figs. 8.2a through 8.2h, 8.3a, 8.3b, 8.7a, 8.7b; Tab. 8.5. 8.6)--along with less-than-fatal degeneration during aging (Tab. 8.8)--are shaped across the adult life cycle in C then C' phases by the way that other G-based, mostly E' and G', patterns with age for specific types of mortality rates (Tab. 8.11; Figs. 8.5a, 8.5b) aggregate to imprint E' or E patterns on overall death rates by age (Figs. 8.2a through 8.2h, 8.4a, 8.4b; Tabs. 8.9, 8.10). At root, this chain of causation appears to be a phenomenon shared closely with the nearest biological relatives of *homo sapiens*, with an acceleration of decline that differs from -.03 among more remote primates, other mammals, birds, and invertebrates (Figs. 8.7c, 8.8; Tabs. 8.14, 8.15). At bottom, the repeated G-related trending in demographic findings appears biological in *origin*, the susceptibility of species--notably our own, with its distinctive -.03 exponential constant--to risks of dying.

Turning to *consequences* of such recurrent patterning in mortality for the continual replacement of populations, the first thing to note is how--moving from death rates for particular causes (Tab. 8.11) through mortality rates in general (Tabs. 8.9, 8.10), to survivorship (Tabs. 8.5, 8.6, 8.8, 8.9) and life expectancy (Tabs. 8.3, 8.4)--the first pattern for losses across adulthood dominates more and more of the total life span. It fits more and more years of aging, pushing earlier into adolescence at the expense of decelerating childhood casualties and simultaneously also later into the tail end of life, holding off further the distinctive patterning of the final years--in the cases of survivorship and life expectancy, delaying the replacement of C by C'.

This elongation of the C curve reaches still further when one moves from survivorship (l_x), the proportion of an original birth cohort left at age *x* (those remaining of an initial 100,000), to $\boldsymbol{T_x}$, or the total number of years lived past age *x* by a birth cohort of 100,000. Aggregating like this generates an even longer C trend.

Table 8.9 demonstrates that point for 23 national populations between 1861 and the 1980s. C' in T_x replaces C mostly only between 65 and 75, and begins by age 5 or 10 (except in 1920 Taiwan)--and, by the 1980s, sometimes as early as the first year of life. In Buffon's life table for Paris and environs as of 1792 (D. S. Smith 1999, 596), C runs from about age 10 through 70. Because the range of ages conforming to C shape has to be estimated in advance as a parameter for the curve-fitting, the spans given in the figures or in Table 8.9 do not identify *exactly* the range of ages most accurately aligning with the curve. In the end, the best C may begin a little later or a little earlier, or run longer or shorter than what is indicated. The eye reveals quite well, however, where the data actually join or depart from the proposed C shape.

Table 8.16 extends the sample to show how the range of the C shape in T_x covers most of the life span in 44 diverse populations. Figures 8.9a through 8.9f display fitted C trends for 31 of them. In order to demonstrate the nature of historical change, these include patterns at more than one point in time for England and Wales, Sweden, Italy, Japan, Taiwan, the United States, New Zealand, Chile, and the 'colored' population of South Africa,. Those comparisons indicate how, with historical improvements in health and living conditions, survival in populations has increased both thanks to a rise of starting level in early childhood and through an extension of the zero year for C later into maturity.

Even through these shifts, however, the aggregate remaining life in a population begins to taper off in C fashion in fairly early childhood and continues to do so into quite old age. The number of people in the active and decision-making years of life--those who work, mate, have children, stop reproduction (naturally or by design), educate, empty the nest, yield power to the next generation, lose partners, and cease work--all tend to be trimmed by mortality in C shape. Just the one pattern imprints itself upon the continual replacement of populations over and over again. In all, T_x depicts the manner in which for a population the aggregate weight of the old peters out in C fashion, giving way to the new.

Since Euler in the 1760s, **age structure** has been seen to play a central role in determining how the continual replacement of populations is shaped. Much as survivorship (l_x) imprints the C then C' patterns upon life expectancy (e_x) and T_x,, it likewise (following childhood) channels age structures into, or toward, two successive segments of the life cycle that take these two familiar G-based forms of decrease.

Figure 8.10 illustrates with 6 varied historical cases how trends of C then C' shape fit most of the age structure for females or for both sexes between about 12 and 77--in other words, through adolescence and the active adult years. Only among children and the oldest survivors do the data depart from these two successive patterns.

Part A of Table 8.17, first of all, shows how these two patterns in succession appeared repeatedly across a comparably long portion of life in the populations of England, France, and Sweden during the three centuries between 1561 and 1861. These three series, once again, provide the longest, most ample, and most reliable insights available into historical demographic change. The dates chosen reflect when growth in the populations shifted from one type of expansion (or contraction) to another, due to changes in death rates and birth rates and in their relationship to each other (Harris 2001, 148-53; Ch. 2 of the present volume).

In 14 of 15 instances, between the ’teens and the 70s just the usual C then C’ patterns of age structure appear. In the one exception of England at 1821, a year chosen because it was given special analysis by Wrigley and Schofield (1981, 117; revised numbers), thanks primarily to a prolonged accelerating E-shape gain in the birth rate from the 1720s to about 1800, natural increase had surged from less than 2 per 1,000 (at 1561, 1656, 1686, and 1726) to more than 16. The constantly more rapid increase in births over decades that produced this surge kept the age structure before about 45 from decelerating via C. Instead, it declined in log-linear form at a rate of rather less than -.03 (Fig. 8.11a). This straightforward exponential tendency began to be evident already by 1816 (at a rate of -.030 rather than -.027), though as yet it pertained only through about age 20. (Noted by the superscript “e” that accompanies the zero year of the C trend which followed--unlike in 1821, when no C appeared.) The ever-faster surge of children under 5 as a proportion of the total population peaked about 1820. By 1841, another year given special attention (Wrigley and Schofield 1980, 117; revised), however, the log-linear tendency in the early age structure had disappeared as the birth rate now declined. This return to C-then-C’ patterning is demonstrated in Figure 8.11a.

In modern times, too--for instance West Cameroon between 1964 and 1985--log-linear tapering in age structure could, as in England during the early 1800s, metamorphose into decline via C (Fig. 8.11b), though the e^{-x}slope was steeper and vestiges of constant exponential decrease persisted through age 15. In Mexico, on the other hand, between 1966 and 1983 log-linear patterning among females under 30 shifted into older parts of the age structure as C-shape contraction appeared preceding it and also probably, to begin with, a bulge for the cohorts 0-4 through 20-24 (Fig. 8.11a). Madagascar between 1966 and 1985 (Fig. 8.11b), in contrast, provides an example of how log-linear sloping with age at least temporarily replaced what had been C-shape decline(s).

Among 45 populations examined for Table 8.17, besides the examples for England, Mexico, Madagascar, and West Cameroon that have been addressed, the log-linear phenomenon appears only in 1966 Costa Rica . Tapering of the age structure in the e^{-x} form--long perceived to be the inevitable ultimate result of constant birth and death rates-- in historical reality has instead just sometimes appeared as a transitory pattern during childhood and early adulthood. It has occasionally supplemented or replaced the much more widely shared C stage in the shape of age structures. It does not, however, intrude upon the C' phase which, it seems, occurs universally across later segments of the life span.

A second exception to the simple C-then-C' generalization appears in the English population as of 1561. There, through the first two decades of life, the age structure bulged to peak in the vicinity of age 10 before beginning to taper. The surge (denoted "b" with the C decline that followed) seems to reflect the kind of "baby boom" found in many 20th-century populations. This 16th-century instance was apparently generated by rates of birth (CBR) and of reproduction (GRR) that were unusually high in the vicinity of 1541, 1546, and 1551 (Wrigley and Schofield 1980, 528) or1539-1553 as a whole (perhaps somewhat earlier). This was a period of major social, economic, political, and cultural change for England between the break with Rome and confiscation of monastic lands (1536) by Henry VIII and the accession of Mary I (1553).

In 30 modern populations of the 20th century, where cases of 'baby boom' and 'population explosion' were common given an environment of two world wars, the Great Depression, and widespread 'demographic transition,' bulges in age structures are familiar and frequent. They and the dips between them, however, for the most part swing across the usual C-then-C' patterns in age structure, as plots for France and the U.S.S.R. indicate (Tabs. 8.12a, 8.12b). In the U.S.A and Taiwan, these underlying paths are less evident. An averaging of 1966 and 1985 for the United States (multiplied by 4 for visibility), however, reveals the decided underlying C-then-C' tendencies even when the swings are fewer and have longer frequencies.

In spite of recurrent bulges, in other words, that C-to-C' sequence of patterns in age structure nonetheless remains a pervasive demographic feature.

In all, among 30 modern populations, in the 12 cases of part B of Table 8.17, four (Sri Lanka, Argentina, Tunisia, the Philippines--all as of the 1960s) display the C and C' patterns alone, as in 12 of the 15 examples before the middle of the 20th century in Part A. In 1966 Taiwan and 1980 Chile, a bulge into the 20s ("b") preceded the common C-then-C' sequence for the rest of adult life (as in 1561 England). In Mexico and Costa Rica in the 1960s and Madagascar and West Cameroon in the 1980s (as noted), some simple exponential tapering occurred through the 'teens or early 20s before the age structure adhered to the usual C and C' paths (as in England at 1561). In 1967 Chile and 1966 Madagascar, finally, up through about age 25 an extra, early C trend ("c") shapes the age structure before the usual C-then-C' patterns of subsequent adulthood. On the whole, however, all 12 age structures of part B display the C-then-C' combination, even if in 8 cases it was preceded by some extra pattern into the 20s.

Of the remaining 18 populations (in part C of the table), 6 fail to display the C-then-C' shape in their age structures. In the United States at 1966 and in Japan and Taiwan in the early 1980s, no C decline precedes the C' pattern. Instead, one or two bulges are evident. In the case of West Cameroon at 1964, C is replaced by decrease in the e^{-x} fashion (-.036), as in 1821 England but more steeply. In 1966 Japan, a C' trend, not the usual C, represents the first tapering in age structure. In the Soviet Union as of 1979, the C pattern lasted through the early 70s and no C' is evident thereafter.

In 12 of these 18 cases of part C, however, the usual C and C' paths capture the general movement of contraction with age but have **short-term fluctuations** across them. Often these bulges in age structure reflect obvious interludes between wars, depressions, and other crises which had clear negative implications for family formation and reproduction--especially in repeatedly ravaged countries such as the Soviet Union or France. Figures 8.12a and 8.12b show

how such bulges remain imprinted in age structures as populations mature across successive decades. They climb the age structure with time as the surge from births (compounded by patterns of adult survival) grows older and older, a phenomenon that is well recognized--even in the daily news, where it is too readily deemed generational.

In the case of Taiwan (Fig. 8.11a), one bulge (“B”) reflecting demographic recovery following the flight from the mainland in 1949 can be seen to advance through the age structure between 1966 and 1985, peaking around age 2 then about age 22. In 1981 China, a crest near age 12 (for cohorts born in the vicinity of 1969) reflects relief from severe measures and harsh conditions during previous years. The births of 1952 through 1956 (about age 27 at 1981), too, swelled relative to their predecessors before reversed circumstances affected those born from 1957 to 1961.

In United States at 1966 (Fig. 8.12a), two separate bulges crest about age 7 then 42. As of 1985, 19 years later, the peaks come in the vicinity of ages 27 and 62. Together, these fluctuations imply maximum births in the vicinity of 1959 (just after the summit of the famous postwar “baby boom”--Figs. 2.2h, 6.1) and around 1924 (following W.W. I). This 35-year spacing exceeds a modern generation (about 27 years) by as much as the 20-year interval in Taiwan falls short. (The spacing may be only about 15 years in China, furthermore--implying extra births around 1954 and 1969.) In the U.S.S.R. and France, multiple bulges in age structure were comparably maintained through time. As in Taiwan and China, furthermore, their spacing tended to be relatively short. In the U.S.S.R. as of 1979 (Fig. 8.12b; Tab. 8.17), the crests came around ages 22, 47, and 67.[42] By 1989 highs appeared about ages 27, 47, 60 and 77 as the 32-62 bulge from 1979 more clearly divided into two. The Soviet birth cohorts of 1957-60, 1927-32, and 1910-12 (and by 1989 also 1940), in short, are larger than others in between, who suffered heavily for various reasons at successive points through their lives (Tab. 8.18). In France (Fig. 8.12a), peaks near ages 17, 42, and 62 in 1967 became crests in the vicinity of 22, 37, 62, and 77 by 1985. This implies maxima for the birth cohorts 1905-08, 1923-25, 1948-50, and 1963 (Tab. 8.18).

Because only 5-year segments of the life cycle are examined, these “points” at which bulges in age structures maximized are just roughly approximated. The quinquennial approach significantly blunts identifying precise ages for peaks at various dates. Even this type of crude analysis nevertheless demonstrates some useful things about how bulges (and intervening contractions) advance through age structures as populations renew themselves. It throws better light upon what might be causing such swings, and how they might tend to reappear in certain rhythms.

The demographic history of the 20th century was notably periodized by two world wars, an international Great Depression, and a burst of nation-building out of former colonies. To a considerable degree, countries can be expected to have shared demographic ‘booms’ and ‘busts’ that resulted from these events and from their ‘echoes’ as cohorts aged and were replaced. Table 8.18 roughly estimates the peak years by *date of birth* for 39 observed 20th-century bulges of varying size and duration in the age structures of the 18 populations covered by part C of Table 8.17. In parentheses, it gives the intervals between these approximate crests in each population.

While some clustering does occur in and around certain birth years between 1901 and 1983, no simultaneous international rhythm stands out. As Table 8.19 indicates, different sets of countries share distinctive timings. On the one hand, France and her former colonies of Algeria and somewhat Mauritius show crests in periods 1, 3, 5, and 7--each about two decades apart. In the U.S.S.R., in contrast, the bulges maximize in periods 2, 4, and 6. In Algeria and Japan crests comparably arrive 22 and 26 years after the highs that precede them. The U.S.A. and Norway, meanwhile, largely share in periods 3 and 6 a distinctively wide spacing--as does Greece earlier in the century.

Even from this small sample of diverse populations, it can be said that in spite of some internationally shared events, there were no dominant, simultaneous fluctuations in age structures during the 20th century. In aggregate, however, these very different peoples--who among them have experienced quite distinct histories--*did* tend to share one significant feature in the fluctuations of their age structures. Repeatedly, that is, the peaks of bulges in age structure have occurred mostly about 20 to 25 years apart.

The analysis of this spacing here is crude, and can be only tentative. The quinquennial nature of the data make timing imprecise, just approximate. Some local maxima or "peaks" are minimal. The intervals between them, as noted, vary considerably. Nonetheless, the central tendency for their spacing promises to be significantly related to the exponential foundation of the G-based family of curves. For instance, the doubling time of $e^{.03}$ is 23.1 years.

For 21 intervals between bulges in 20th-century age structures displayed in Tab. 8.18 (noted in parentheses), the mean is 23.6 years, the median 25.0, and the standard deviation 7.19. The distribution is weakly bi-modal, with 3 intervals each of 15 and of 25 years.

In the United States in particular, the spacing between bulges has popularly been considered to reflect "generations." In fact, the U.S. interval--which persisted from 1966 to 1985, Figure 8.12a shows--was more like 34 or 35 years, or 8 to 9 years (1/3) longer than the actual generation at those dates. Only Greece in the vicinity of 1967 and Norway at 1967 and 1985 also display intervals of as much as 30 years (Keyfitz and Flieger 1971, 1990). Generations for 17 of these 18 populations, meanwhile, are in fact calculated to have run 26.2 to 28.5 years--from the U.S.A. in 1966 to Algeria in 1965.[43] In the other tail of the distribution, the timing of first economic crisis then the Cultural Revolution during the early years of the People's Republic carved out an exceptionally short 15-year spacing in China, while something in Norway generated a crest in the birth cohorts of around 1965, unusually soon after the postwar peak at 1953. Much more typical are intervals from 20 through 25 years, where 1/3 of the cases fall.

As noted, the 20th century famously produced a few widely-felt crises that impacted age structures, affecting both the number of surviving potential parents and the typical number of children that they produced. Did these well-known modern shocks then shape age structure for recent generations in historically *unrepresentative* ways, including how the approximate average interval between bulges, at 23.6 years, fell significantly below the typical 1960s and 1980s generation of more like 27.3 years?

Apparently that was not the case. Table 8.20 presents the proportional distribution by age of the population of England at 5-year intervals from 1541 through 1621 (Wrigley et al. 1997, 615). The reported percentage in each age group (0-4, 5-14, 25-44, 45-64, and 65-84) is adjusted to display a 5-year equivalent. Hence, 6.40 for the four 5-year age segments 25 through 44 in 1541 is 1/4 of the published figure; 8.73 for 15-24 is 1/2; and so forth. This technique--though crude, especially where age categories are broad--makes possible an approximate understanding of how an age structure with bulges evolves through time. The percentages in brackets in Table 8.20 denote single or adjacent quinquennial proportions with high values relative to others.

First of all, those born roughly from the mid-1540s through the mid-1550s repeatedly have extra weight within their age category relative to neighboring cohorts. This is true for them at all subsequent ages, from when they were 0-4 in 1549-58 (mid-points 1551 and 1556) to when they fell within the 65-84 bracket as of 1614-18 (1616). Like the 20th-century postwar 'baby boom' in the United States, the males and females from the mid-16th-century cluster of births kept leaving a fat footprint on the English age structure throughout the remainder of their lives.

Another bulge, now something under rather than over 14 percent of the total population, appears for children 0-4 in the years 1579 through 1588 (quinquennia 1581 and 1586). It, in turn, visibly advances through the age structure as far as the 1620s or later. The percentage advantages for this later bulge, age level by age level, relative to neighboring cohorts roughly equal those for 1551-1556. A third, intervening birth peak, consisting of a single quinquennium for those 0 through 4 in the vicinity of 1566, appears in between those of 1551-1556 and 1581-1586. It, too, leaves echoes that can be followed through older ages--except for the age group 25 through 44, where it tends to fuse with effects of the cohorts of the next 0-4 bulge of 1581 and 1586. Finally, a fourth bulge--among those 0-4 around 1611 and 1616--begins by the 1620s to percolate up the age structure of England..

On average, from 1541 through 1621 the high cohorts for each age group (in brackets) run 1.088 to 1.115 times the proportion who were of a given age at other times--9.5 percent more overall. This is not as much a difference as found in some 20th-century populations, notably in the United States and Taiwan; but it is comparable to other modern fluctuations, as in France and the U.S.S.R. Four centuries ago, in short, bulges rose through the age structure of England much as they did during the later 20th century in some populations of Europe, Asia, North America, Latin America, and Africa (Tab. 8.17; Figs. 8.12a, 8.12b).

Before the 1960s, furthermore, it was not just the population of England in the later 16th century that experienced periodic bulges in its age structure. Children ages 0-4 as a proportion of total population repeatedly fluctuated in England, France, and Sweden (Figs. 8.13a, 8.13b) from the time where records begin for each country down through the modern era. If the peaks for children 0-4 in England (Fig. 8.13a) are compared with an underlying 25-year moving average for the data (5 quinquennial observations at a time), the periodic crests rise from 1.1 to 10.8 percent above the underlying trend, with a mean of 4.84 and a median of 4.0 percent.[44] Swings in France (Fig. 8.13b) were clearly more subdued than those in England and Sweden. The French are well known for managing their family size. Furthermore, no clear French peak appears between 1821 and 1866 (though 1841 stays level in a period of decline). In Sweden as well, none is evident (at least not when employing only decadal evidence) between 1910 and 1950, as fertility fell the most precipitously among these three European series (Fig. 8.13b; Tab. 8.21). On the whole, nonetheless, relative high points of some sort kept occurring in all three countries across long stretches of history.

The typical spacing of all possible 17 English peaks between 1541 and 1871--only 17.4 years--is considerably narrower than the 23.6 years found in populations of the 20th century (part A, Tab. 8.22). For 6 French intervals, however, the average comes to 21.7 years; and for 6 Swedish gaps it is 26.7 years (Tabs. 8.21, 8.22). In each of these two continental series, one long hiatus of 45 or 40 years without a peak is not considered in the averaging. For 29 other intervals in all three European series, the mean is 20.2 years, the median 20.0, and the standard deviation 6.28. The distribution tends to be bi-modal, but with narrowly separated peaks at 20 and 25 (reflecting the 5-year nature of most evidence).

If these 29 historically earlier spacings are added to the 21 findings from age structures of the later 20th century, for 50 intervals overall the mean is 21.6 years and the median 20 ("Total" for part A of Tab. 8.22). The mode is 20 years and the standard deviation 6.88. Other perspectives suggest, however, that differences between the two groups of populations (and within the earlier European set) may be somewhat less than this.

First, the 5 available *lows* from the Swedish series average 24.0 years apart, in contrast to the 26.7 years for the 6 highs. This perspective would make Sweden look less different from England and France than it first seems. More consequentially, if fluctuations in the English cohorts *aged 5-14* are followed instead of peaks among children under 5, there are only 14 intervals in the 293 years between 1558 and 1851, not 17 (Tab. 8.21, part B of Tab. 8.22). That is, certain bulges in the 0-4 series had no staying power as children aged. There was no 5-14 'echo' a few years later from 0-4 highs at 1621, 1656, or 1691. The just 14 intervals between bulges for English children 5-14 consequently average 20.9 years in duration rather than the 17.4 for 17 peaks for those 0-4 from 1551 through 1846. If these spacings for older children are substituted for the English 0-4 intervals, the joint European historical mean for 26 gaps becomes 22.4 years and the average for this group plus the modern evidence ("Total") becomes 23.0 years, while the standard deviation falls somewhat, from 6.88 to 6.54. The overall median for these 47 intervals rises to 23. The distribution is essentially bi-modal at 20 and 25.

In still another perspective, Table 8.21 denotes with "*" single-quinquennium English peaks from Figure 8.13a at 1621 and 1646. About 25 years apart, these two highs enter a temporary rhythm into the English series that runs opposite to the usual fluctuations. As noted, the 1621 peak produces no 'echo' among ages 5-14 a few years later, while the 1651 bulge among older children comes only 10 years after the 1641 'echo' of 1633 for those 0-4. If this contrary pair of high points is omitted from the series for English children 0-4, intervals of 25 then 23 years replace short spacings of 13, 12, 13, and 10 years, which lost their impact as children grew older. Adjusted this way, the mean for 15 English intervals becomes 19.7 years--more like that for bulges when these children reached 5 through 14 (20.9) than for the original 0-4 English spacing (17.4). For the three older European series together, the mean then becomes 21.7 years. For the older and the more modern evidence combined, the mean for 48 intervals is now 22.5 years. The median becomes 22 years, while the distribution is bimodal at 20 and 25. The standard deviation is reduced a little further, to 6.40.

Again, this is very crude, at best suggestive, analysis. The 5-year intervals for the data blur actual short-term movement. All peaks are far from equally significant--whether perceived absolutely or viewed relative to an underlying, long-term trend. But fluctuations across widely differing eras and cultures, while not simultaneous, seem nonetheless to have occurred in populations repeatedly with an average rhythm of about 22 or 23 years. How a frequency of something like this might tend to recur in worldwide age structures is a topic worth pursuing when the nature of demographic renewal is reexamined in the next chapter. A clue may be that the doubling time of a population growing at a rate of $e^{.03}$, the exponential foundation of all the G-related patterns which permeate so much demographic change, is 23.10 years.

Digesting inputs from births and from exogenous shocks or long-term pressures on populations, whether exercised through fertility or via mortality, it is survivorship (l_x) that continually shapes the momentum of demographic change in it own G-based image. Its imprint stands out, among other places, on e^x (life expectancy by age) and on T_x (the total number of years a population lives beyond age x).

Specific death rates at certain ages due to various causes, which themselves take G-related forms, combine to generate the mostly E'-shape patterns of age-specific mortality as a whole. This G-based 'force of mortality' in turn imprints the typical C then C' declines on survivorship (l_x) across most of adult life. The interactions of death rates from particular hazards (who is left at risk after other threats have taken their toll, and so forth) repeatedly compound into a simply-patterned overall G-related net result, first in age-specific mortality then in survivorship. The same variety of risks also stamp C then C' patterns like those of survivorship upon deterioration for humans that falls short of actual fatality, on how we wear out.

This shaping of survivorship (and sub-fatal degeneration) for humans in C then C' patterns is found for modern peoples, in the earliest historically recorded societies, and even among prehistoric populations. It is also shared by both captive and wild chimpanzees, who are among the closest current biological relatives of *homo sapiens*. Some mammals, birds, and other organisms likewise appear to share comparable two-stage accelerations of decline in adult survivorship, but with their own distinctive exponential coefficients in lieu of the G-derived .03 involved in C and C'. In short, shrinking survival first via a characteristic downwardly accelerating path of the general C type, then according to the derivative of this species-specific curve, seems to be a widely shared feature of biological organisms in general.

Survivorship notably shapes change over time according to G-connected patterns through the way that age structures evolve along G-based paths, continually imprinting the past on demographic systems while incorporating the new. Age structures themselves retain G-connected forms even as they alter significantly through time. The result of this chain of effects is that all demographic change tends to unfolds along G-related paths.

What particular results are is largely determined by the dynamics of demographic renewal. How do G-related patterns observed in populations alter within this familar system of replacement by deaths and births while so reliably retaining a G-connected shape? It is possible to determine whether G-based trends in fact appear as expected when demographic regimes are arbitrarily altered experimentally and to examine where the G formula and its relatives fit into the long-evolving study of the mathematics of population change.

Notes

1. G-shape increases in e_0 are evident from the 1970s through 2004 for all males and all females in India, and for their urban and rural components separately--though flatter for urban males than for others (Saikia et al. 2011, 78).

2. Nearby within the Netherlands, a rough indicator of trend in life expectancy (the percentage of grooms whose fathers were still alive the time of the wedding) in the industrial province of Limburg increased via E from 1816 to 1845, then again from 1845 through 1916. In maritime, less developed Zeeland, meanwhile, the percentage grew in G fashion instead--between 1825 and 1865, then from 1875 to 1916 (van Poppel et al. 2009, 135). The Limburg path resembles that for life expectancy at 25 in somewhat-earlier-industrializing England into the early years of the 19th century and ${}_{20}e_{25}$ in particular: the probability that individuals age 20 would survive for 25 years or more (Fig, 1.10). Compare the properly opposite C trend possible for *missing* fathers of brides in East Kent and likely in the mortality rate for tontines 31 to 45 during the late 18th century (Fig. A.1).

3. So did life expectancy for all five types of men in their 20s studied by Razzell. In four of these groups, however, the preceding pattern from 1625 through 1725 was E (Fig. A.1a, Tab. A.1 in Appendix A).

4. Overall, roughly from 1407 through 1487 in C shape targeting about 1509 (ibid.).

5. Alternatively, the French trend between 1950 and 1975 could be G, based about 1918.

6. For *cohort* e_0 among just females in the United States, approximately 1908 (Li and Lee 2005, 588).

7. C then C' succession in life expectancy, however, emerges for *unmarried* Yale graduates of the 18th century and Andover *females* born between 1730 and 1755, while Plymouth women of the 17th century,

in contrast, seem to have lost years yet to live along a single C path from 25 through 85.

8. Even considering just the rural population at the later point.

9. Excepting 1964 West Cameroon and 1966 Algeria.

10. For a simple modeling of how, with age, mortality due to aging becomes increasingly significant relative to 'background' losses that affect all adult ages fairly comparably across the life cycle and age-specific mortality rates as a whole, and an illustration of how these weights have changed historically, see Bongaarts 2005, 27.

11. Compare, also, the C' patterns of several European localities between 1660 and 1850 (Tab. 8.6) and 1964 West Cameroon or 1881 Italy (Tab. 8.5).

12. For some reason, this was the timing also for Qing females born between 1644 and 1739, perhaps in large part because they died off so much more steeply during the preceding C phase from childhood to 40 than males, suggests Fig. 8.3b.

13. Though for some of these populations the C pattern began as early as age 5.

14. Estimating via log-linear interpolation from 36 percent loss by age 6 and 60 percent by age 16.

15. Data for Schenectady between the 1880s and 1930 take a parallel, somewhat higher C path, while evidence for the observed New York counties of 1850 to 1865 and certain Pennsylvania counterparts in the 1890s indicate a somewhat flatter decline earlier, with zero year in the early 1930s if the infrequently observed trends took C shape.

16. England and Wales, the United States, and New Zealand, finally, display C' trends for chronological reduction in deaths by age 10 also during the later 20th century, a pattern not developed elsewhere among these seven examined populations by the 1980s.

17. Possibly also Galicia and Lower Austria.

18. Rather earlier in eastern Belgium.

19. For men with *foreign*-born parents, the rate for major crime fell largely parallel with the one for second-generation natives until the mid-40s, but then followed a much flatter C trajectory through the 60s. The minor crime rate for these men, however, for some reason continued to rise in G fashion from

under 20 until 70 (ibid.).

20. If, however, the C’ shape were applied to values from 60 through 80 (accepting only a rough fit), for each strength the zero year would come in the early 50s--at worst still a somewhat later C’ path.

21. For example, Keyfitz and Flieger 1990, 22-25, or Newell 1988, 67-78.

22. The initial, childhood drop in l_x in relatively modern populations tends to be completed as early as about age 5.

23. Perhaps only one E’ trend in Italy as of 1881 and Tunisia and Fiji in the 1960s, and probably as many as four in 1960 Mexico. The interested reader can explore the consequences of possibly E-shaped alternative trends.

24. Italy at 1881 and 1983, the registered districts (“r”) of the United States at 1900 and 1985 and Canada at 1921, Fiji at 1966, and Ecuador at 1965.

25. Though the opening E’ trends for Madagascar, Tunisia, and the Peninsular Malays in the 1960s do commence from comparably low *levels*, while populations before the 1960s do not.

26. In 1985 England and Wales, for example, while between ages 15 and 45 age-specific mortality for females multiplied in E’ fashion by a factor of almost 9, the increase in death rate was only from 0.028 percent to 0.25 percent (Keyfitz and Flieger 1990, 544).

27. See also approximations for 2000 Sweden in Tab. 8.10.

28. And also for males, indicates the lighter accompanying but unfitted line with “X” at t_0.

29. Though by the end of the 20th century it was to reappear in deadly, drug-resistant form.

30. Except in the specific case of respiratory tuberculosis before about 1950.

31. Having ignored pre-adult movements, however, the fit is already not general for mortality at all ages.

32. Reference lost.

33. For some reason, in the 1690s and 1700s the death rate from small pox was low simultaneously in Geneva and in London--a phenomenon worth investigating. A similar deviation from the surrounding G’ tendency appears for Geneva in the 1610s.

34. As a percentage of all burials, deaths from smallpox in the metropolis between 1710 and 1740

surged then tapered off after a peak near 1718. Once more, the rate in the vicinity of 1700 was exceptionally low (Davenport et al. 2011, 1291).

35. Smallpox deaths relative to baptisms in London, meanwhile, between the 1740s and the 1800s rose then receded in G' manner, peaking at about 14 percent near 1755. In the one parish of St. Mary Whitechapel, the child mortality rate from small pox relative to baptisms instead took G' form from the 1770s to 1811 or later with a maximum of about 67 per 1,000 around 1788 (Razzell 2011, 1332).

36. As a proportion of all London burials, small pox deaths from 1740 to 1770 approximately took a G' path peaking in the vicinity of 1766. Between 1770 and 1810, they came down via a C' trend based about 1770. Then from 1800 to 1820 they began to 'bottom out' in a D' trajectory that would minimize around 1840 (Davenport et al. 2011, 1291).

37. While Bongaarts et al. projected that cases per year among adults 15-49 declined slightly between 2005 and 2010 (from about 2.6 to about 2.5 million), total new cases for all ages are calculated to have remained level at about 2.7 million (Donald G. McNeil, Jr., 2011b, *New York Times*, Nov. 21, citing U. N. AIDS).

38. Ancient development in the case of Ulpian's Rome of 225.

39. The mean level of survival at t_0 in these more recent instances, near 37 percent, was rather higher, however.

40. All trends from Gage are estimated from his graphs on pages 204 and 20,5 not the original data upon which he based these. The patterns offered are thus only rough approximations; but they should serve to illustrate parallels and discrepancies among humans and primates and perhaps inspire others to analyze these and additional appropriate populations more precisely in comparable terms.

41. The small scale of the graph makes exact curvature for these steeply rising trends difficult to ascertain (Gage, 212); but E' patterns 30 to 45 then 45 to 65 (*Pan*), 1 to 20, 20 to 30, then 30 to 55 (OWM), and 1 to 15 then 15 to 35 seem to occur.

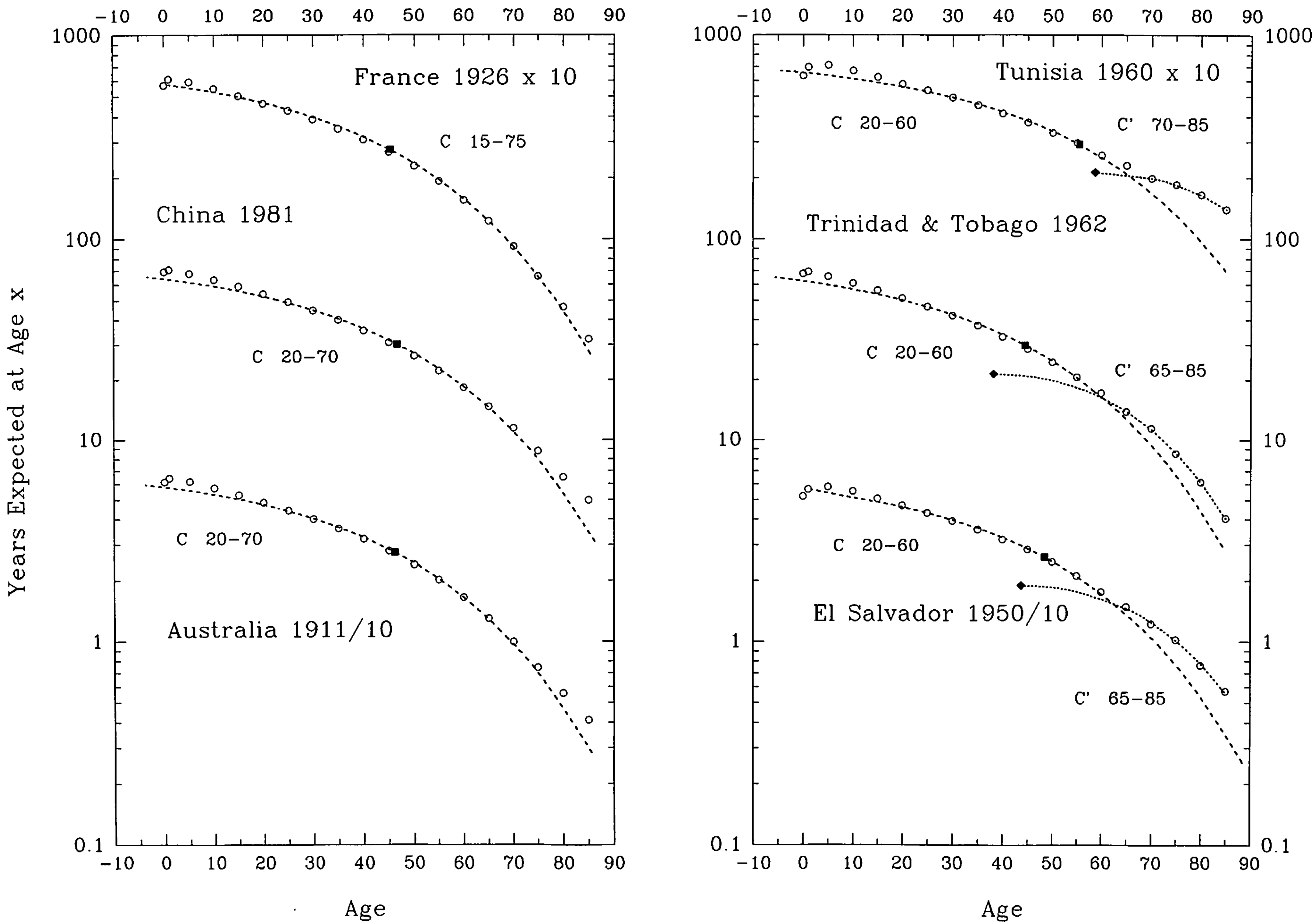
42. Age 47, in actuality, constitutes a slight middle dip among three 5-year points above the underlying trend (Fig. 8.12b. But it marks the center of a bulge between age 32 and 62.

43. Algeria at 1985 is not given.

44. Calculated but not shown. The least difference occurs at 1846, the most around 1556 and 1571, though the absolute quinquennial peaks instead come at 1551 and 1566 (Fig. 8.13a).

Figure 8.1a

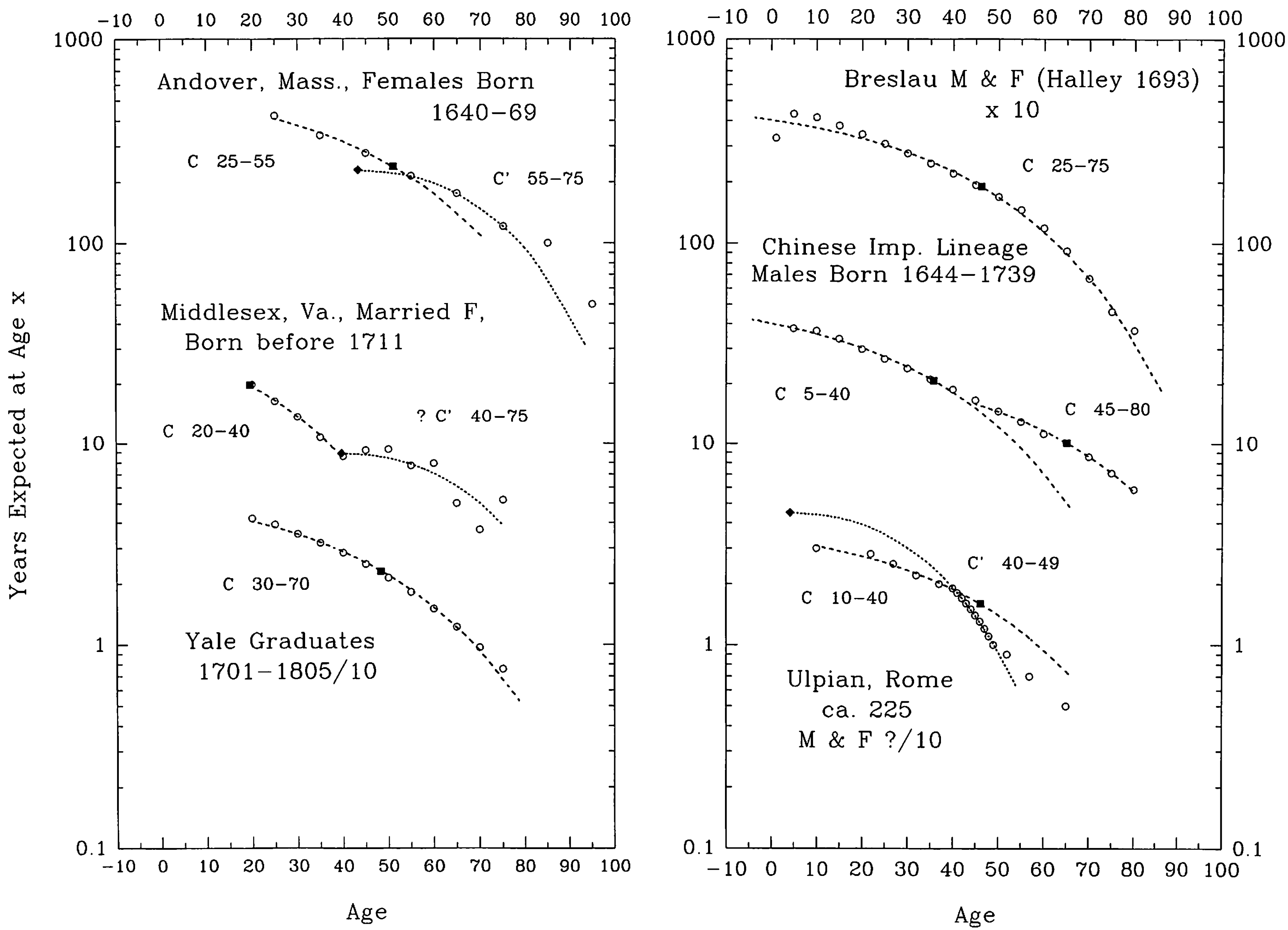
Life Expectancy by Age in Certain Populations: In the 20th Century



Sources: Preston et al. 1972, 286, 70, 222: Keyfitz and Flieger 1971, 224, 350; 1990, 350.

Figure 8.1b

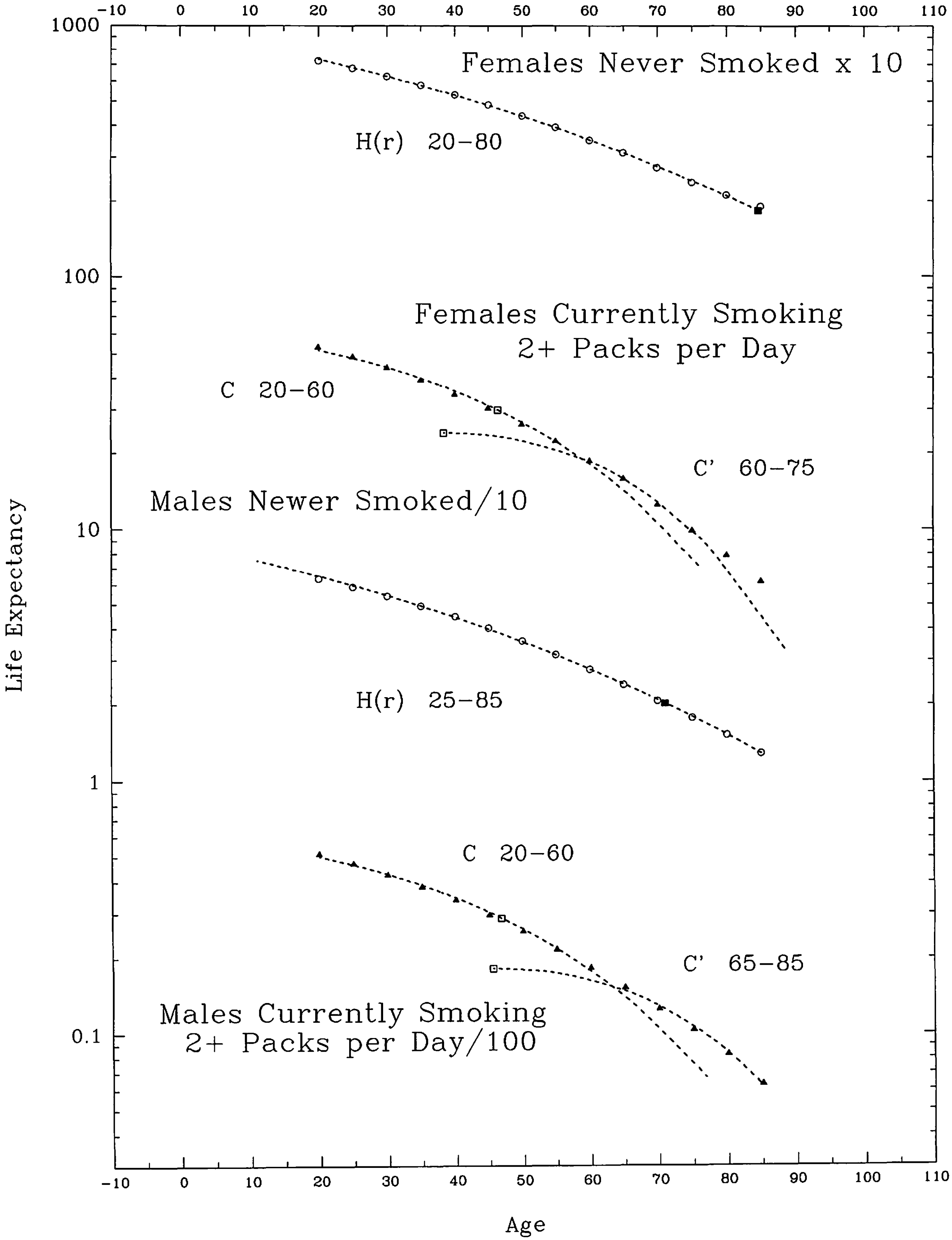
Life Expectancy by Age in Certain Populations: Some Early Examples



Sources: Vinovskis 1972, 198; Rutman and Rutman 1979, 172; Hacker 1997, 495; Smith and Keyfitz 1977, 5, 7; Campbell 1997, 196.

Figure 8.1c

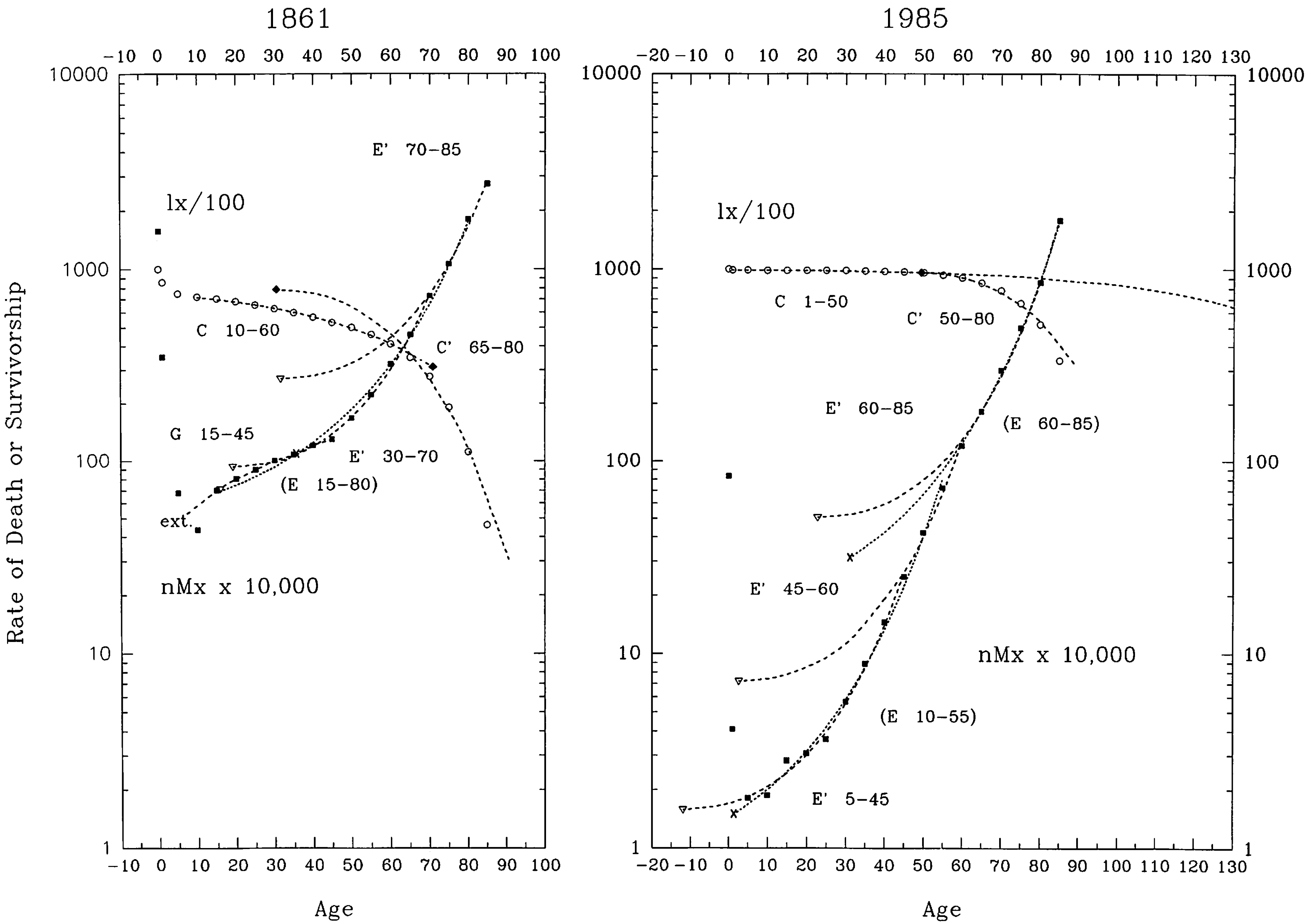
Life Expectancy by Age for 'Average' U.S. Females and Males 1990–1997



Source: Rogers et al. 2005, 283, 285.

Figure 8.2a

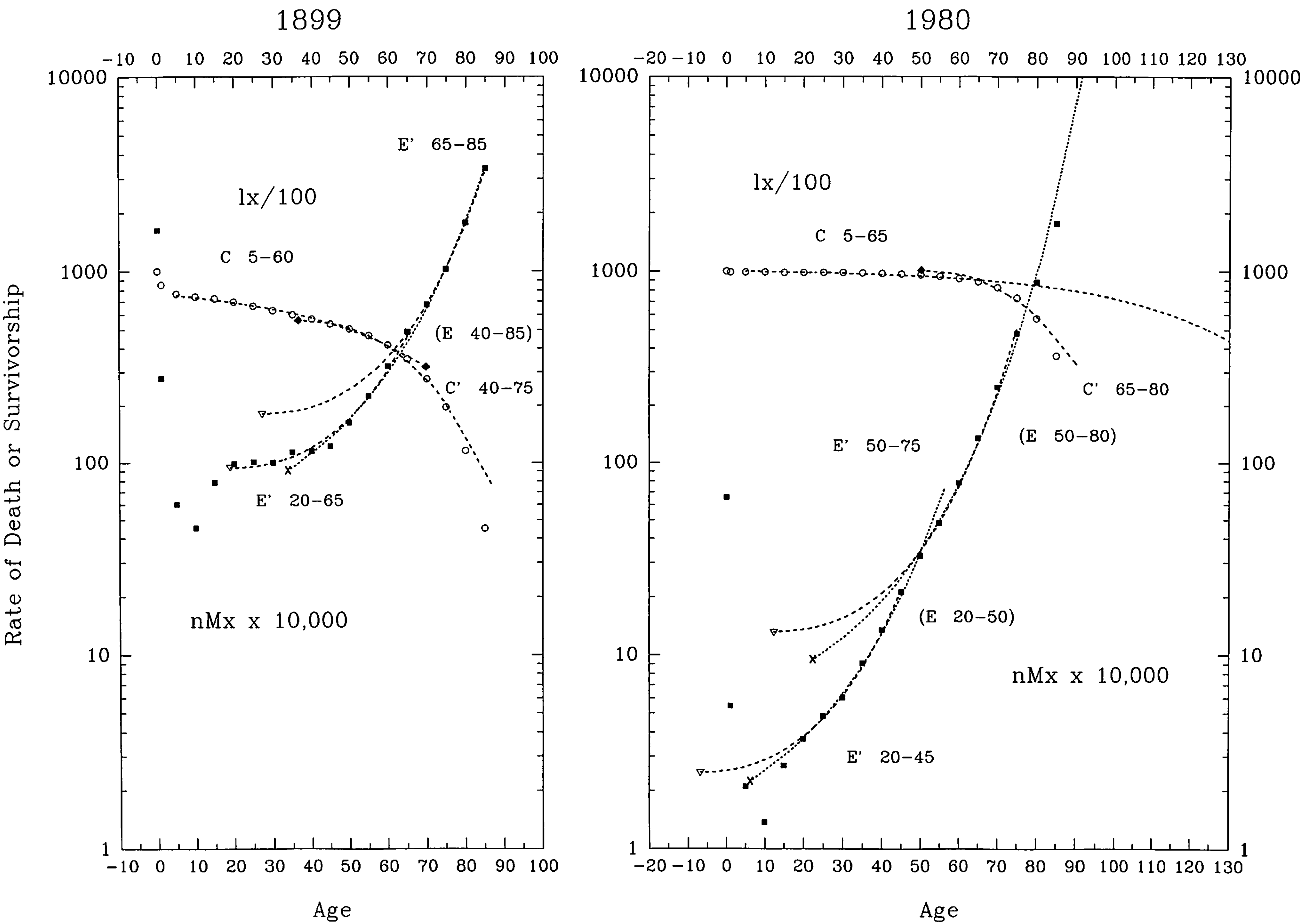
Trends of lx and nMx for Females: England and Wales



Sources: Preston et al. 1972, 226; Keyfitz and Flieger 1990, 544.

Figure 8.2b

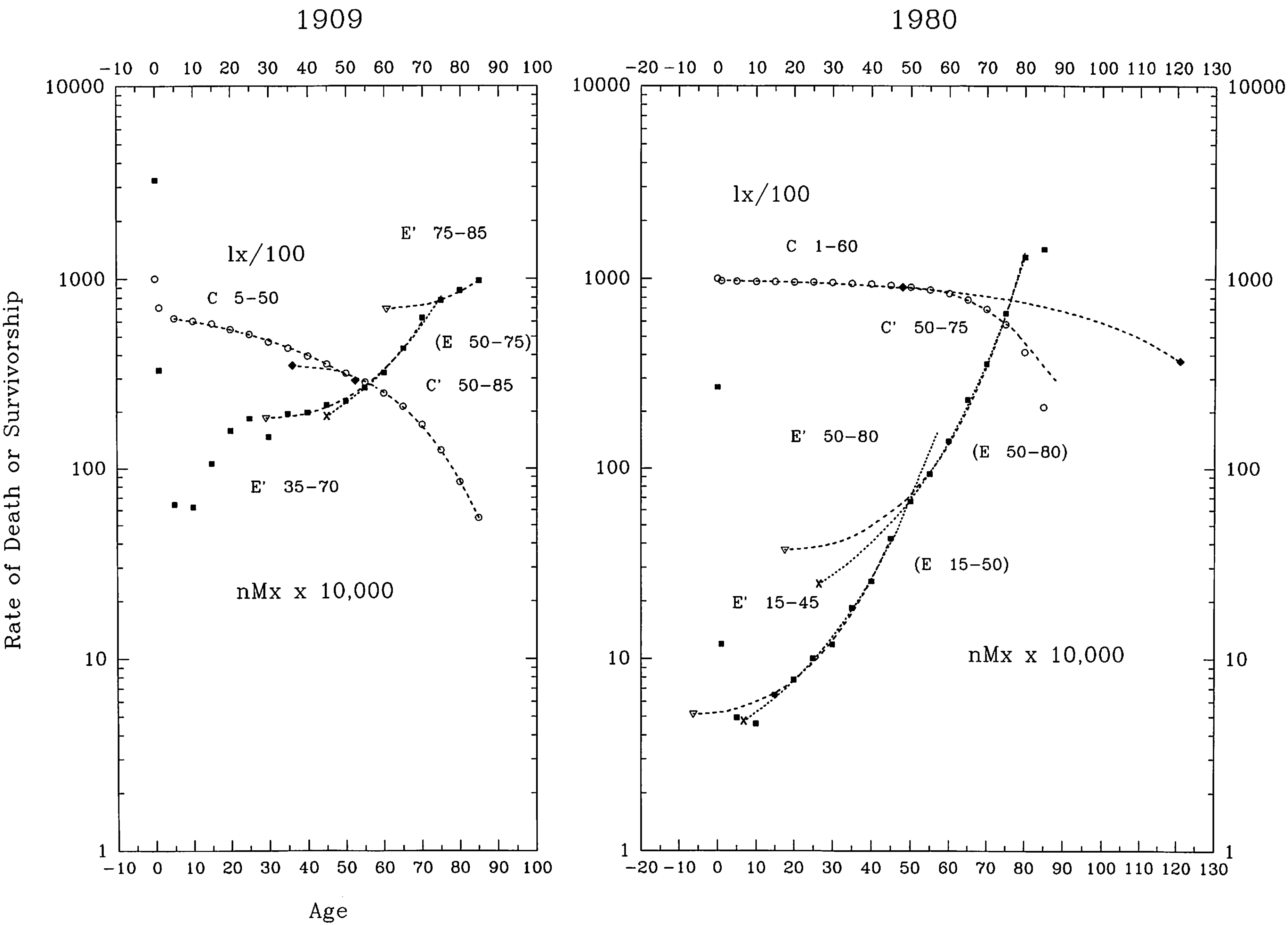
Trends of lx and nMx for Females: Japan



Sources: Preston et al. 1972, 418; Keyfitz and Flieger 1990, 374.

Figure 8.2c

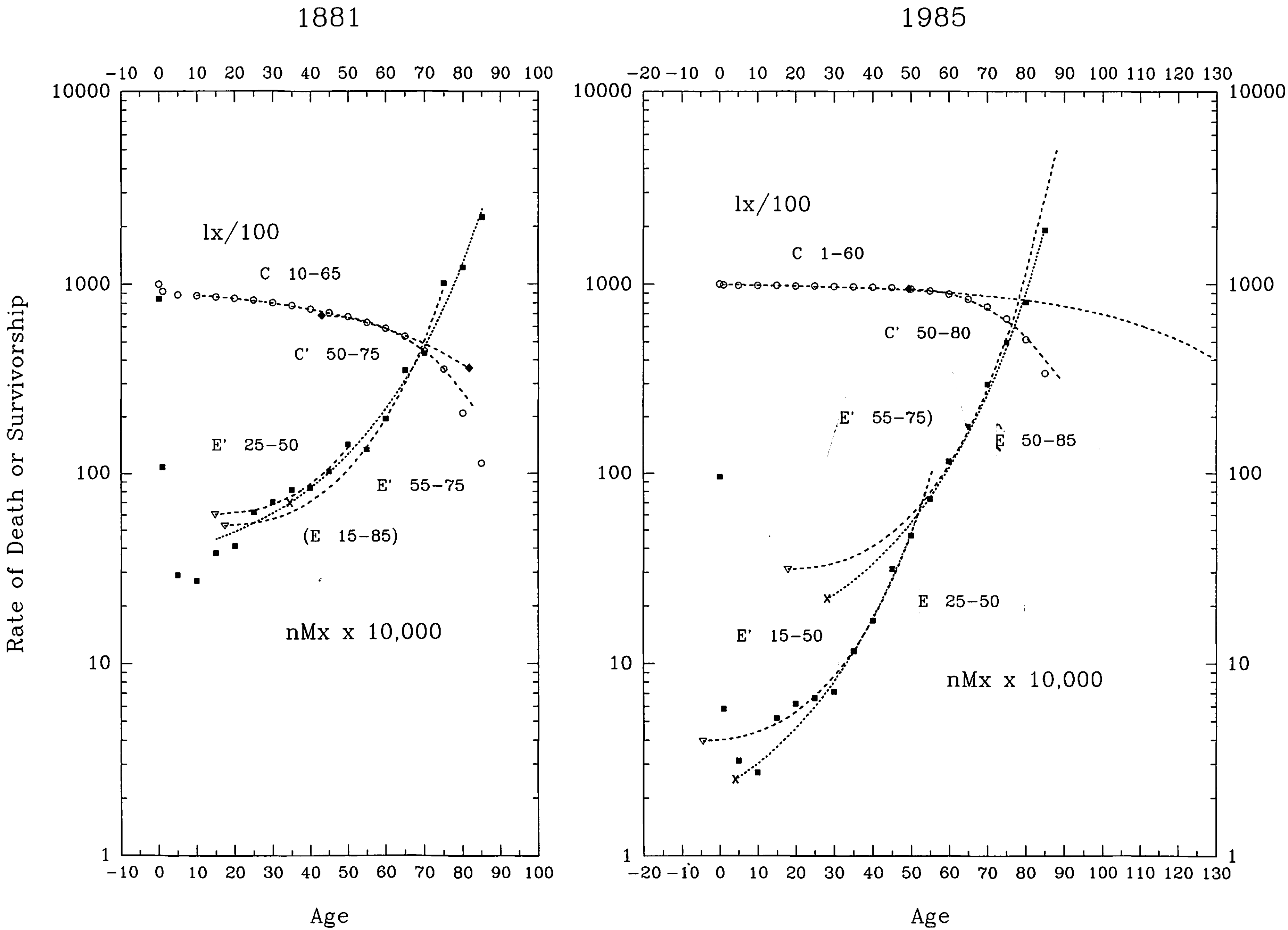
Trends of lx and nMx for Females: Chile



Sources: Preston et al. 1972, 146; Keyfitz and Flieger 1990, 308.

Figure 8.2d

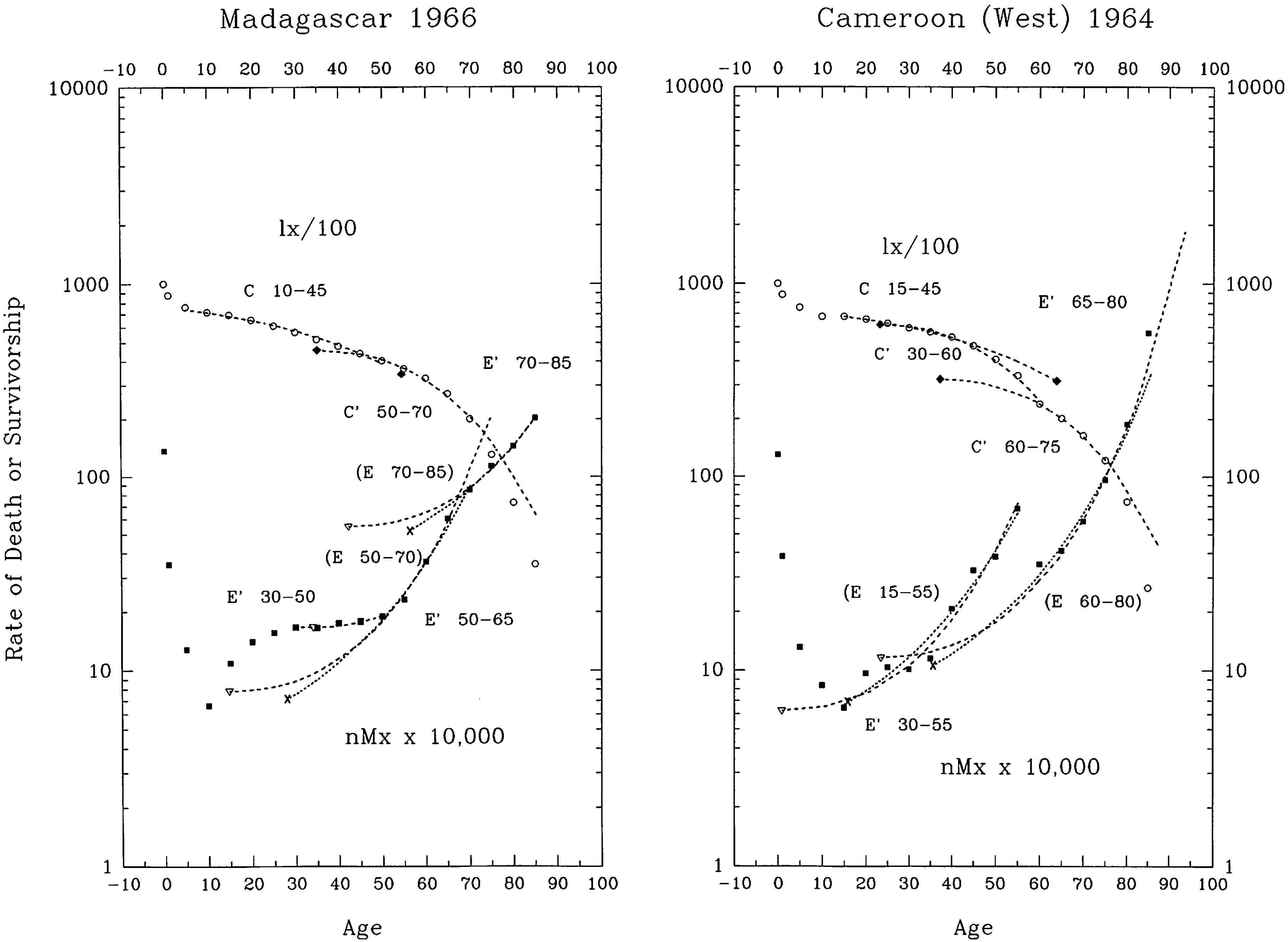
Trends of lx and nMx for Females: New Zealand



Sources: Preston et al. 1972, 482; Keyfitz and Flieger 1990, 578.

Figure 8.2e

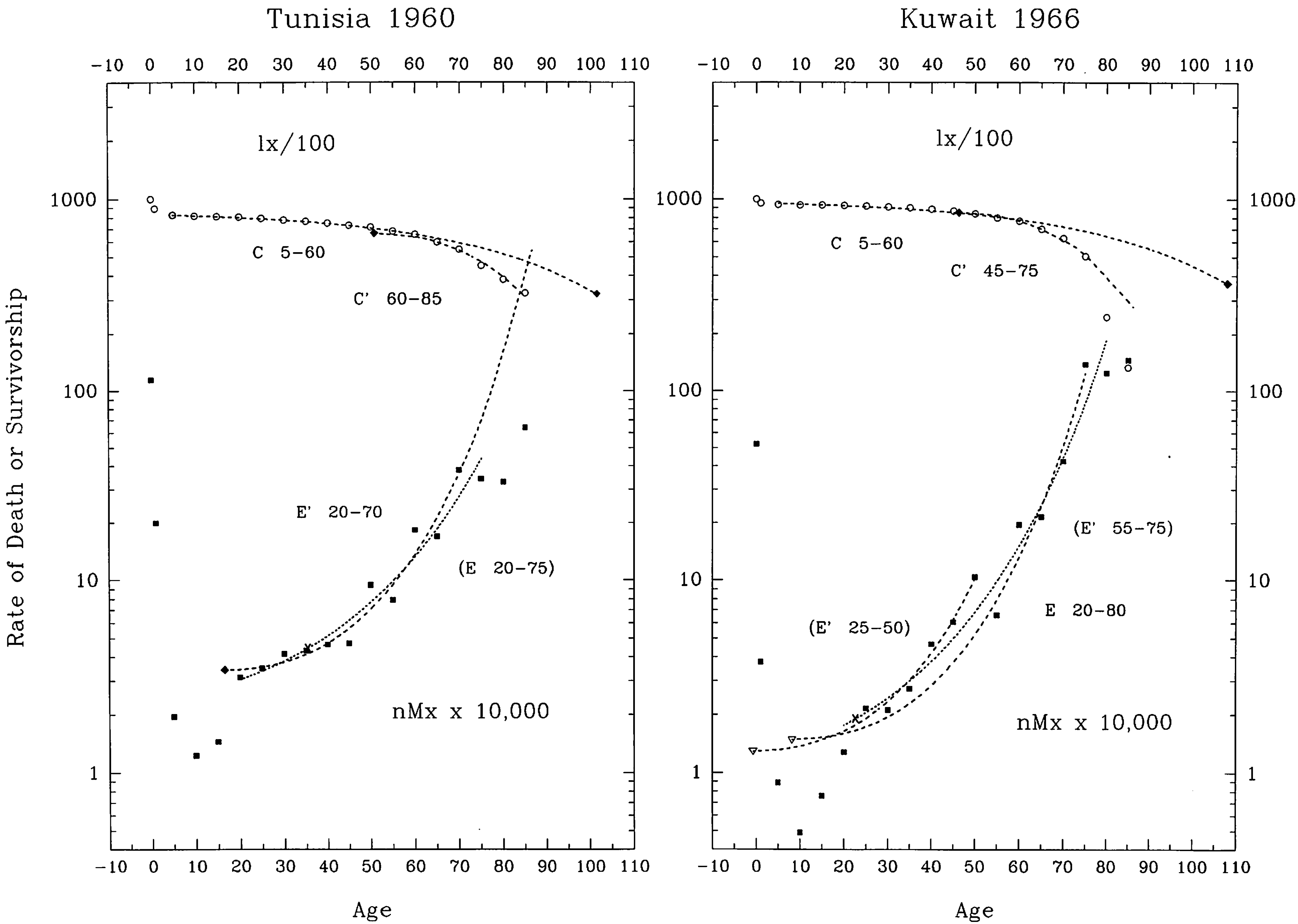
Trends of lx and nMx for Females: Madagascar and Cameroon



Sources: Keyfitz and Flieger 1971, 312, 310.

Figure 8.2f

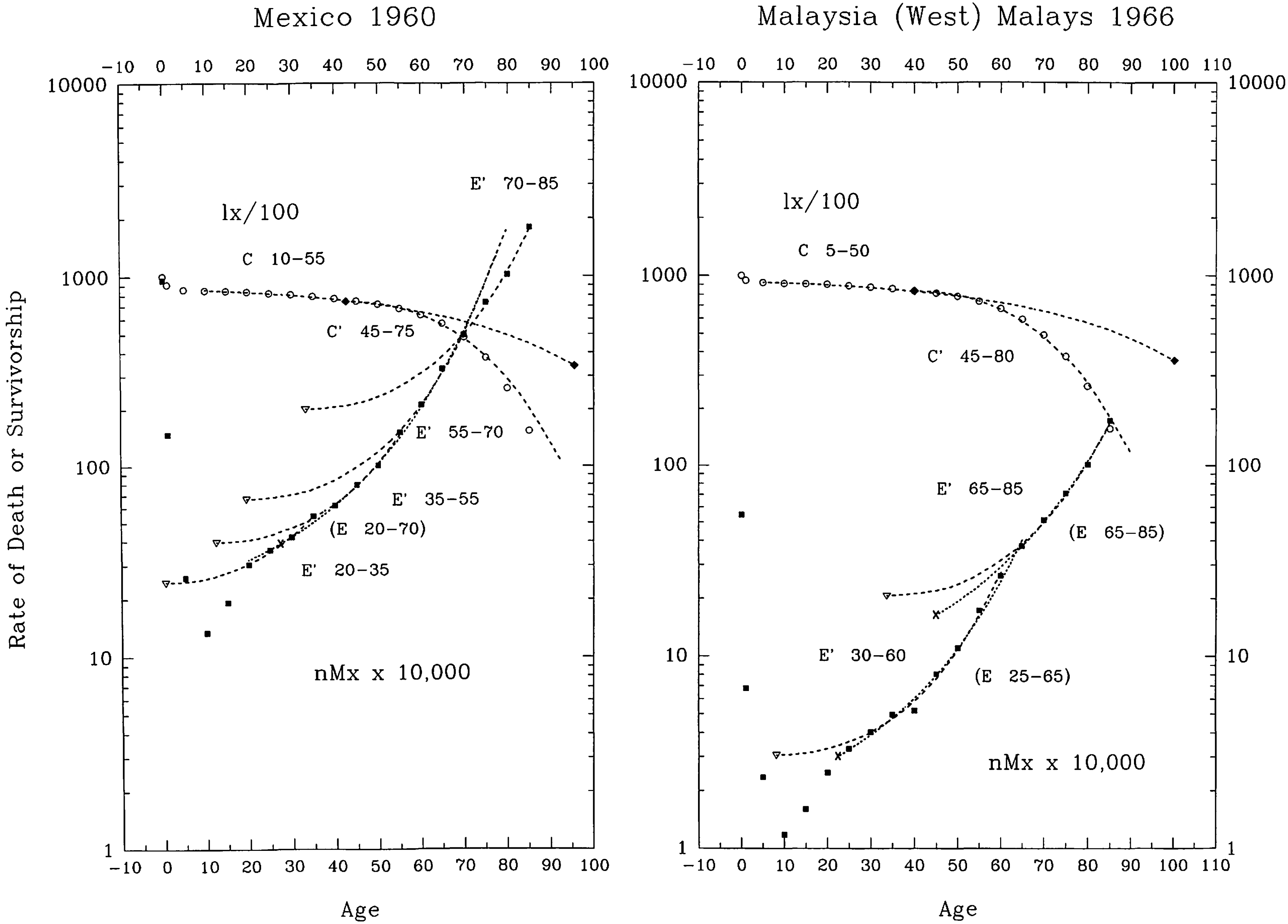
Trends of lx and nMx for Females: Tunisia and Kuwait



Sources: Keyfitz and Flieger 1971, 324, 400.

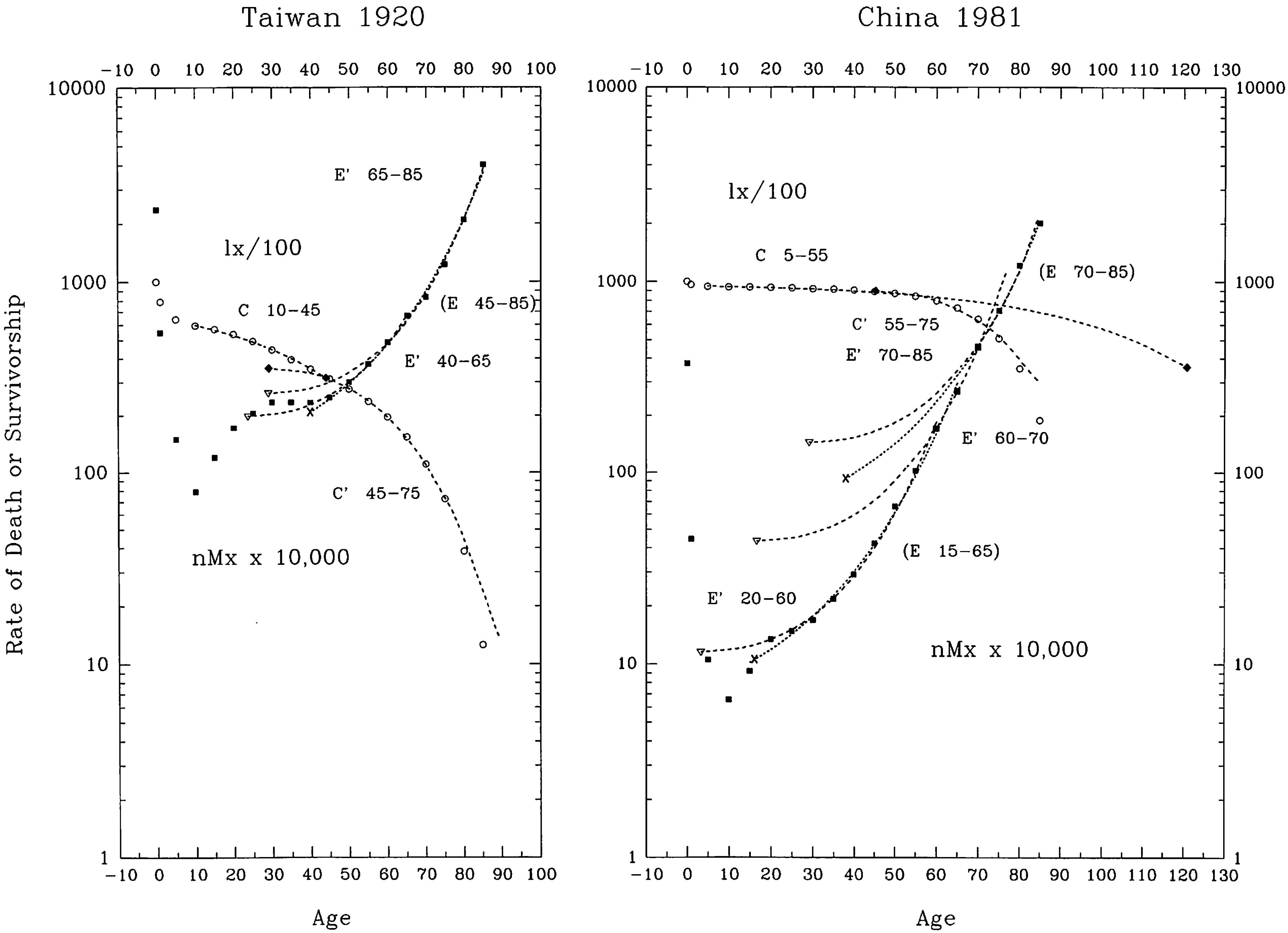
Figure 8.2g

Trends of lx and nMx for Females: Mexico and Malays of West Malaysia



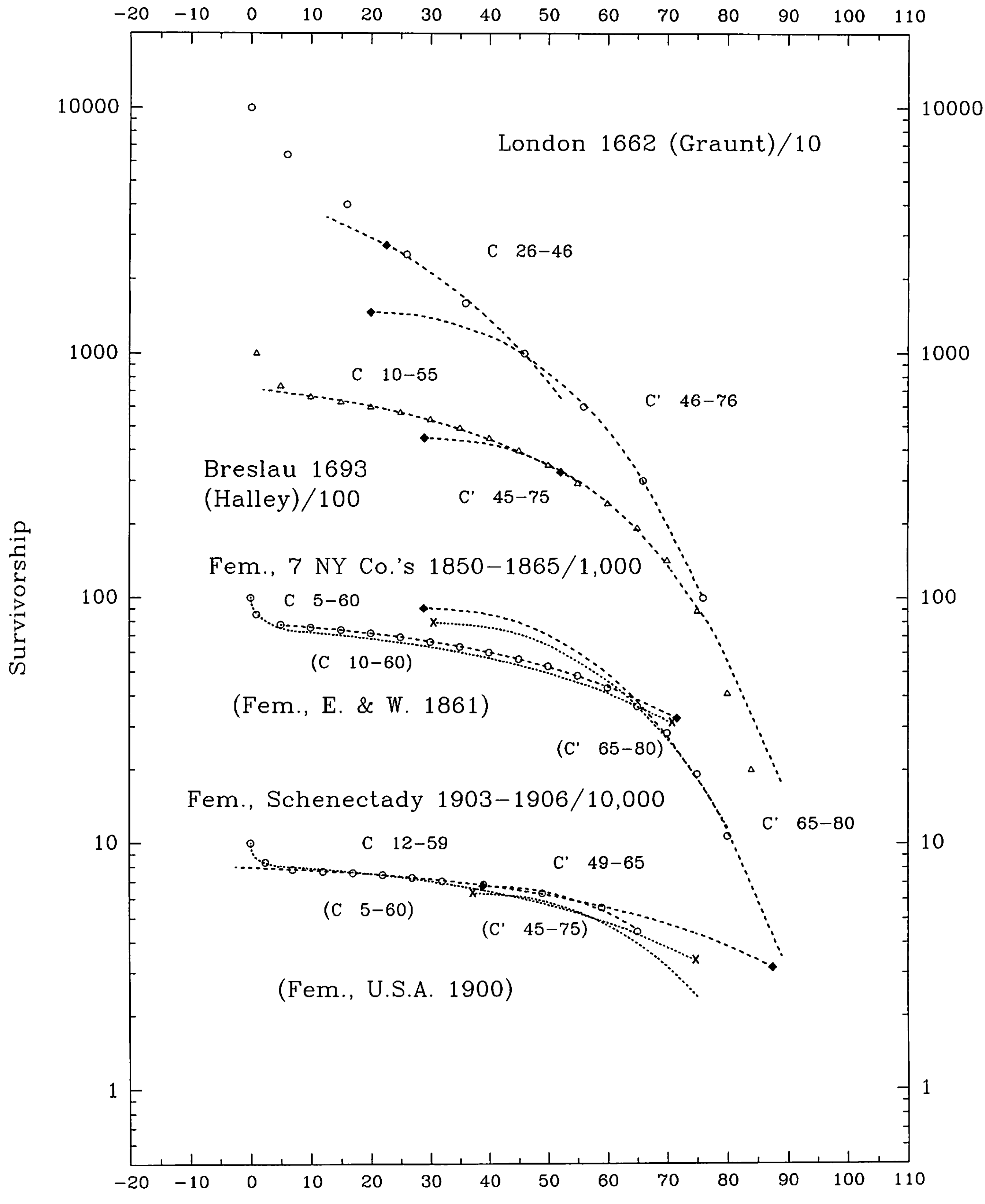
Sources: Preston et al. 1972, 454; Keyfitz and Flieger 1971, 404.

Figure 8.2h
Trends of lx and nMx for Females: Taiwan and China



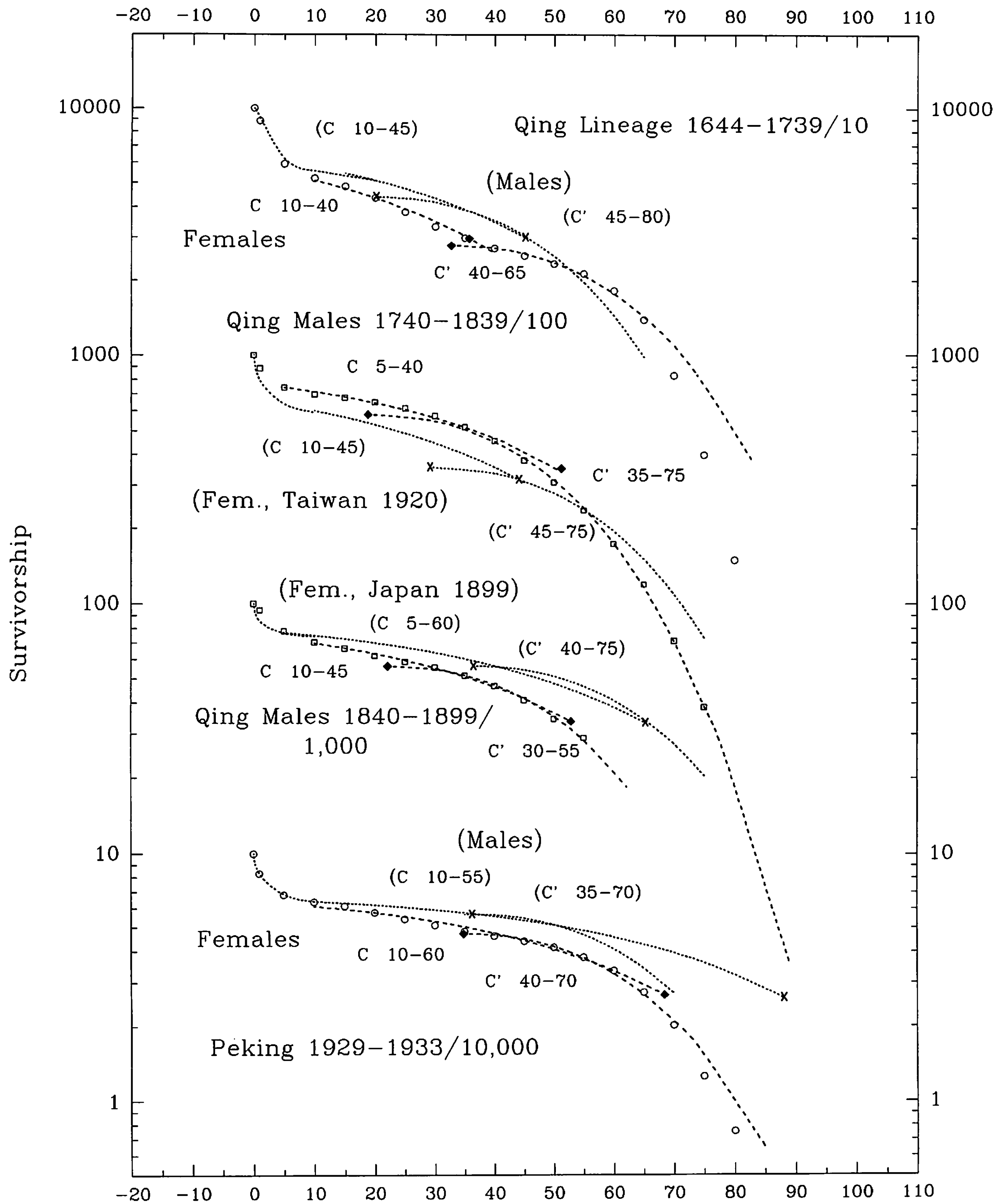
Sources: Preston et al. 1972, 702; Keyfitz and Flieger 1990, 350.

Figure 8.3a
Survivorship (lx) in Some Earlier Historical Contexts: Europe and the United States



Sources: Smith and Keyfitz 1977, 19, 24; Haines 1976, Appendix; Fig. 8.2a; Wells 1995, 420; Preston et al. 1972, 726.

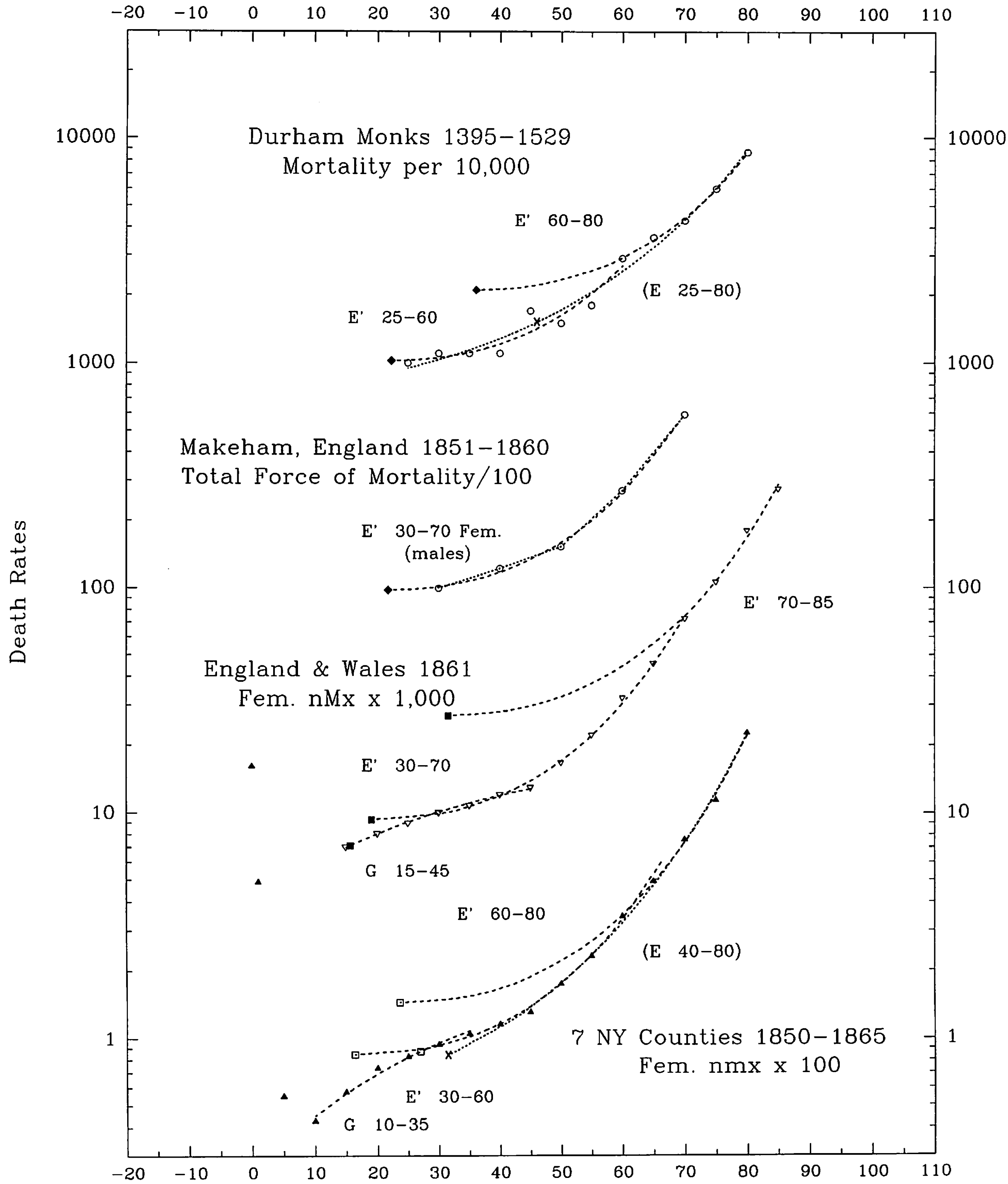
Figure 8.3b
Survivorship (lx) in Some Earlier Historical Contexts:
China and Japan



Sources: Campbell 1997, 196-98; Figures 8.2b, 8.2h.

Figure 8.4a

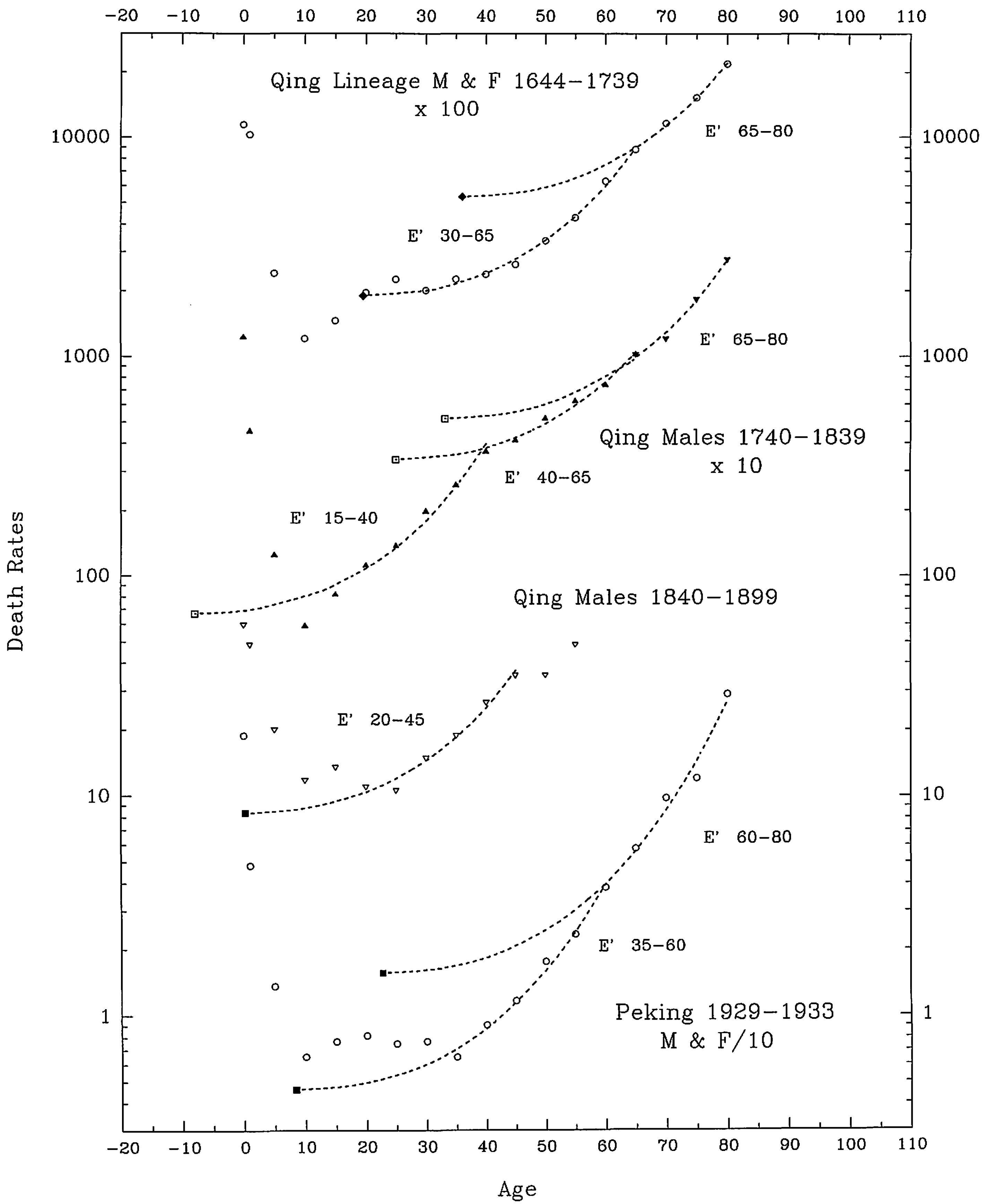
Death Rates by Age in Earlier Populations: England and the United States



Sources: Hatcher et al. 2006, 681; Smith & Keyfitz 1977, 285; Figure 8.2a; Haines 1976, Appendix.

Figure 8.4b

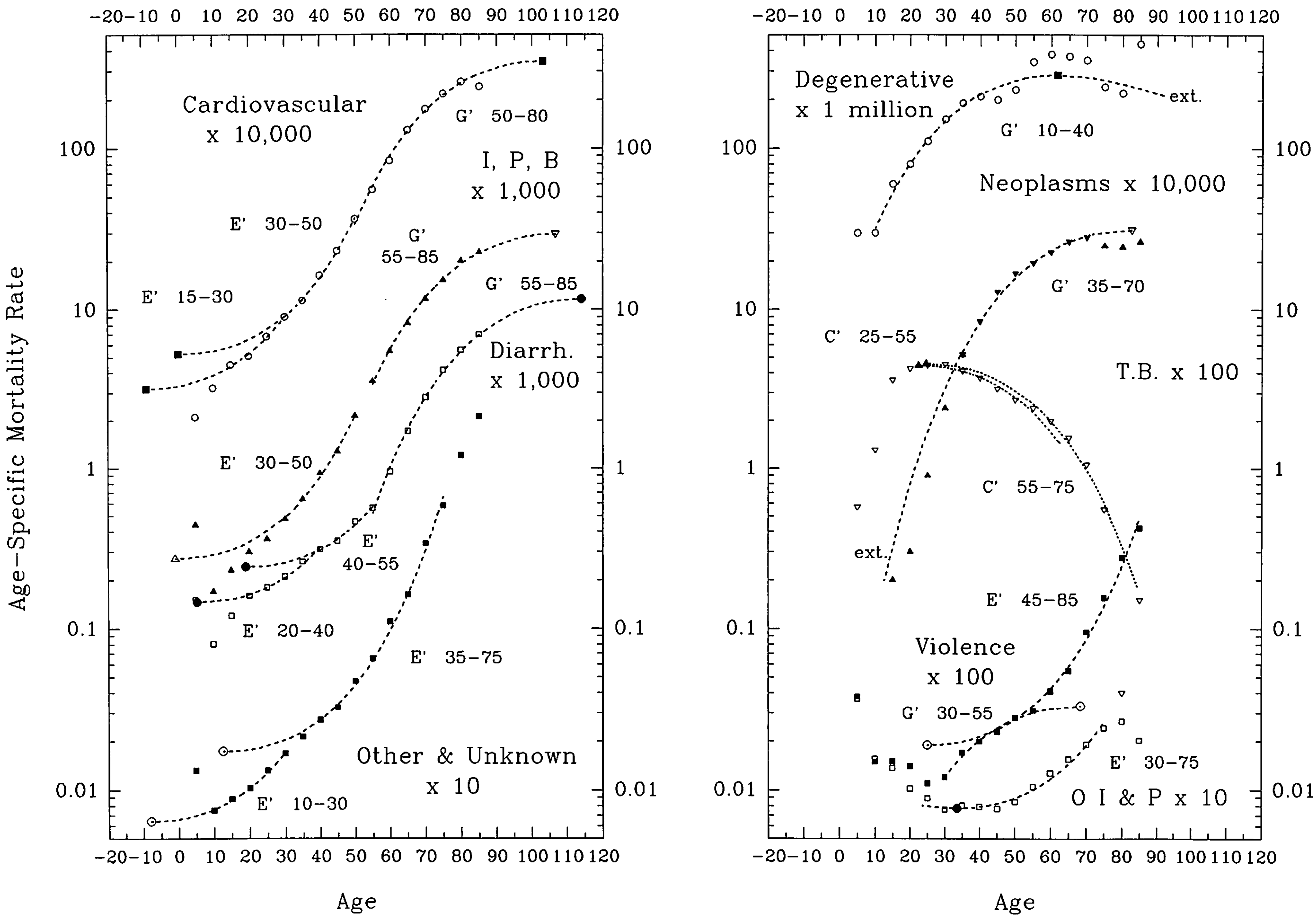
Death Rates by Age in Earlier Populations: China



Source: Campbell 1997, 196–98.

Figure 8.5a

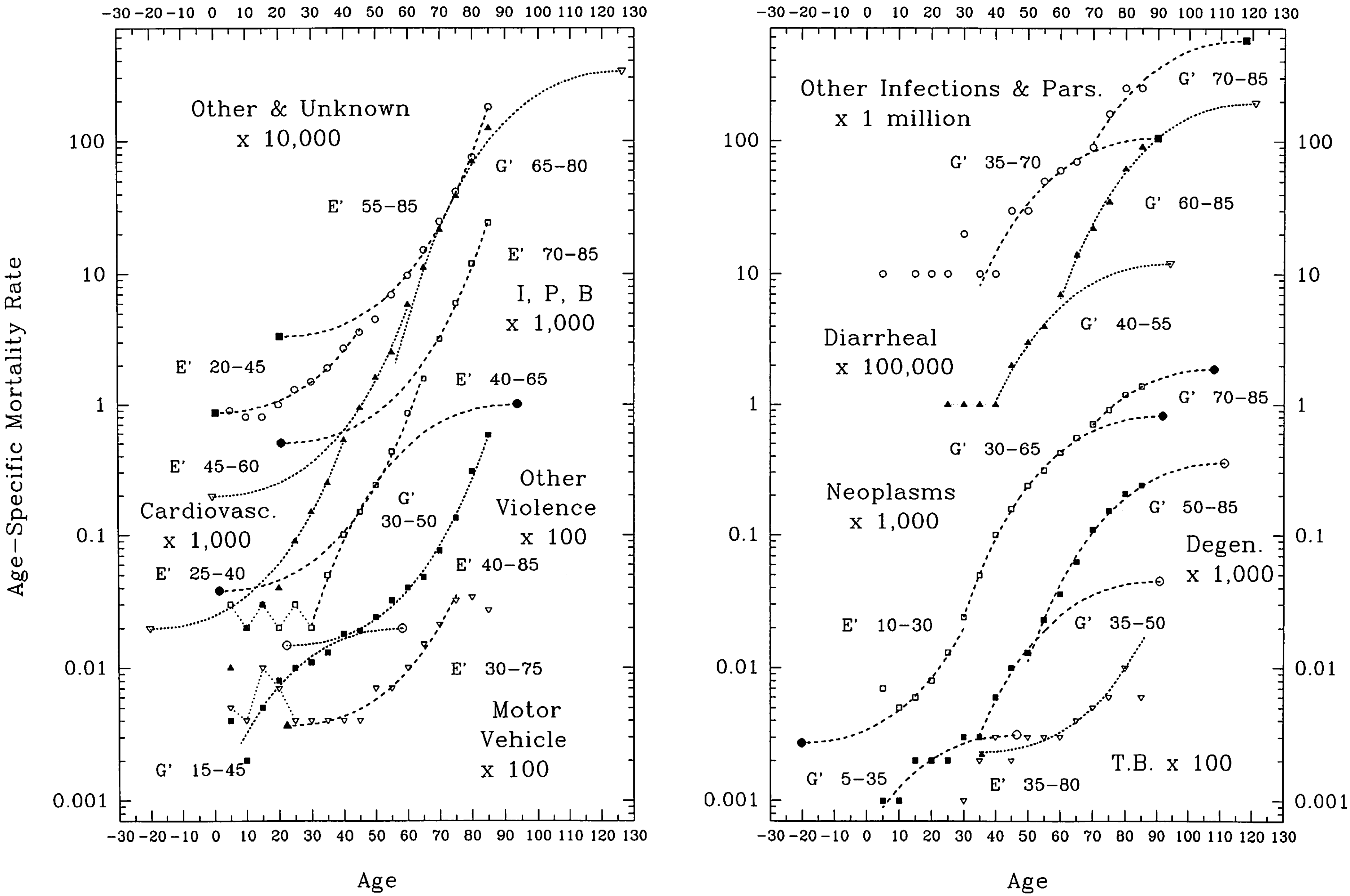
Age-Specific Mortality Rates from Certain Causes: England and Wales 1861



Source: Preston et al. 1972, 226.

Figure 8.5b

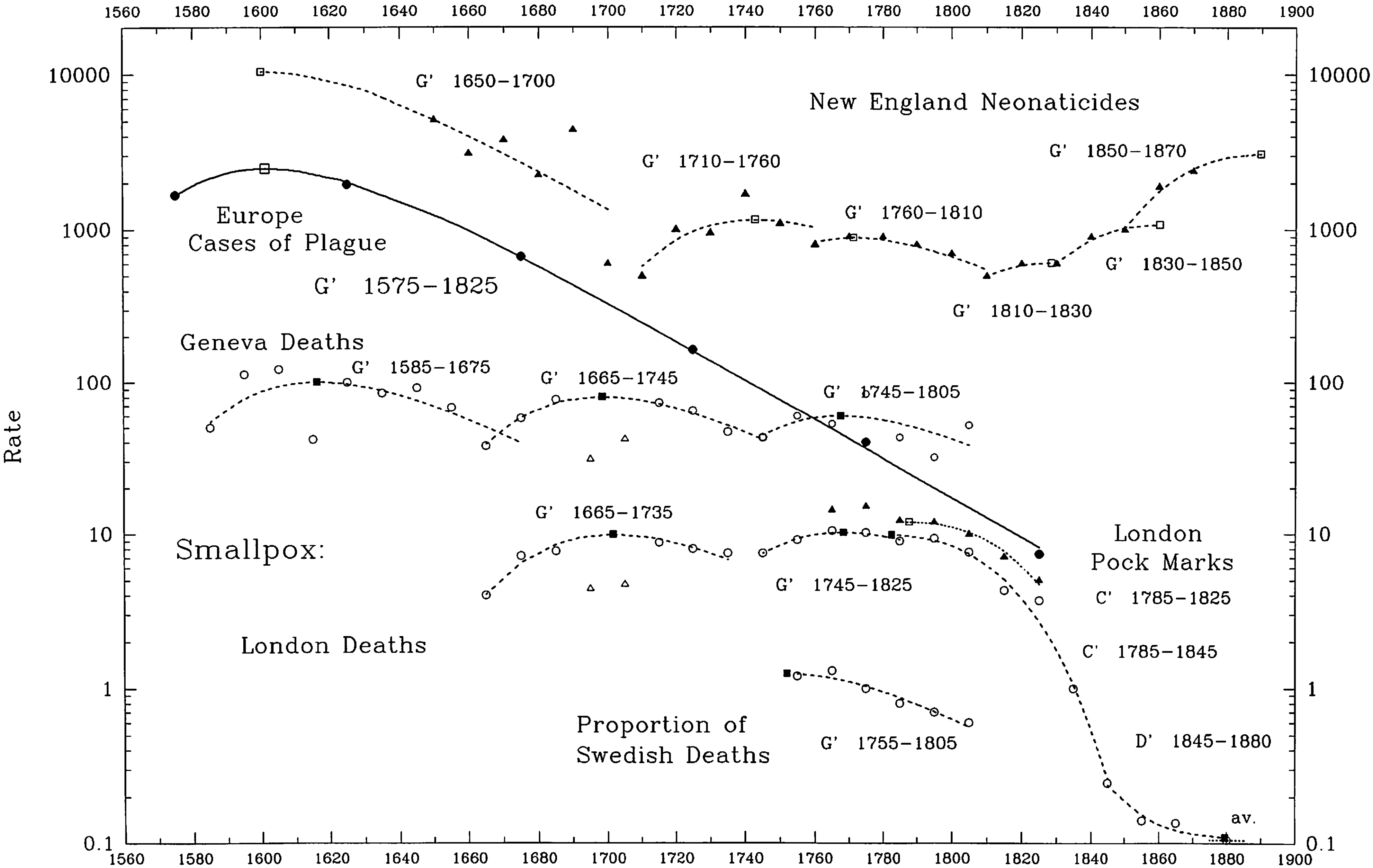
Age-Specific Mortality Rates from Certain Causes: England and Wales 1964



Source: Preston et al. 1972, 270.

Figure 8.6a

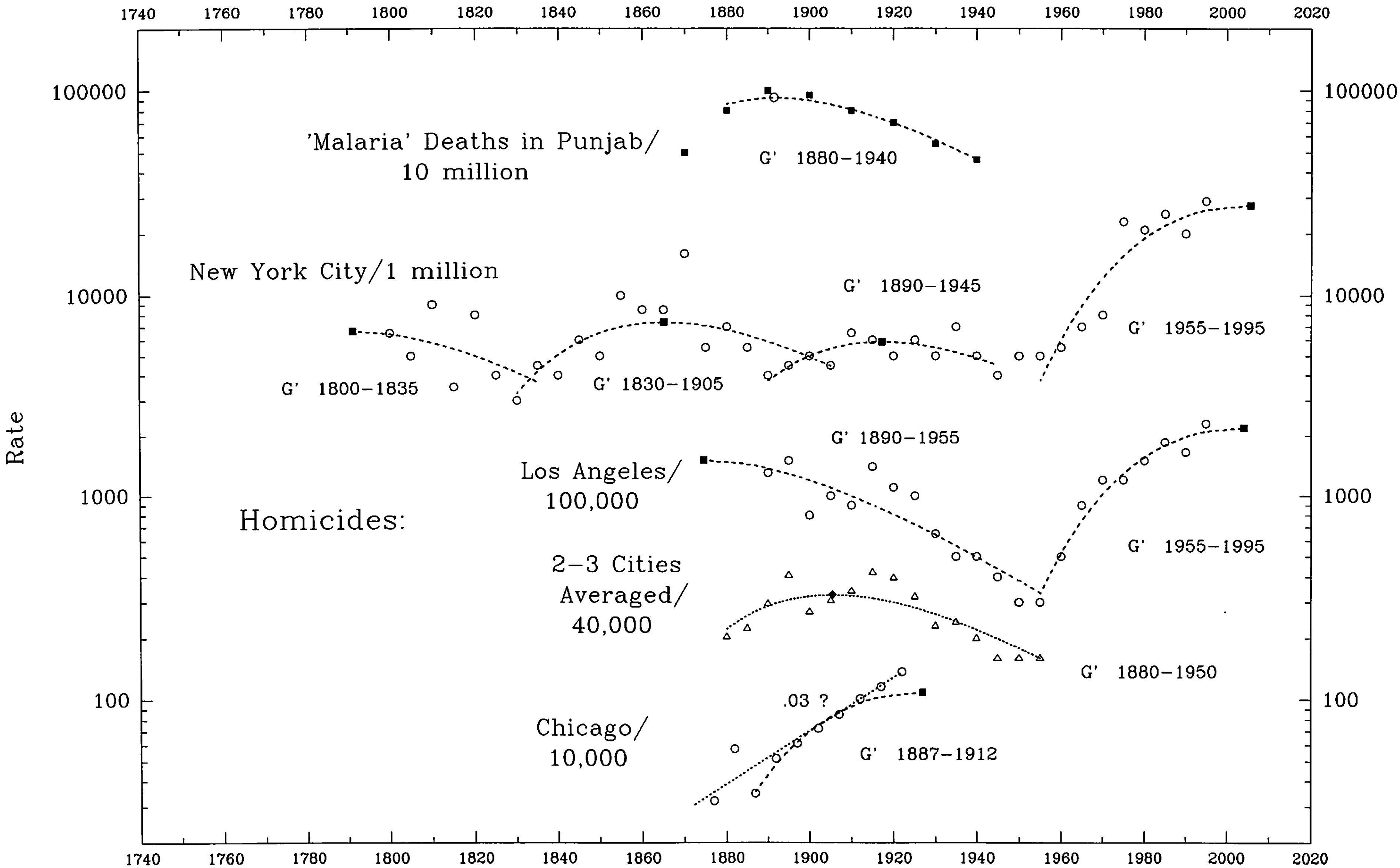
Deaths from or Exposure to Various Risks of Mortality: Plague, Smallpox, Neonaticide



See Table 8.13 and text for sources, base levels for rates, and other particulars.

Figure 8.6b

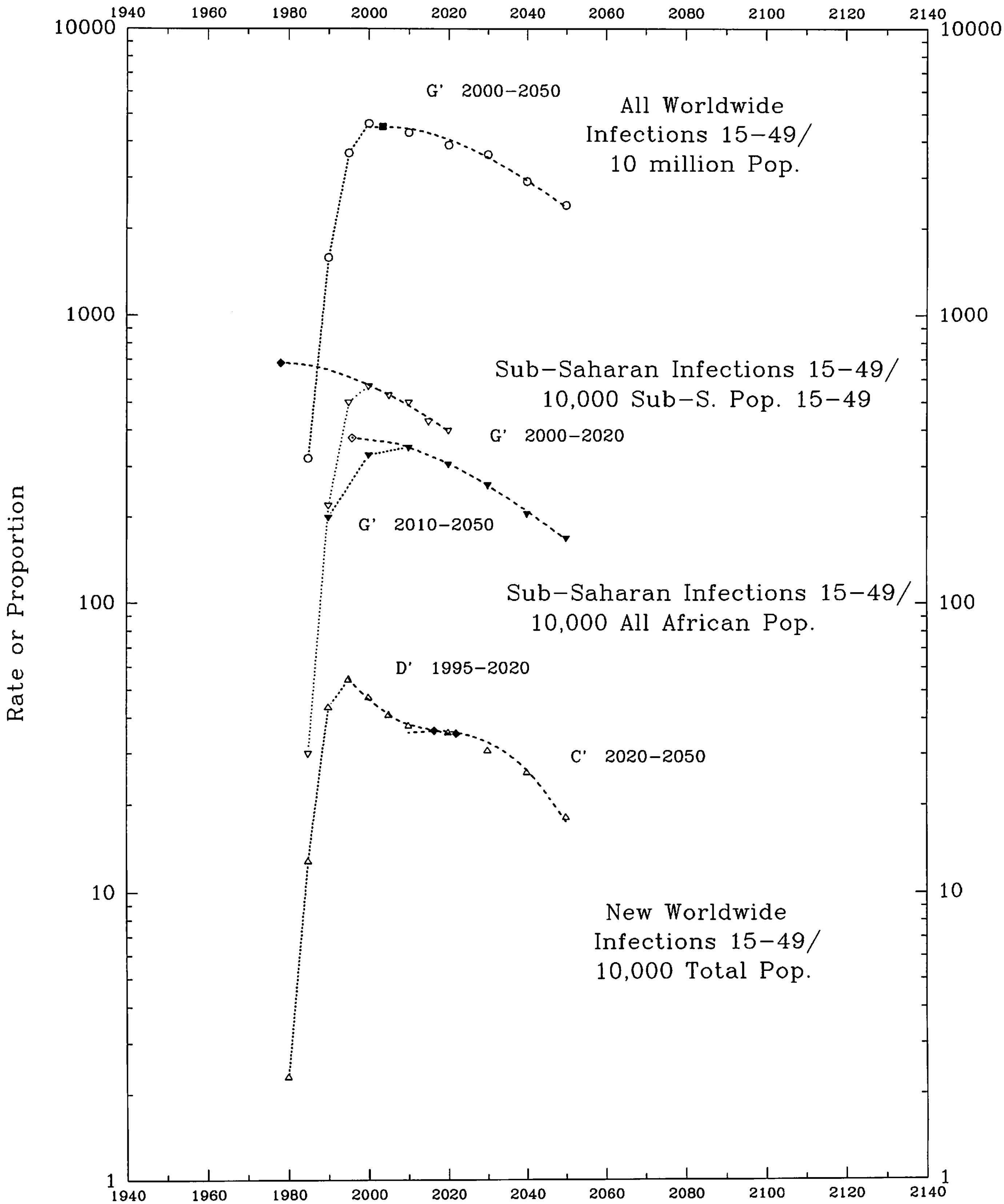
Deaths from or Exposure to Various Risks of Mortality: Malaria and Murder



Sources: Zurbrigg 1997, 32; Monkonnen 2001, 63; Adler 2001, 30.

Figure 8.6c

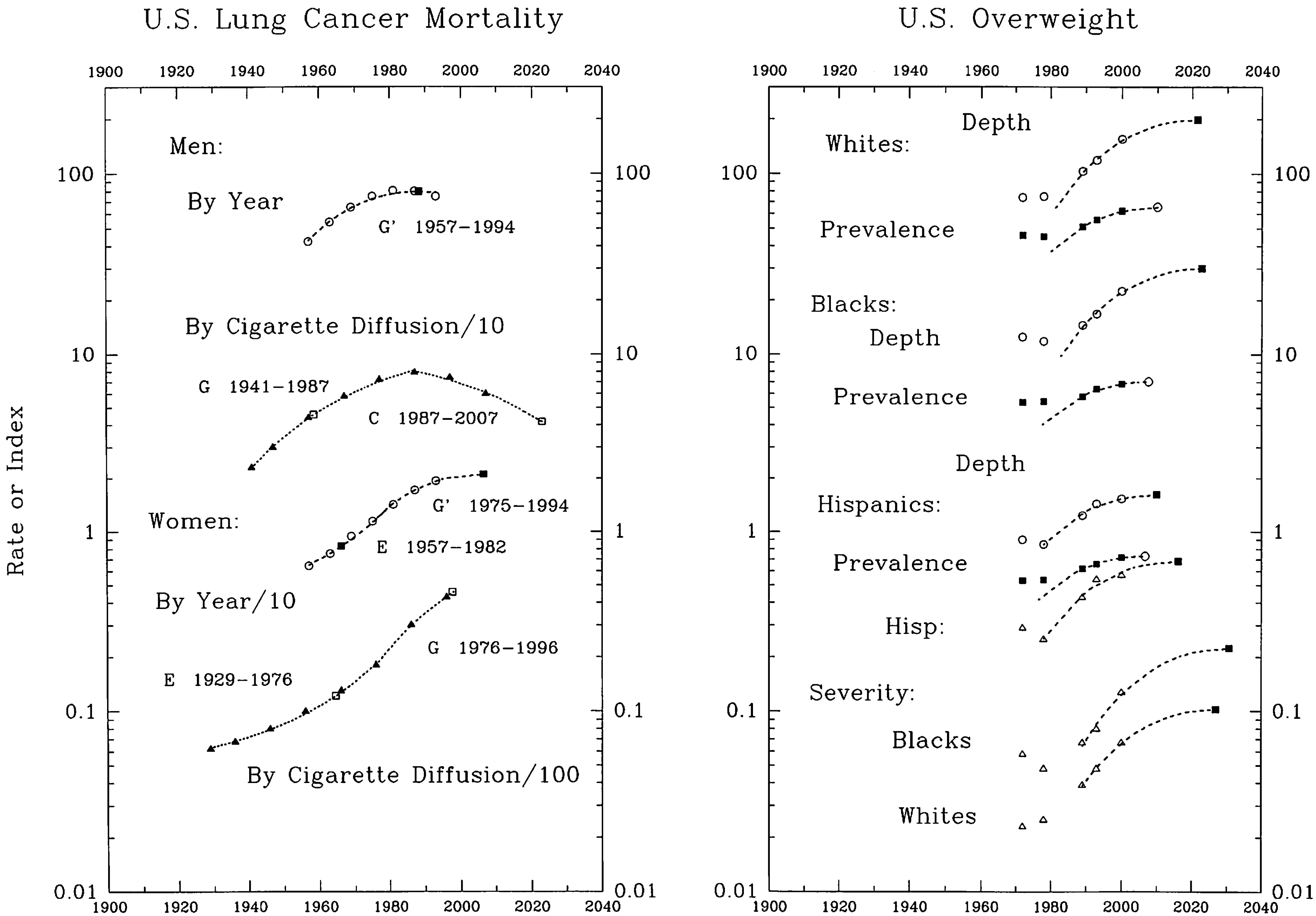
Deaths from or Exposure to Various Risks of Mortality: HIV–AIDS Globally and in Africa



Sources: Bongaarts et al. 2008, 210, 205; Harris 2001, 385.

Figure 8.6d

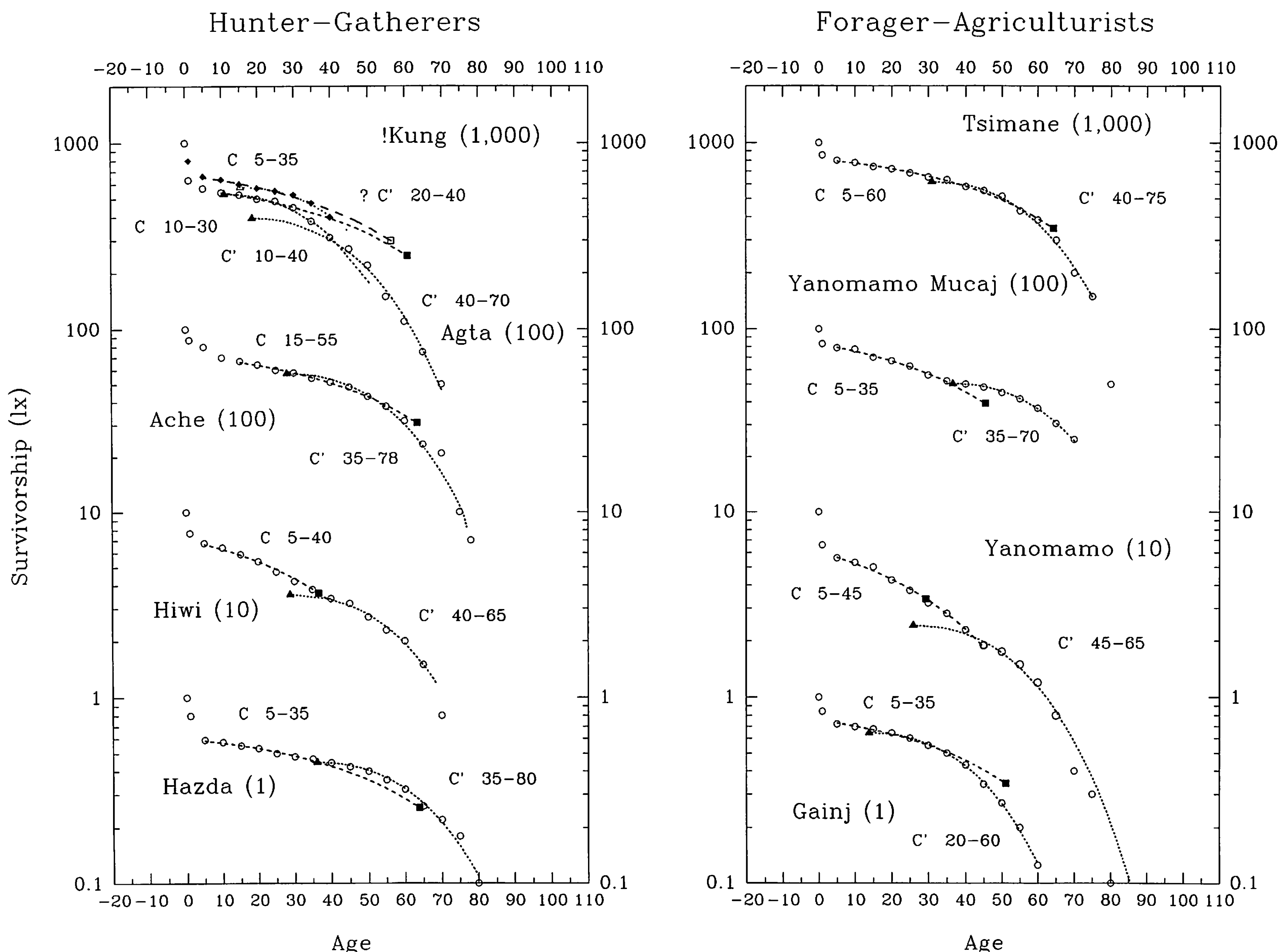
Deaths from or Exposure to Various Risks of Mortality:



Sources: Pampel 2003, 56, 61; Jolliffe 2004, 312. For timing of deaths relative to cigarette diffusion and for level and range of overweight G' trends see text.

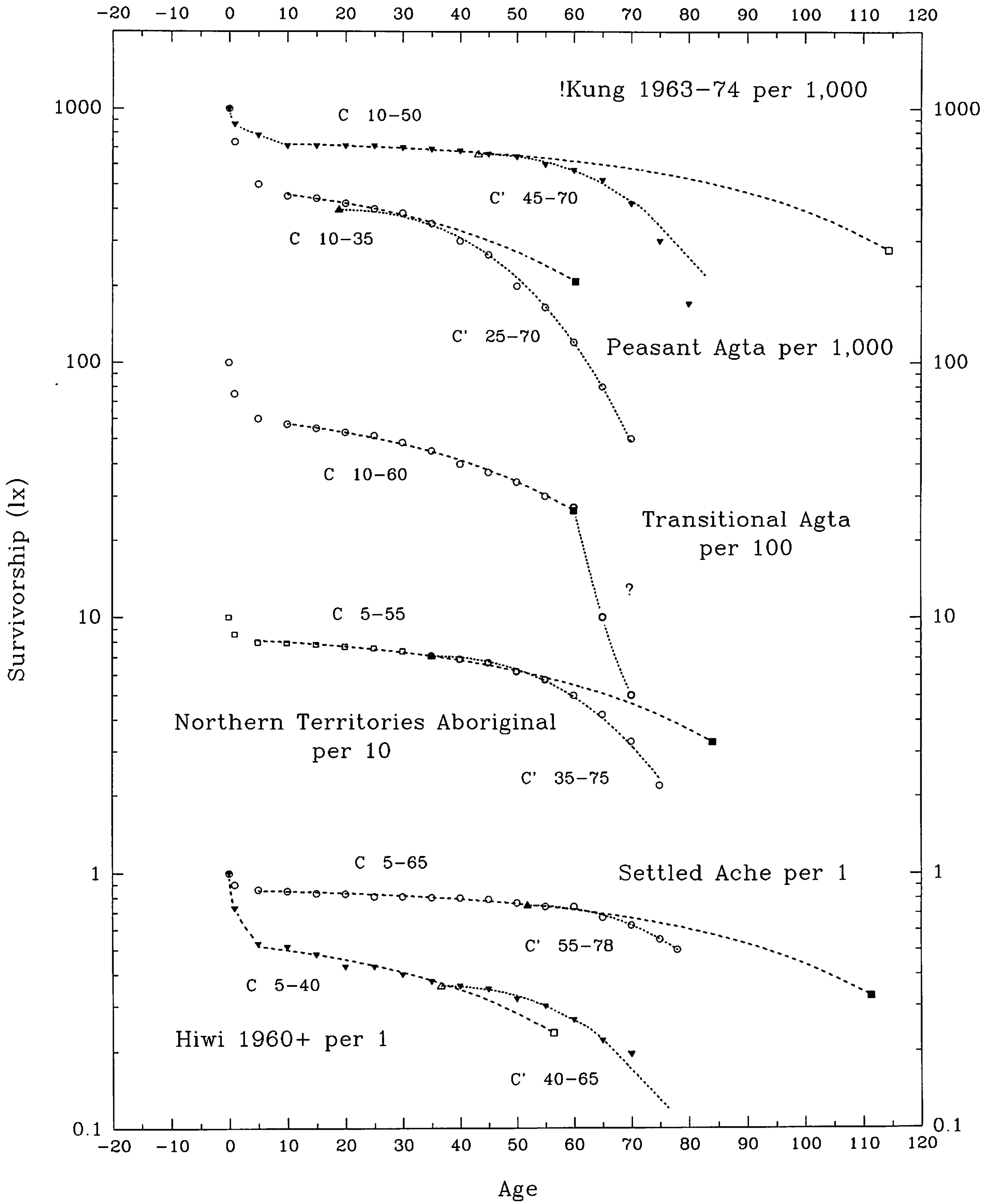
Figure 8.7a

Survivorship in Certain Other Human and Primate Populations:



Source: Gurven and Kaplan 2007, 328.

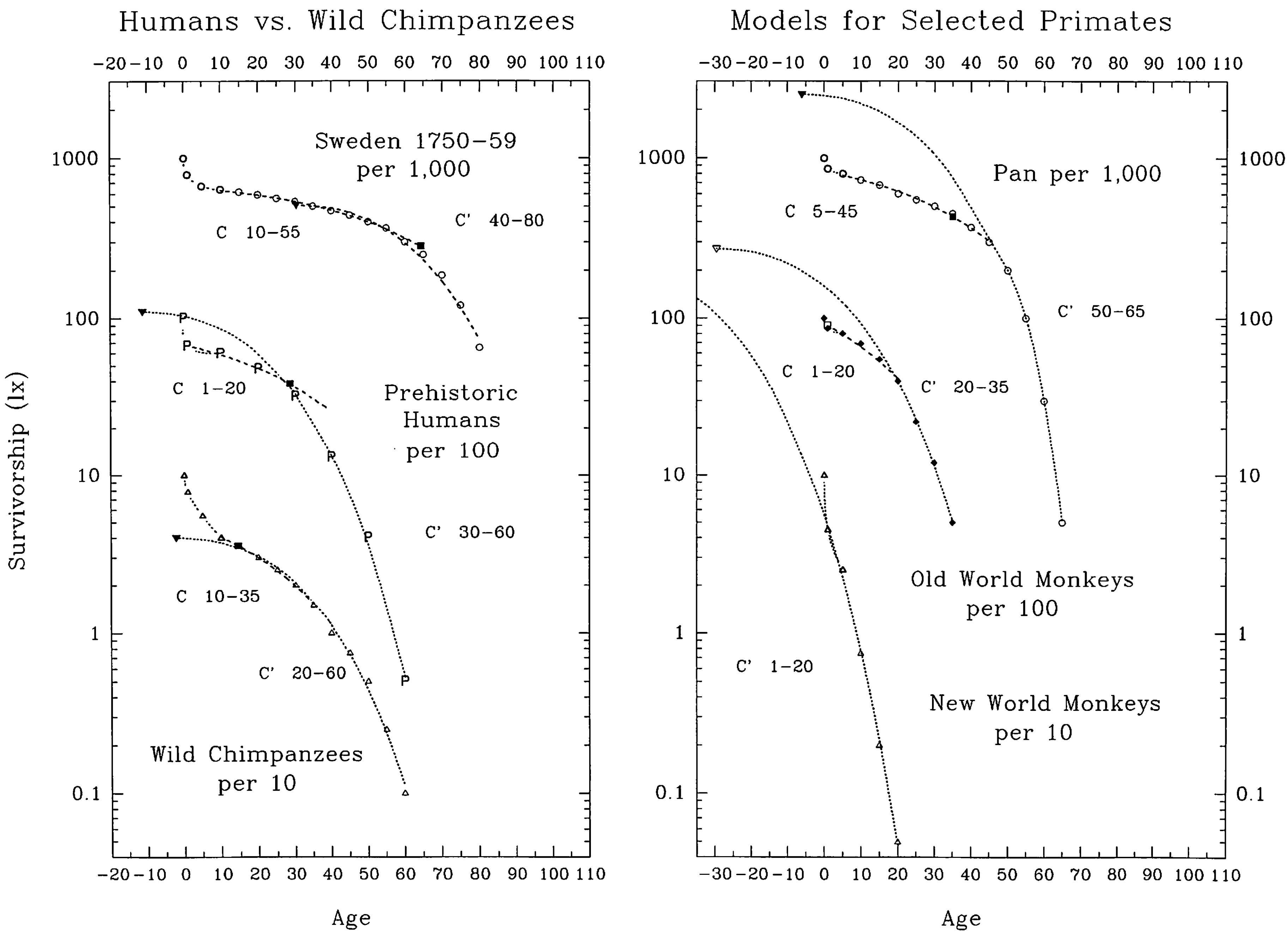
Figure 8–7b
Survivorship in Certain Other Human and Primate Populations: Acculturated Hunter–Gatherers



Source: Gurven and Kaplan 2007, 328.

Figure 8–7c

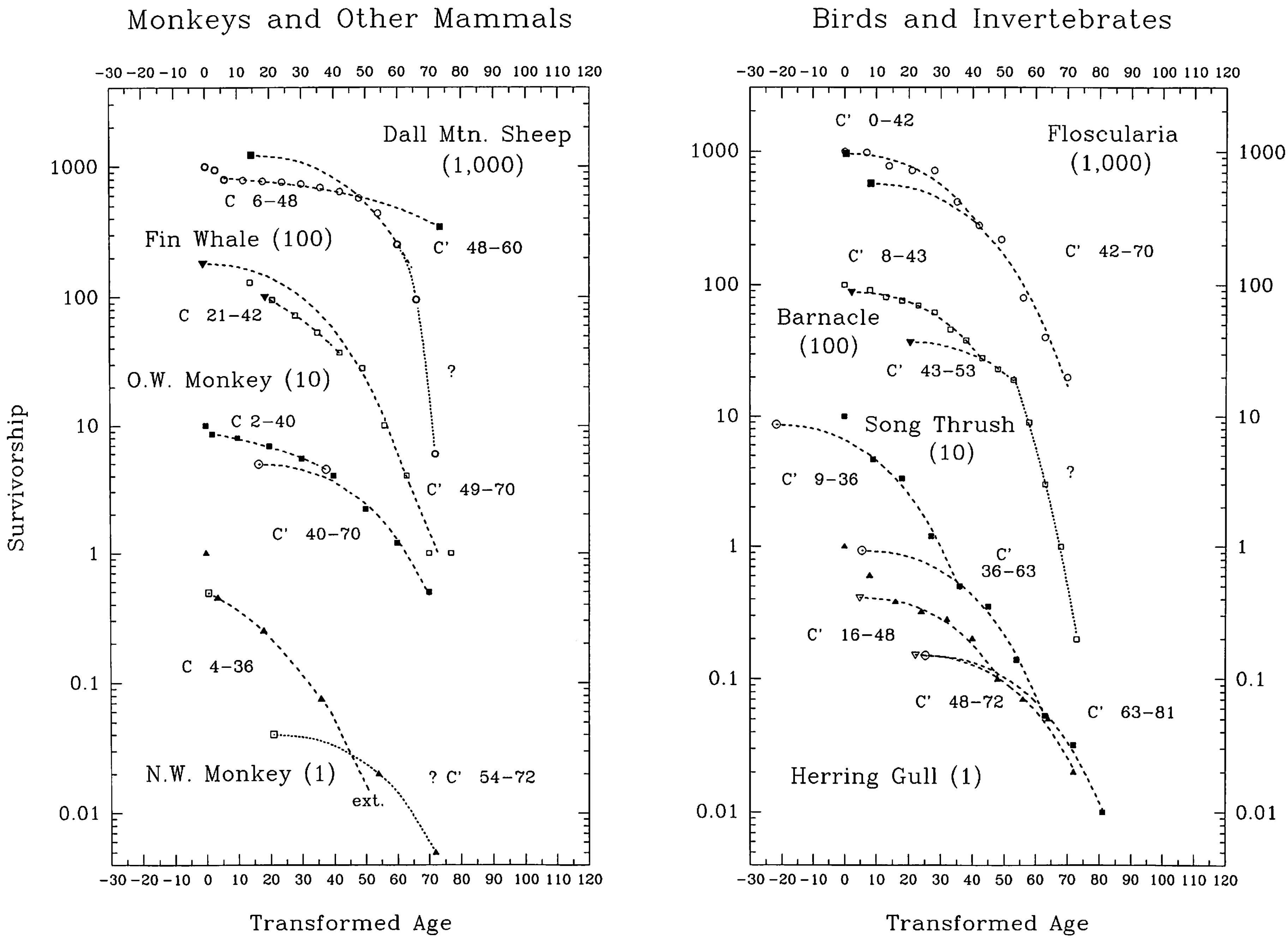
Survivorship in Certain Other Human and Primate Populations:



Sources: Gurven and Kaplan 2007, 328; Gage 1998, 204–05.

Figure 8.8

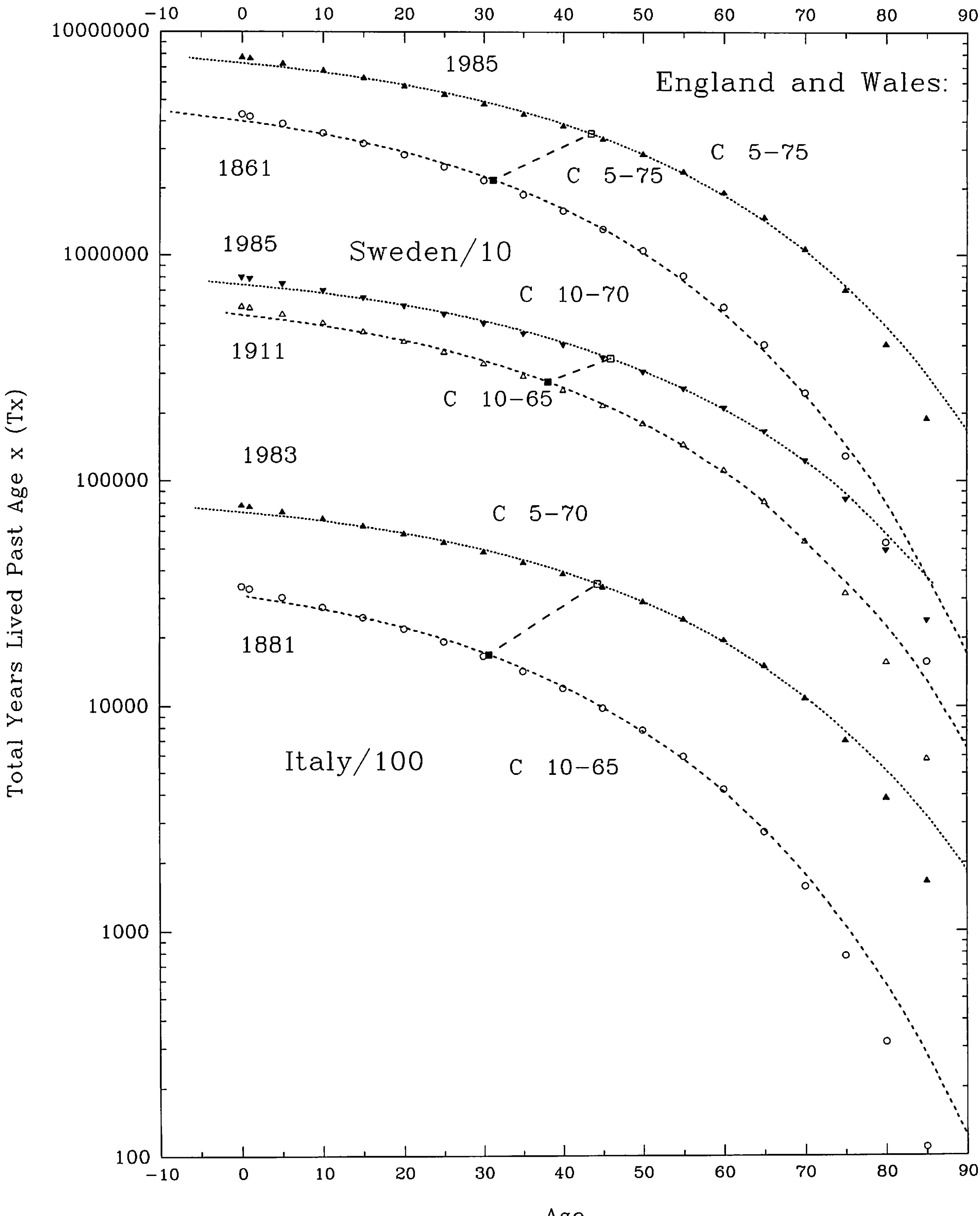
Trends of Survivorship in Various Animals, Adjusted to Human Life Span



Sources: Gage 1998, 204; Smith and Keyfitz 1977, 64–72.

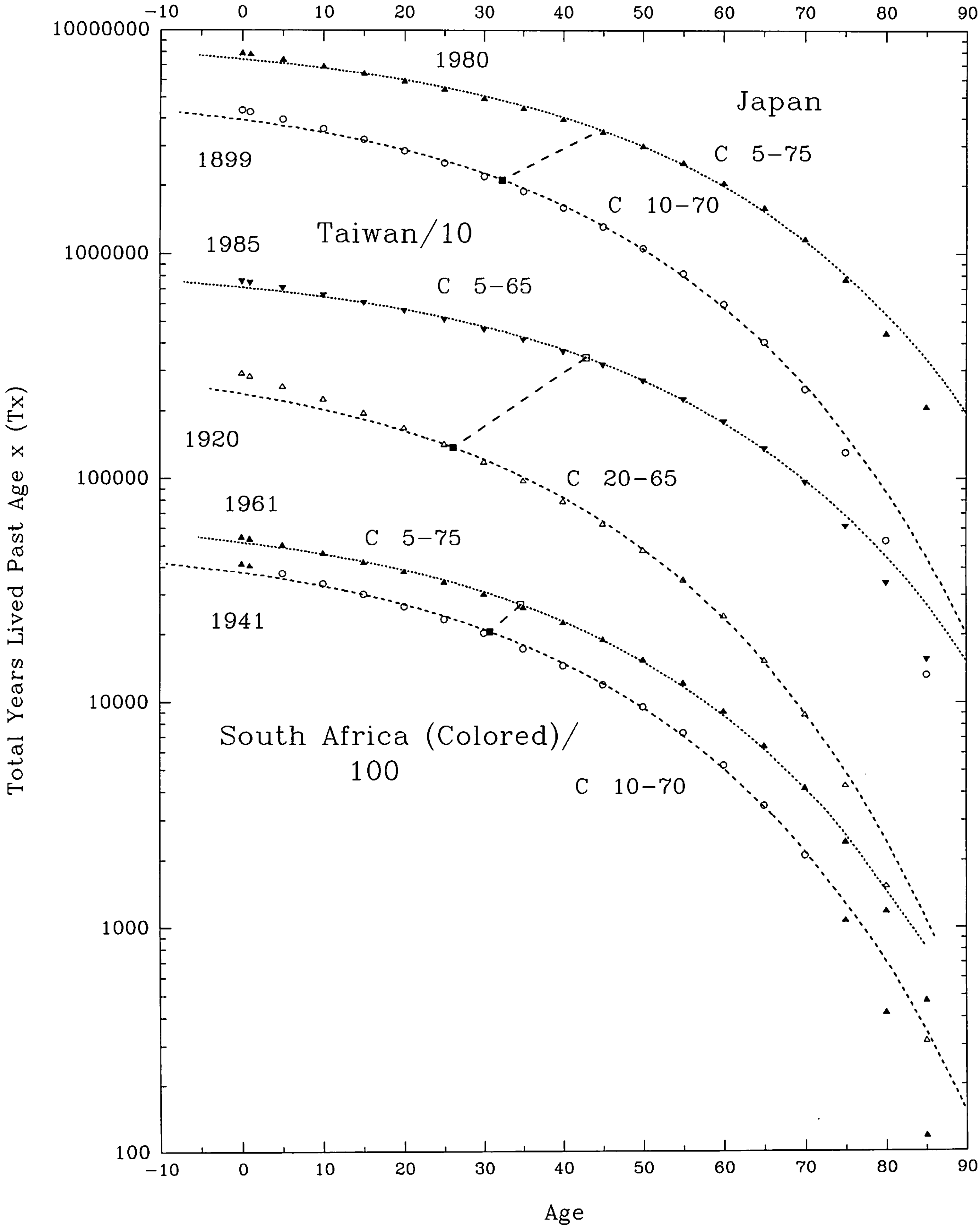
Figure 8.9a

The C Shape in Tx for Females:
England and Wales, Sweden, and Italy



Sources: Preston et al. 1972, 226, 654, 386; Keyfitz and Flieger 1990, 544, 528, 480.

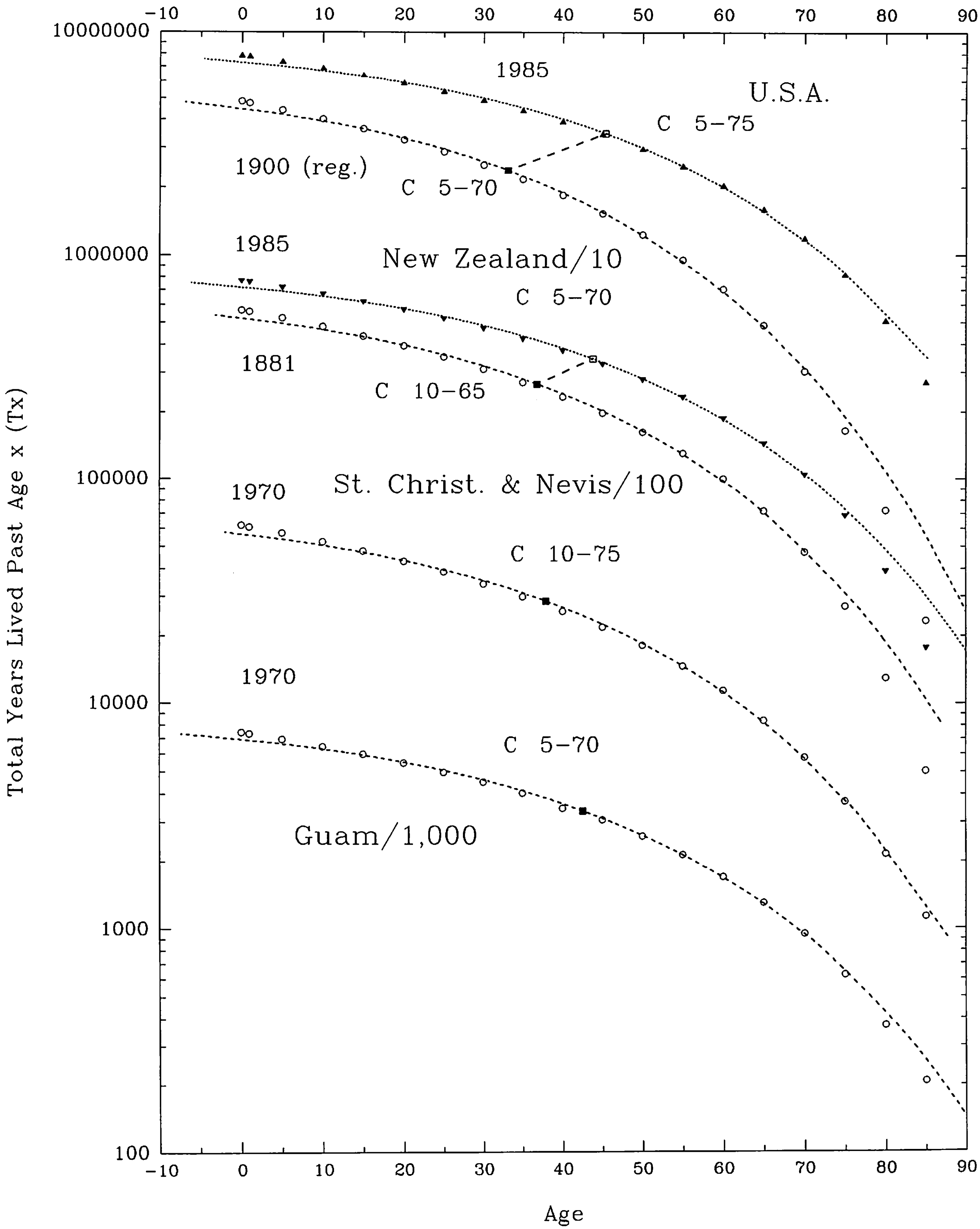
Figure 8.9b
The C Shape in Tx for Females:
Japan, Taiwan, and the Colored Population of South Africa



Sources: Preston et al. 1972, 418, 356, 618; Keyfitz and Flieger 1990, 374, 356; 1971, 320.

Figure 8.9c

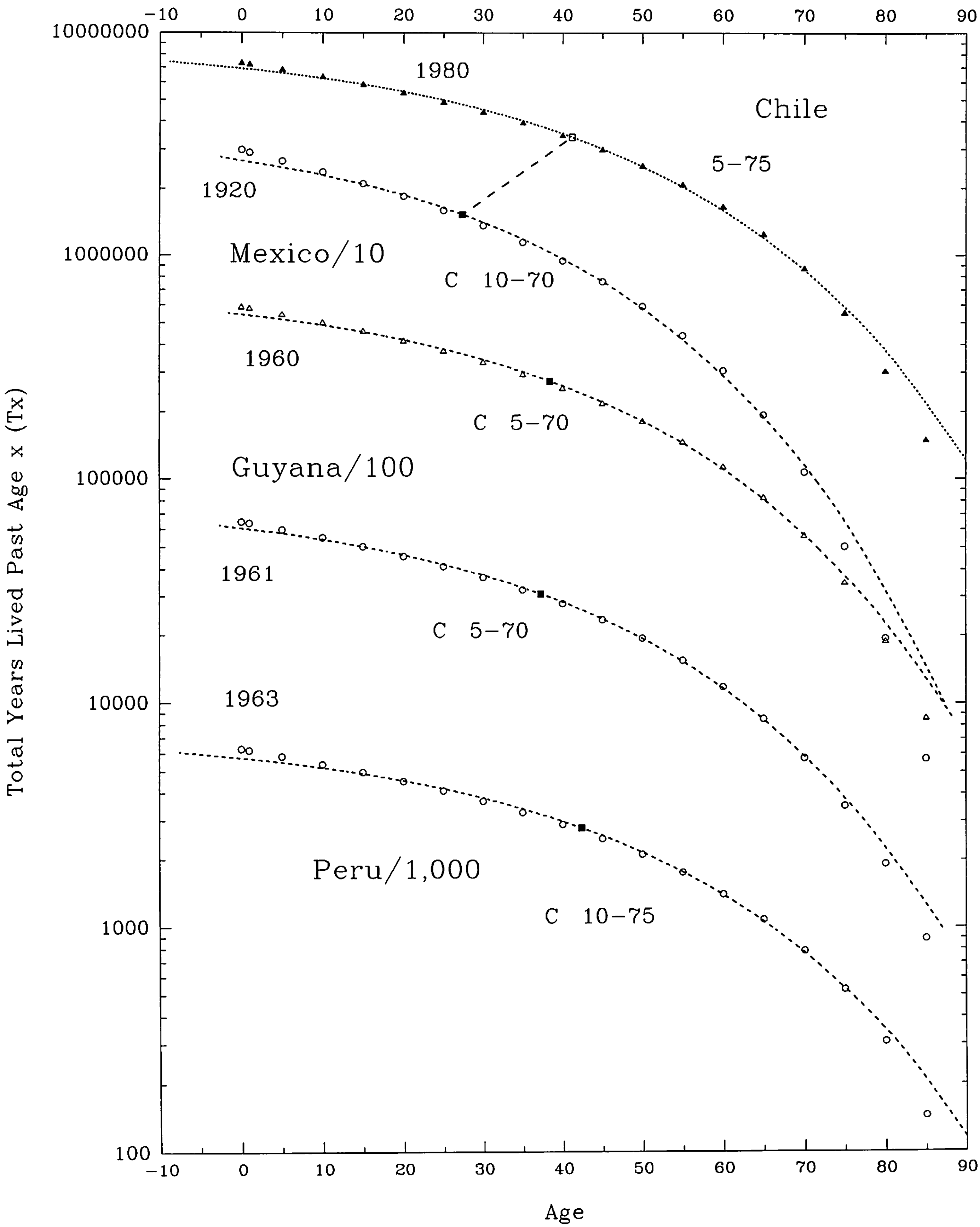
The C Shape in Tx for Females:
The U.S.A., New Zealand, St. Christopher & Nevis, and Guam



Sources: Preston et al. 1972, 726, 482; Keyfitz and Flieger 1990, 348, 578, 324, 570

Figure 8.9d

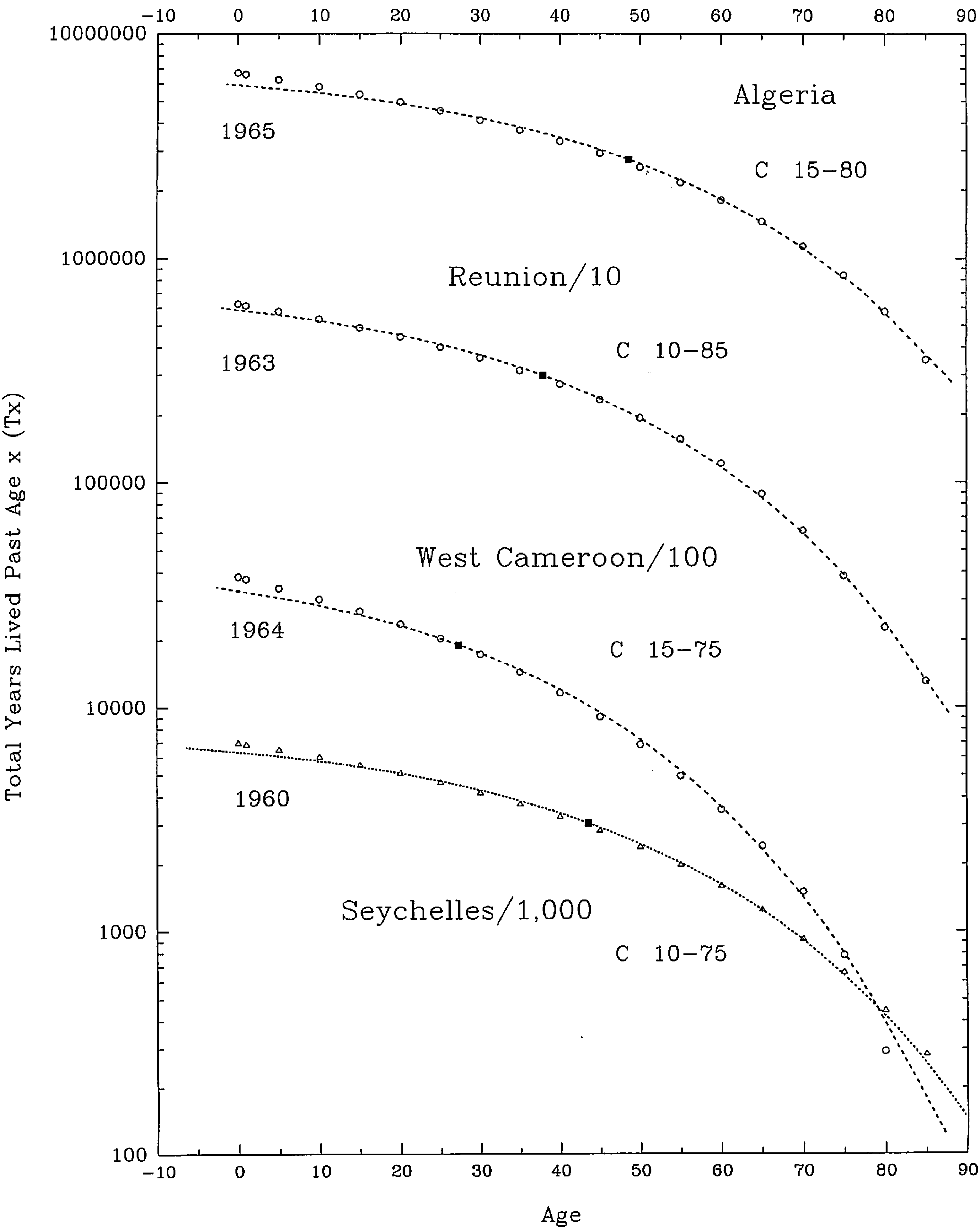
The C Shape in Tx for Females:
Chile, Mexico. Guyana, and Peru



Sources: Preston et al. 1972, 150, 146, 454; Keyfitz and Flieger 1990, 308, 314; 1971, 370, 372.

Figure 8.9e

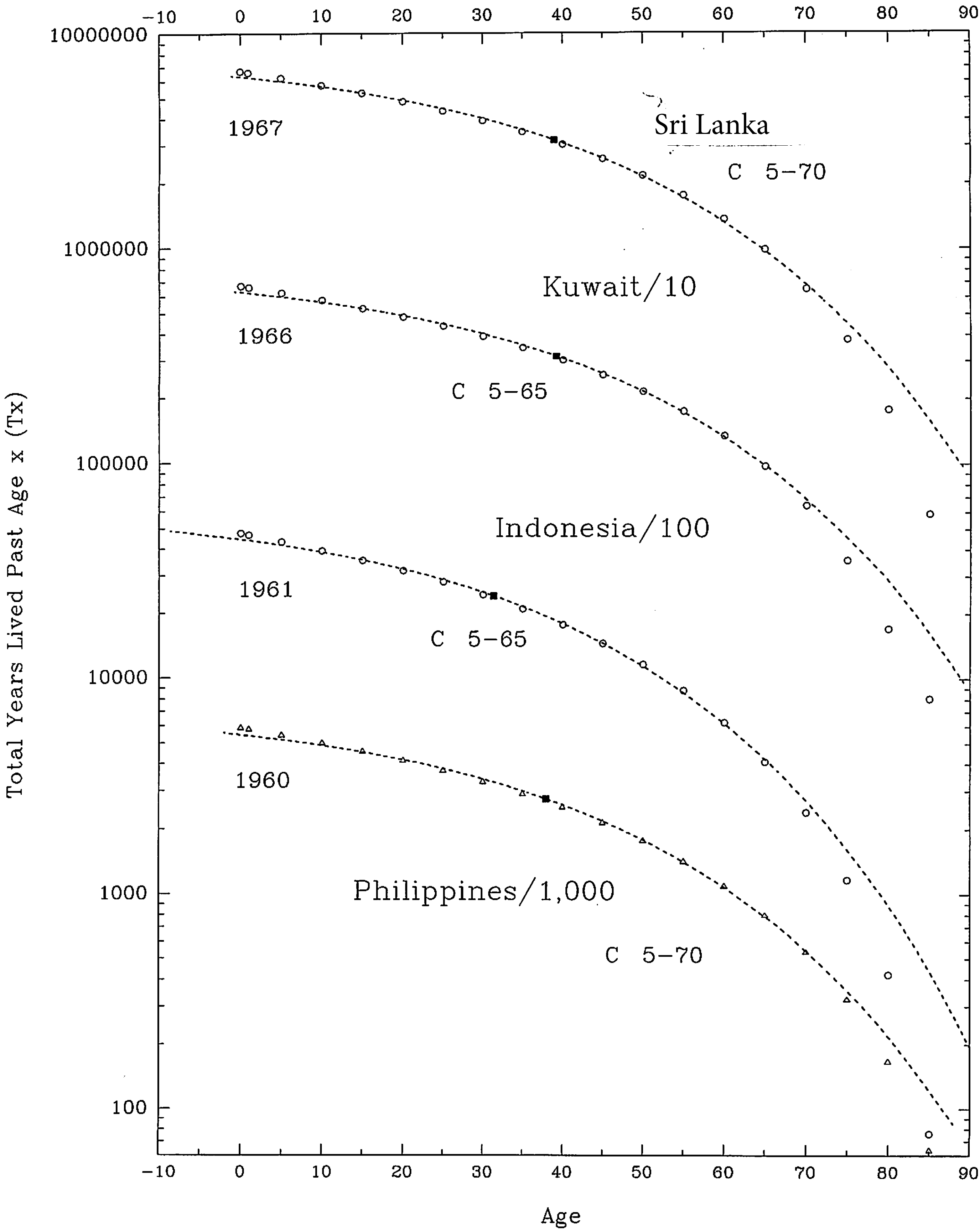
The C Shape in Tx for Females:
Algeria, Reunion, West Cameroon, and the Seychelles



Sources: Keyfitz and Flieger 1971, 308, 316, 310, 318.

Figure 8.9f

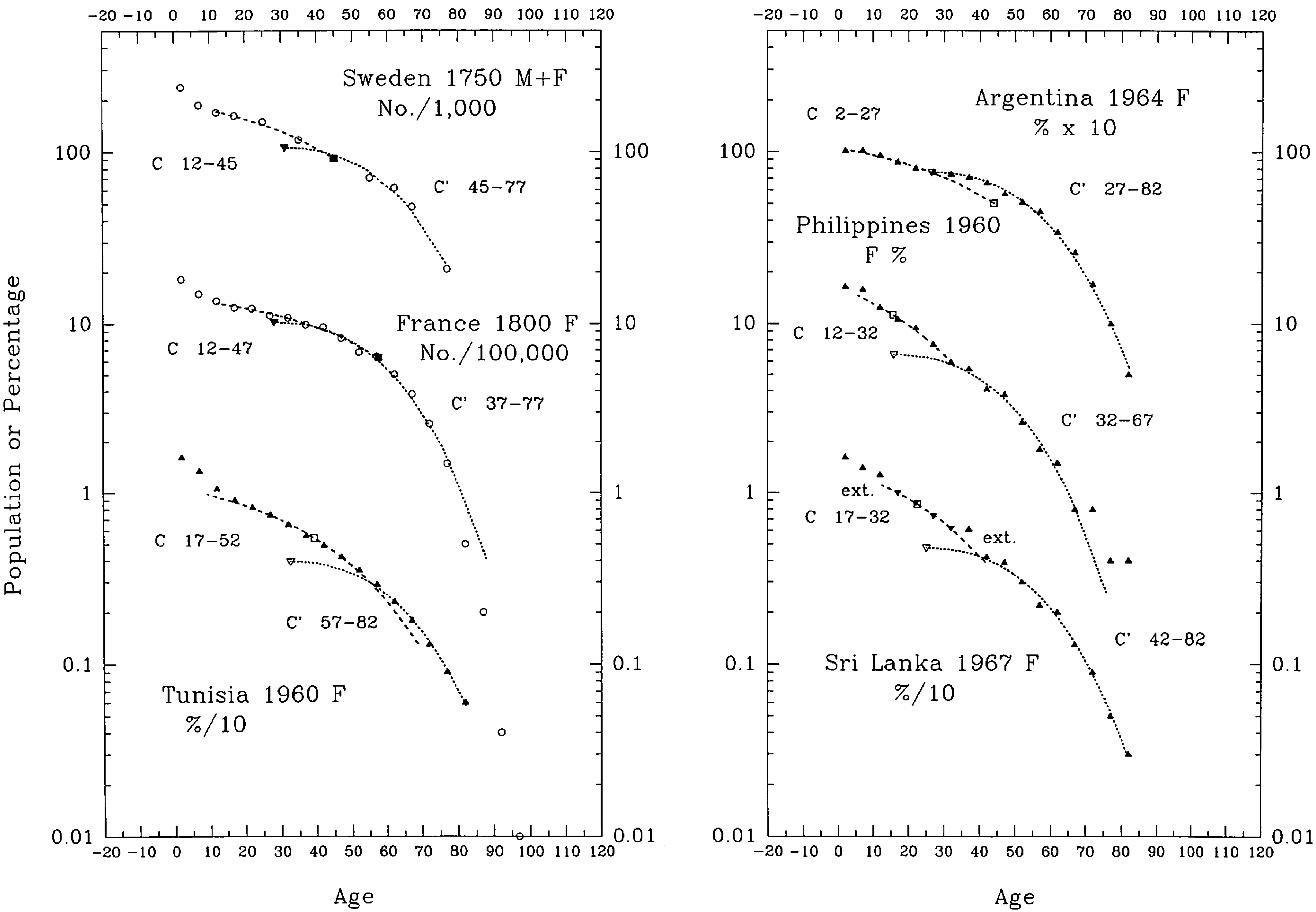
The C Shape in Tx for Females: Sri Lanka, Kuwait, Indonesia, and the Philippines



Sources: Keyfitz and Flieger 1971, 380, 400, 392, 410.

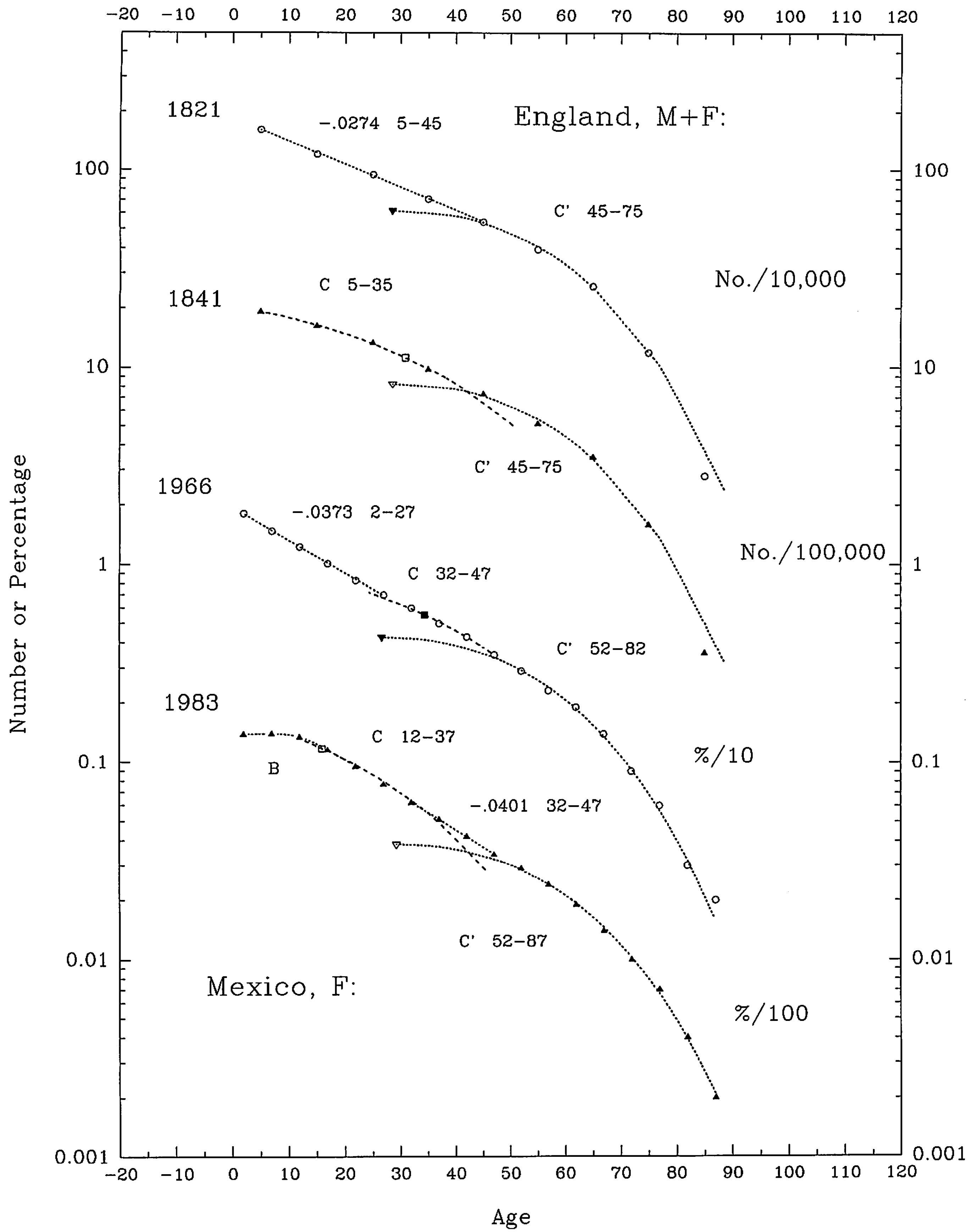
Figure 8.10

The Age Structures of Selected Historical Populations



Sources: Historisk statistik 1969, 68; Henry and Blayo 1975, 93; Keyfitz and Flieger 1971, 324, 362, 410, 380.

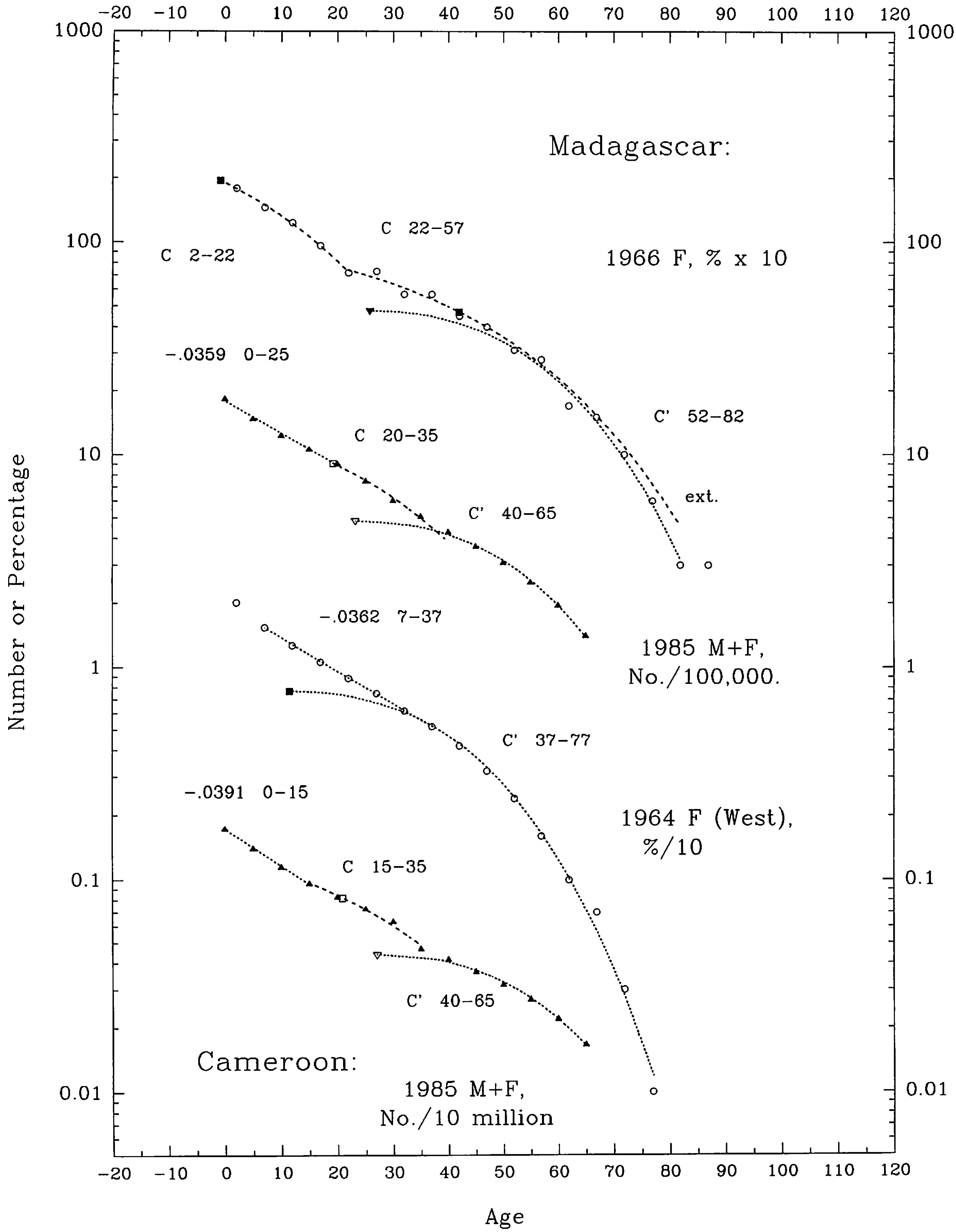
Figure 8.11a
Early Log-Linear Trends in Some Age Structures: England and Mexico



Sources: Wrigley and Schofield 1981, 117; Keyfitz and Flieger 1971, 344; 1990, 314.

Figure 8.11b

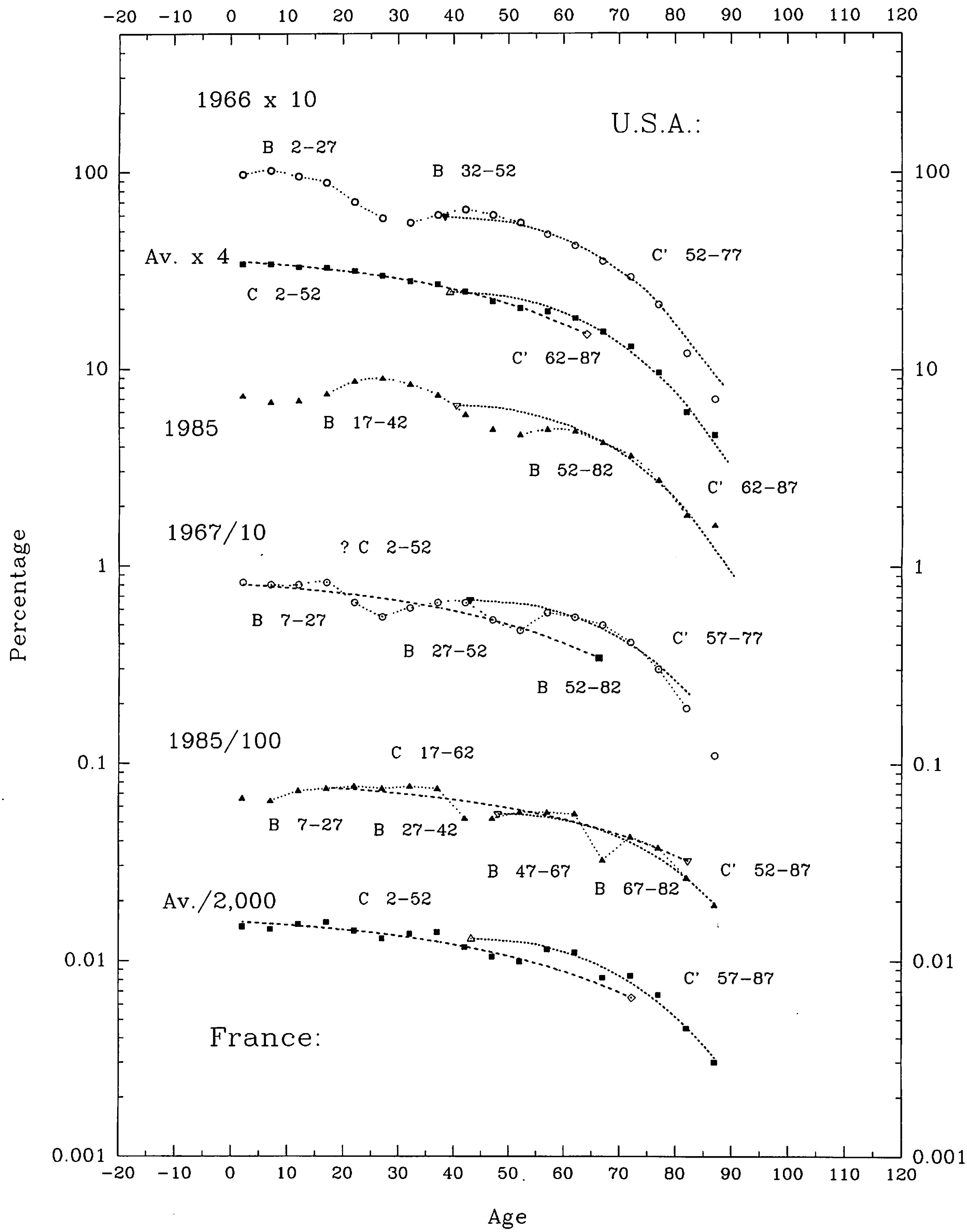
Early Log–Linear Trends in Some Age Structures: Madagascar and Cameroon



Sources: Keyfitz and Flieger 1971, 312, 310; 1990, 141, 121.

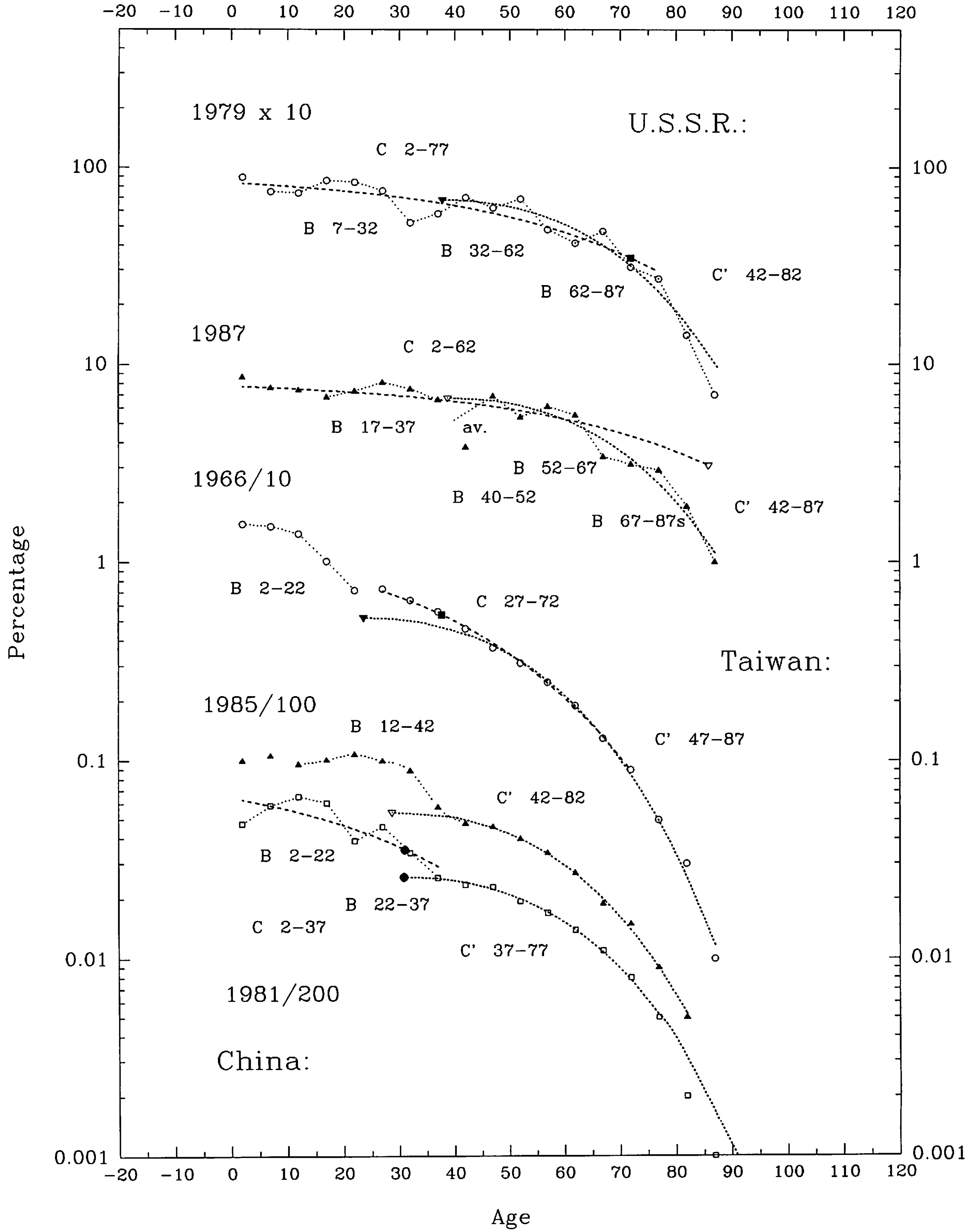
Figure 8.12a

Age Stuctures with Bulges, and Their Underlying Trends: The United States and France



Sources: Keyfitz and Flieger 1971, 354, 434; 1990, 348, 440.

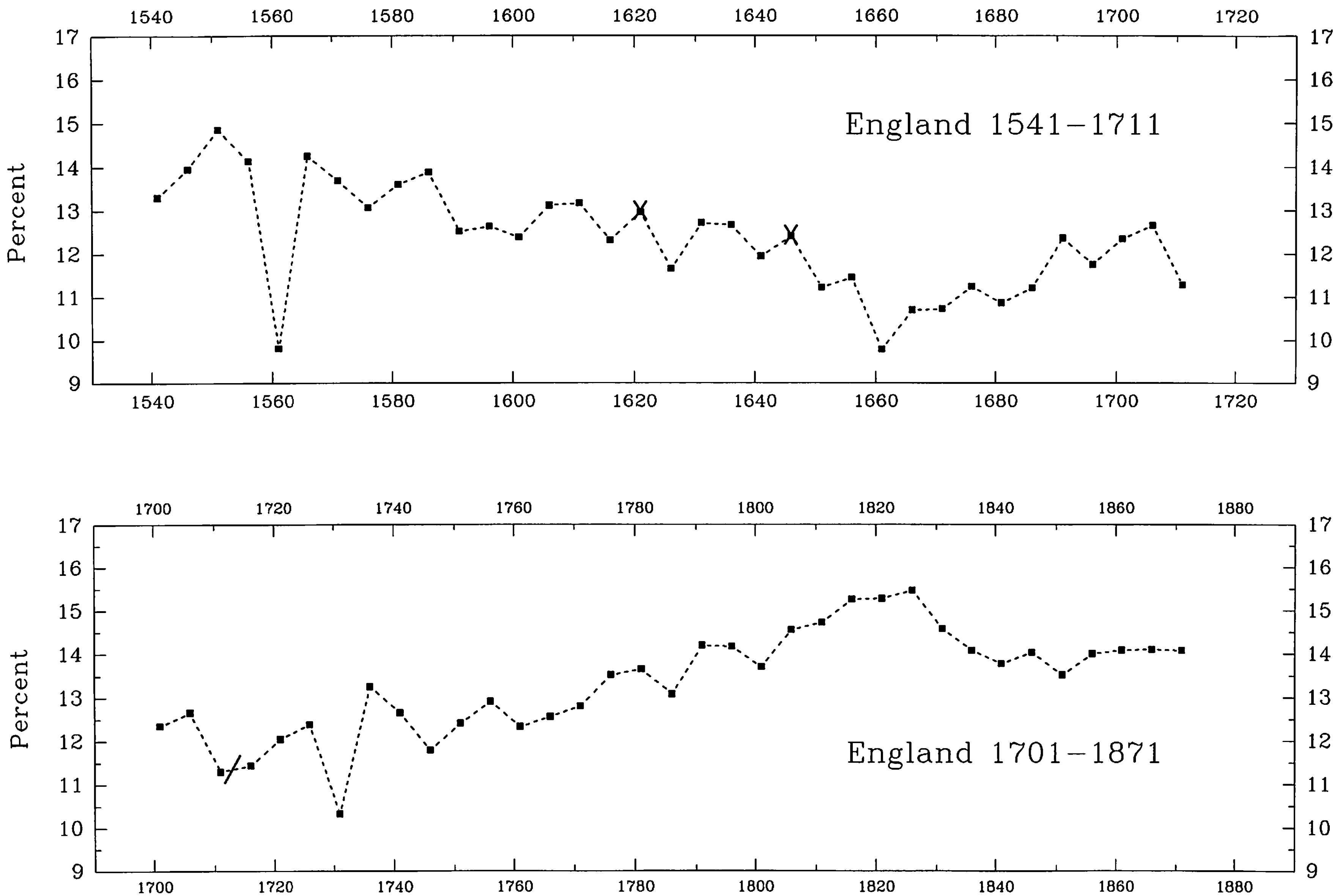
Figure 8.12b
Age Structures with Bulges, and Their Underlying Trends: The U.S.S.R., Taiwan, and China



Sources: Keyfitz and Flieger 1971, 382; 1990, 580, 582, 356, 350.

Figure 8.13a

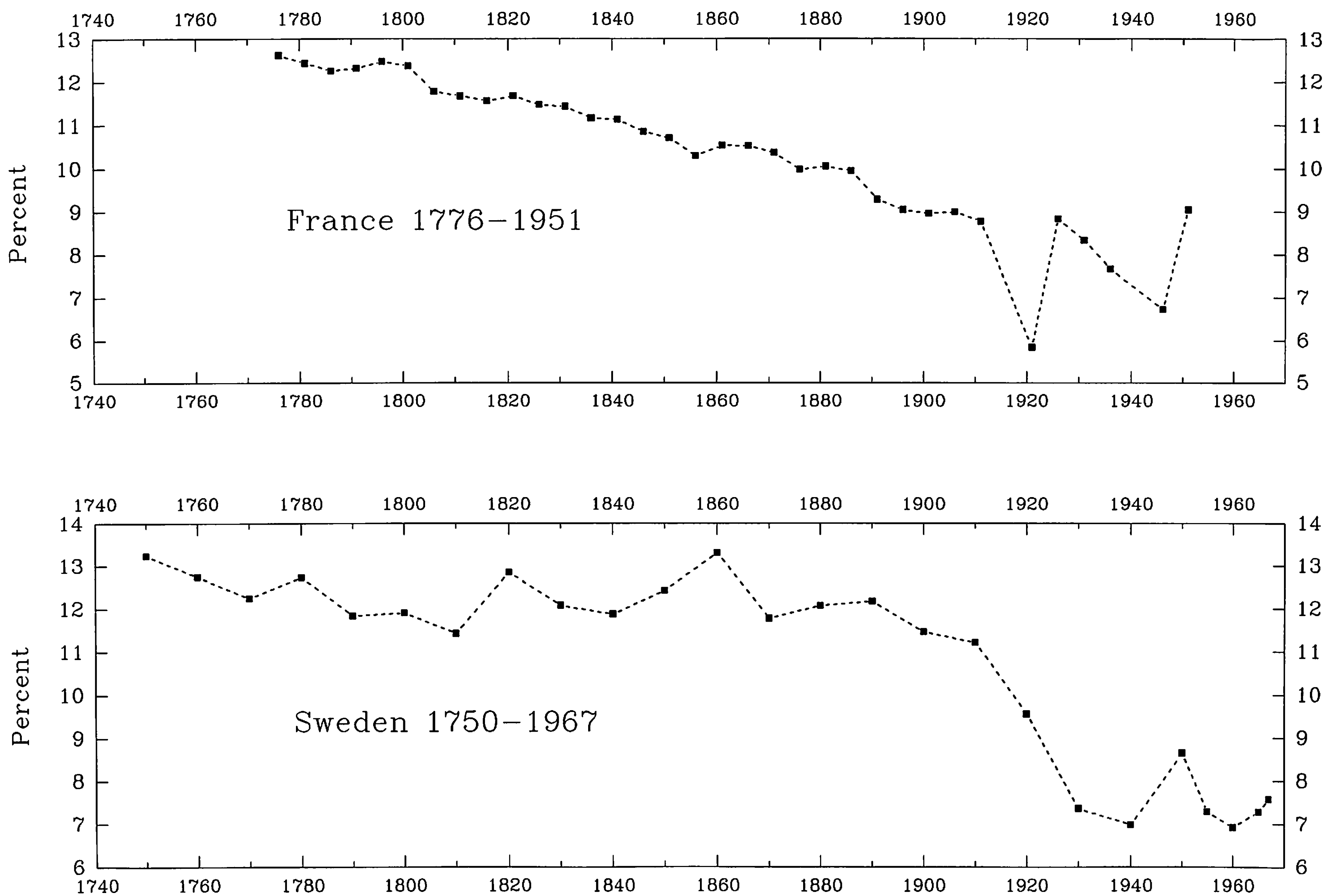
Children 0 through 4 as a Proportion of the Total Population



Source: Wrigley et al. 1997, 615.

Figure 8.13b

Children 0 through 4 as a Proportion of the Total Population



Sources: Bourgeois–Pichat 1965, 502–03; Historisk Statistik 1969, 68.

Table 8.1

Some Approximate Trends over Time in Life Expectancy at Birth

	1			2			3			4		
Global							1800-1950	E	1971	1950-2001	G	1922
Europe w/o Soviet U.	1800-1870	G	1730	1870-1913	G	1832	1900-1950	E	1970	1950-2001	G	1922
Americas							1830-1913	E	1948	1950-2001	G	1908
Oceania				1870-1913	G	1852	1900-1950	E	1982	1970-2001	G	1925
Former Soviet Union							1900-1950	G	1893	1950-1990	G	1915
Africa							1925,1950	?E	1975	1950-1990	G	1930
"							" , "	?G	1902			
Japan				1880-1930	G	1832	1890-1960	E	1974	1945-1990	G	1922
Kerala (India)							1915-1935	G	1890	1935-1985	G	1928
France	1745-1775	G	1705	1785-1865	G	1760	1865-1925	E	1945	1960-2000	G	1926
Sweden	1775-1815	G	1730	1815-1875	G	1777	1885-1925	E	1958	1925-2000	G	1882
Denmark										1950-2030	G	1880
England since 1730	1731-1811	E	1875				1831-1921	E	1952			
U.S.A.							1900-1930	G	1867	1930-2000	G	1893
" 10	1772-1792	E	1852	1792-1837	D	1748	1910-1930	G	1852			
" "				1837-1877	D'	1847						
Sart (Belgium)				1829-1855	E	1922						
Verviers (Belgium)	1665-1750	E	1814									
Villages of Verviers	1675-1760	G	1652									
Paraguay Missions	1710-1760	G	1672									
England to 1730	1561-1681	C	1731	1681-1721	G'	1701						

10 = e_{10}

Sources: Riley 2005a, 538; Riley 2001, 38-39; Tab. 1.2; Wrigley 1985b, 35; Keilman 2008, 141; Canudas-Romo 2010, 302; Li and Lee 2005, 582, 588; Haines 2000, 171; Livi Bacci and Maeder 2004, 205; Gutmann 1991, 440; Alter 2000.

Table 8.2

Estimated Trends of Life Expectancy, GDP per Capita, and Literacy in Latin America and the United States

	Life Exp. at Birth	GDP per Capita	Literacy
United States	1900-1930 G 1867	1900-1930 G 1882	1900-1990 G 1834
	1930-2000 G 1893	1940-1960 G 1940	
		1960-2000 G 1964	
Argentina	1900-1940 G 1878	1900-1940 G 1875	1910-2000 G 1858
	1940-2000 G 1900	1950-2000 G 1934	
Mexico	1900-1930 G 1882	1900-1940 G 1877	1900-1930 G 1878
	1940-2000 G 1930	1940-2000 G 1954	1930-2000 G 1931
El Salvador	1930-1980 G 1925	1900-2000 G 1935	1930-1960 G 1927
	1980-2000 G 1948		1960-2000 G 1931
Honduras	1900-1950 G 1895		1900-1940 G 1866
	1950-2000 G 1936	1940-2000 G 1920	1960-2000 G 1948
Ecuador		1900-1930 G 1910	1900-1940 G 1880
	1960-2000 G 1929	1940-1990 G 1953	1950-2000 G 1937
Cuba	1930-1990 G 1934	?	1900-1960 G 1884
			1960-2000 G 1932
Haiti	1950-2000 G 1933	?	1970-2000 G 1981
Dominican Rep.	1930-1990 G 1932	1950-1980 E 1968	1940-2000 G 1944
Bolivia	1900-1930 G 1874		1910-1940 G 1888
	1940-1970 G 1905		
	1970-2000 G 1946	1960-2000 G' 1988	1950-2000 G 1957
Paraguay	1900-1950 H 1857		1900-1990 G 1918
	1950-2000 G 1924	1960-2000 G' 1992	
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Brazil	1900-1960 E 1971	1900-1930 G 1882	1920-1950 G 1898
		1930-1950 E 1954	
	1960-2000 G 1925	1950-1990 G 1940	1950-2000 G 1936
Chile	1900-1960 E 1964	1900-1940 G 1894	1900-1950 G 1891
		1930-1970 E 1980	
	1940-2000 G 1929	1950-1990 G 1939	1950-2000 G 1912

Colombia	1900-1960	E	1966	1910-1960	G	1922	1910-1940	G	1891
				1940-2000	?E	1978			
	1950-2000	G	1927	1960-1990	G	1958	1950-2000	G	1927
Nicaragua	1920-1940	E	1950	1920-1970	E	1958	1920-1950	flat	
	1950-2000	G	1935				1960-2000	G	1935
Peru				1900-1930	E	1928	1900-1930	G	1890
	1940-1960	?E	1978	1930-1970	E	1968	1940-2000	G	1934
	1950-2000	G	1934	1970-2000	flat				
Uruguay	1900-1950	E	1978	1900-1940	G	1880	1900-1940	G	1870
	1940-2000	G	1897	1940-2000	G	1935	1940-2000	G	1894
Costa Rica	1900-1940	E	1958				1900-2000	G	1900
	1940-2000	G	1918	1960-2000	G	1952			
Panama	1930-1960	E	1968				1900-1990	G	1918
	1960-2000	G	1917	1950-2000	?G	1951			
Venezuela	1900-1940	E	1966	1920-1970	G	1954	1900-1950	E	1960
	1950-2000	G	1921	1940-2000	G'	1978	1940-2000	G	1937
Guatemala	1900-1940	flat					1900-1950	E	1946
	1940-2000	G	1936	1920-2000	G	1927	1960-2000	G	1954

Source: Astorga et al. 2005, 791, 788, 790.

Table 8.3

Some National Patterns of Female Life Expectancy by Age

Sweden 1903[b]	10-80	C	47.0 = 25.0			
France 1926*	15-75	C	45.3 = 27.5			
Greece 1928	5-75	C	48.0 = 26.0			
Australia 1911*	20-70	C	46.2 = 27.5			
Canada 1921 (reg.)	10-70	C	37.0 = 28.0			
Sweden 1953[b]	10-80	C	46.0 = 34.0			
El Salvador 1960s	10-70	C	46.0 = 28.0			
Madagascar 1966	5-70	C	50.0 = 20.0			
Argentina 1964	10-70	C	49.0 = 30.0			
China 1981*	20-70	C	46.7 = 30.3			
Tunisia 1960*	20-60	C	55.4 = 29.2	70-85	C'	58.7 = 21.3
El Salvador 1950*	20-60	C	48.4 = 26.0	65-85	C'	43.7 = 18.9
Trinidad & Tobago 1962*	20-60	C	44.5 = 29.9	65-85	C'	38.2 = 21.5
Sarawak 1961	10-60	C	49.0 = 27.0	60-85	C'	40.0 = 23.0
Honduras 1960s	10-60	C	46.0 = 27.0	60-75	C'	36.0 = 22.0
Fiji 1975	5-50	C	42.0 = 32.0	55-75	C'	38.0 = 25.0
China 1964-1982	15-70	C	44.0 = 29.0	75-85	C'	44.0 = 13.0
" 1982-1990	15-70	C	44.0 = 30.0	70-85	C'	42.0 = 17.0
" 1999-2000	10-75	C	46.0 = 32.0	70-85	C'	41.0 = 18.0
Sweden 1998[b]	10-70	C	49.0 = 32.0	70-90	C'	43.0 = 23.0
U.S.A. 1990-97 F 2-P Smokers*	20-60	C	46.4 = 29.8	60-75	C'	38.4 = 24.1
" " M " " *	20-60	C	46.8 = 28.8	65-85	C'	45.5 = 18.2
U.S.A. 1990-97 F Never Smoked*	20-80	H_r	84.7 = 18.3			
" " M " " *	25-85	H_r	71.1 = 20.2			

* Fitted in Fig. 8.1a or 8.1c, others estimated; [b] = both sexes..

Sources: Figs. 8.1a, 8.1c; Preston et al. 1972, 118, 326, Keyfitz and Flieger 1971, 312, 362, 414; 1990, 566; Vaupel and Canudas-Romo 2003, 208; Palloni and Kominski 1984, 490; Bannister and Hill 2004, 71-73; Rogers et al. 2005, 283, 285.

Table 8.4

Life Expectancy by Age in Certain Historical Sub-Populations

Ulpian, Rome ca. 225*	M+F	10-40	C	46.2 = 16.0	40-49	C'	4.2 = 45.6
Graunt, London 1662	M+F	6-36	C	60 = 8.4	36-76	C'	36 = 14.5
de Wit, Holland? 1671	M+F?	5-40	C	55 = 10.2	40-80	C'	31 = 17.0
Halley, Breslau 1693*	M+F	25-75	C	46.2 = 19.0		-	
Crulai 1700	M+F	5-50	C	43 = 19.0	50-80	C'	34 = 16.5
Chinese Lineage 1644-1739*	M	5-45	C	35.7 = 20.9	45-80	C	65.1 = 10.1
" " 1644-1739	F	20-55	C'	19 = 30.0	40-70	C	38 = 26.0
" " 1740-1839	M	5-40	C	34 = 21.0	45-80	C	52 = 12.5
Daoyi 1792-1867	F	6-51	C	53 = 18.0	41-76	C'	36 = 25.0
Gaizhou 1813-1855	F	6-56	C	50 = 23.0	51-76	C'	34 = 26.0
Plymouth 17th Century	F	25-85	C	60 = 20.0		-	
Ipswich 17th Century	F	25-65	C	52 = 26.0	65-85	C'	44 = 21.0
Andover 1640-1669*	F	25-55	C	51.1 = 23.8	55-75	C'	43.4 = 22.9
" 1670-1699	F	25-65	C	54 = 23.0	75-95	C'	57 = 14.0
" 1700-1729	F	25-75	C	67 = 18.0		-	
" 1730-1755	F	25-75	C	59 = 22.0	75-95	C'	55 = 14.5
Buffon-Jeff., Paris vic. 1772	M+F	20-70	C	51 = 17.0		-	
Wigglesworth, Mass. 1789	M+F	5-75	C	56 = 17.0		-	
Yale Graduates 1701-1805*	M[a]	30-70	C	48.4 = 22.9		-	
" " 1701-1805	M[b]	20-50	C	49 = 17.0	50-75	C'	37 = 19.0
Maryland 17th Century	M	20-40	C	40 = 16.0	40-60	C'	38 = 16.0
Middlesex, Va., 17th Century	M[a]	20-50	C	22 = 26.0	50-75	C'	35 = 8.8
" " " " *	F[a]	20-40	C	19.5 = 19.7	40-75	C'	39.7 = 8.9
Native Md. Legs. 1600-1800	M	25-50	C	42 = 19.0	50-80	C'	35 = 17.0
Immigrant Md. Legs. 1600-1800	M	25-40	C	33 = 33.0	40-75	C'	34 = 16.0
Philadelphia Elite 1700-1800	F	7-75	C	53 = 22.5	75-95	C'	54 = 20
" " 1800-1850	F	7-85	C	54 = 25.0		-	
Salem 1818-1822	F	25-75	C	57 = 20.0		-	
" 1859-1861	F	15-95	C	54 = 24.0		-	
Boston 1826-1835	M+F	35-85	C	58 = 17.0		-	
" 1859-1861	F	25-75	C	57 = 20.0		-	
7 N.Y. Counties 1850-1865	F	15-85	C	45 = 24.0		-	
Schenectady 1883-1886	M+F	7-77	C	47 = 25.0		-	
7 Pa. Counties 1885-1900	F	15-80	C	45 = 24.0		-	
Rural Jalisco 1880-1960	M+F	5-55	C	50 = 19.0	55-75	C'	42 = 15.0
Western Oaxaca 1880-1960	M+F	5-55	C	49 = 14.5	55-75	?C'	46 = 13.0
Guadalajara 1880-1960	M+F	5-35	C	38 = 22.0	45-65	C'	36 = 20.0
Coastal Jalisco 1880-1960	M+F	5-45	C	49 = 17.5	55-75	C'	44 = 16.0
Plateau " 1880-1960	M+F	5-55	C	50 = 19.0	55-75	C'	40 = 18.0
Mixteca Alta 1880-1960	M+F	5-55	C	51 = 16.0	55-65	?C'	39 = 15.0
Coastal Oaxaca 1880-1960	M+F	5-25	C	29 = 18.0	35-55	C'	28 = 17.0
Peking 1st Station 1929-1933	F	5-70	C	45 = 22.0		-	
" " " " "	M	10-70	C	40 = 27.0		-	

* = Fitted in Fig. 8.1b, others estimated; [a] = married; [b] = never married.

Sources: Fig. 8.1b; Smith and Keyfitz 1977, 5, 7, 24; Campbell 1997, 196-99; in B&S 2000, 390; Vinovskis 1971, 580-81; 1972, 198-99, 206-07; D. S. Smith 1999, 596; Rutman and Rutman 1979, 172; Levy 1983, 37; Kantrow 1989, 226-27; Haines 1976, 41, 44; Wells 1995, 419; Cook and Borah, vol. 2, 1974, 384, 388, 393, 397.

Table 8.5

Survivorship by Age (per Initial 1,000) in Representative Modern Populations

	Year	Second Trend			Third Trend		
Europe:							
England and Wales*	1861	10-60	C	70.8 = 311.0	65-80	C'	30.6 = 788.1
Italy	1881	10-65	C	70.0 = 240.0	65-80	C'	26.0 = 740.0
Portugal	1920	10-65	C	78.0 = 250.0	40-70	C'	38.0 = 500.0
Greece	1928	5-50	C	76.0 = 310.0	45-70	C'	43.0 = 600.0
France	1926	5-65	C	84.0 = 350.0	40-70	C'	41.0 = 740.0
Sweden	1911	5-65	C	86.0 = 350.0	45-75	C'	42.0 = 750.0
U.S.S.R.	1979	5-60	C	107.0 = 380.0	45-80	C'	45.0 = 920.0
Italy	1983	1-60	C	118.0 = 390.0	50-75	C'	52.0 = 940.0
England and Wales*	1985	1-50	C	157.1 = 368.9	50-80	C'	49.4 = 962.2
Europeanized Ex-Colonies:							
United States (r)*	1900	5-60	C	74.7 = 336.0	45-75	C'	37.2 = 631.2
Canada (r)	1921	5-65	C	90.0 = 340.0	45-75	C'	42.0 = 700.0
Australia	1911	5-65	C	87.0 = 370.0	45-75	C'	41.0 = 780.0
New Zealand*	1881	10-65	C	81.7 = 362.8	50-75	C'	43.0 = 686.6
United States	1985	1-60	C	120.0 = 380.0	50-80	C'	50.0 = 940.0
New Zealand*	1985	1-60	C	135.8 = 376.3	50-80	C'	49.5 = 947.4
Latin America & West Indies:							
Chile*	1909	5-50	C	52.5 = 292.0	50-85	C'	36.2 = 351.3
Guatemala	1964	5-60	C	80.0 = 320.0	60-80	C'	49.0 = 800.0
St. Christopher-Nevis	1970	5-65	C	82.0 = 380.0	45-75	C'	42.0 = 750.0
Ecuador	1965	5-65	C	92.0 = 330.0	45-75	C'	45.0 = 700.0
Peru	1963	5-65	C	93.0 = 340.0	50-80	C'	46.0 = 750.0
Mexico*	1960	10-55	C	95.5 = 340.0	45-75	C'	42.7 = 742.5
Venezuela	1965	5-50	C	98.0 = 350.0	45-80	C'	42.0 = 850.0
Guyana	1961	5-50	C	95.0 = 370.0	40-80	C'	39.0 = 890.0
Dominican Republic	1966	5-70	C	98.0 = 350.0	40-85	C'	49.0 = 800.0
Argentina	1964	5-55	C	107.0 = 370.0	50-70	C'	48.0 = 860.0
Chile*	1980	1-60	C	120.8 = 371.7	50-75	C'	48.0 = 905.2

Table 8.5 (cont.)

Surviviorshiip by Age (per Initial 1,000) in Representative Populations

	Year	Second Trend			Third Trend		
Sub-Saharan Africa, etc.:							
Madagascar*	1966	10-45	C	54.5 = 342.6	50-70	C'	35.1 = 457.6
Cameroon (West)*	1964	15-45	C	63.9 = 315.6	30-60	C'	23.3 = 616.8
"	"				60-75	C'	37.3 = 322.3
Réunion	1963	5-65	C	89.0 = 360.0	45-75	C'	42.0 = 800.0
So. Africa (colored)	1941	5-65	C	95.0 = 370.0	45-75	C'	42.0 = 860.0
Mauritius	1966	5-65	C	96.0 = 350.0	40-75	C'	42.0 = 850.0
"	1980	1-55	C	108.0 = 380.0	45-75	C'	44.0 = 900.0
North Africa & Middle East:							
Tunisia*	1960	5-60	C	101.5 = 322.6	60-85	C'	50.9 = 644.8
Algeria	1965	5-70	C	100.0 = 330.0	60-85	C'	54.0 = 700.0
Kuwait*	1966	5-60	C	107.9 = 366.0	45-75	C'	46.2 = 851.9
Cyprus	1980	5-55	C	125.0 = 370.0	50-80	C'	46.0 = 960.0
Northeastern Asia:							
Taiwan*	1920	10-45	C	44.1 = 315.9	45-75	C'	29.2 = 355.0
Japan*	1899	5-60	C	69.8 = 319.6	40-75	C'	36.5 = 560.9
Ryukyu Islands	1965	5-65	C	96.0 = 390.0	45-75	C'	44.0 = 900.0
Rural Taiwan	1966	5-60	C	103.0 = 370.0	45-75	C'	43.0 = 900.0
China*	1981	5-55	C	120.7 = 360.9	55-75	C'	45.3 = 897.5
Japan*	1980	5-65	C	135.8 = 376.3	65-80	C'	50.1 = 1016.6
Southern Asia & Oceania:							
Indonesia	1961	5-60	C	78.0 = 320.0	50-75	C'	34.0 = 680.0
Philippines	1960	5-55	C	90.0 = 335.0	45-70	C'	42.0 = 760.0
Sarawak	1961	5-60	C	87.0 = 370.0	45-75	C'	42.0 = 780.0
W. Malaysia (Malays)*	1966	5-50	C	100.3 = 360.7	45-80	C'	40.7 = 834.3
" " (I & P)	1966	5-45	C	94.0 = 370.0	40-70	C'	35.0 = 880.0
Seychelles	1960	5-60	C	95.0 = 380.0	45-80	C'	44.0 = 840.0
Ceylon	1967	5-50	C	100.0 = 350.0	45-75	C'	44.0 = 820.0
Fiji	1966	5-60	C	98.0 = 380.0	45-85	C'	47.0 = 860.0
Singapore	1967	5-50	C	111.0 = 380.0	45-75	C'	43.0 = 920.0

* Fitted in Figs. 8.2a through 8.2h; others estimated from graphing.

Sources: Figures 8.2a through 8.2h; Preston et al. 1972, 386, 578, 326, 286, 654, 118, 70, 342, 774, 626; Keyfitz and Flieger 1971, 338, 368, 372, 376, 370, 330, 362, 316, 314, 308, 412, 388, 392, 410, 414, 408, 318, 380, 484, 416; Keyfitz and Flieger 1990, 582, 480, 348, 324, 296, 358.

Table 8.6

Some Early Survivorship Trends and Comparisons (per 1,000)

	Period	Sex	Second Trend	Third Trend
Western Cities:				
London (Graunt)	1661*	M+F	26-46 C 22.6 = 272.6	46-66 C' 20.0 = 146.8
Breslau (Halley)	1693*	M+F	10-55 C 52.1 = 324.9	45-75 C' 29.0 = 447.4
Hamburg (I)	1750	M+F	5-60 C 56.0 = 300.0	60-85 C' 18.0 = 2000.0
Schenectady	1903-1906	F	12-59 C 87.5 = 315.5	49-65 C' 38.9 = 674.7
Western Nations and Their Regions:				
German 7 (I)	1740	F	10-55 C 74.0 = 260.0	60-80 C' 24.0 = 900.0
East Friesland (I)	1750	F	10-50 C 70.0 = 290.0	60-75 C' 14.0 = 1780.0
Saarland (I)	1740	F	5-65 C 88.0 = 290.0	?
Massachusetts (W)	1789	M+F	5-50 C 47.0 = 260.0	50-80 C' 35.0 = 280.0
Paris Vicinity (B)	1792	M+F	10-39 C 50.0 = 240.0	50-70 C' 30.0 = 380.0
Bavaria (L)	1820	F	10-60 C 64.0 = 240.0	65-80 C' 22.0 = 800.0
Massachusetts (U)	1830	F	15-65 C 72.0 = 270.0	?
Saxony (L)	1844	M+F	10-50 C 68.0 = 190.0	55-75 C' 27.0 = 800.0
Belgium (Quetelet)	1841-1845	M+F	10-60 C 66.0 = 290.0	55-75 C' 33.0 = 540.0
Oldenburg (L)	1859	F	10-55 C 70.0 = 300.0	55-75 C' 29.0 = 620.0
7 N.Y. Counties	1850-1865*	F	5-60 C 71.3 = 325.1	65-80 C' 28.9 = 904.5
England & Wales	1861*	F	10-60 C 70.8 = 311.0	65-80 C' 30.6 = 788.1
Massachusetts (U)	1870	F	10-65 C 80.0 = 300.0	?
Prussia (L)	1872	F	10-55 C 73.0 = 260.0	55-75 C' 31.0 = 560.0
Mecklenburg (L)	1874	F	10-55 C 74.0 = 300.0	55-75 C' 30.0 = 700.0
German Empire (L)	1876	F	10-60 C 75.0 = 250.0	65-80 C' 26.0 = 860.0
United States (r)	1900	F	5-60 C 74.5 = 336.0	45-75 C' 37.2 = 610.0
Sweden	1911	F	5-65 C 86.0 = 350.0	65-80 C' 38.0 = 900.0
Western Communities:				
Colyton [1581]	1538-1624	M+F	25-50 C 70.0 = 450.0[h]	40-70 C' 28.0 = 900.0[h]
" [1662]	1625-1699	M+F	25-60 C 48.0 = 610.0[h]	40-70 C' 24.0 = 900.0[h]
Schwalm (I)	1690	F	5-55 C 65.0 = 300.0	40-85 C' 32.0 = 520.0
Herrenberg (I)	1690	M+F	15-45 C 97.0 = 250.0	35-85 C' 25.0 = 670.0
Colyton [1737]	1700-1774	M+F	25-60 C 66.0 = 470.0[h]	40-70 C' 30.0 = 800.0[h]
Ortenau (I)	1740	F	10-40 C 63.0 = 300.0	30-70 C' 20.0 = 600.0
Hartum (I)	1740	F	20-50 C 78.0 = 230.0	60-85 C' 18.0 = 1300.0
Vajszló-Besence (A)	pre-1790	M+F	30-60 C 65.0 = 520.0[h]	60-80 C' 22.0 = 1400.0[h]
Alsóyék (A)	pre-1790	M+F	30-60 C 70.0 = 480.0[h]	60-80 C' 20.0 = 1450.0[h]
Sárpilis (A)	pre-1790	M+F	30-80 C 57.0 = 560.0[h]	-
Vajszló-Besence (A)	1836	F	30-60 C 85.0 = 420.0[h]	60-80 C' 30.0 = 1000.0[h]
Alsónyék (A)	1836	F	30-70 C 66.0 = 520.0[h]	70-90 C' 22.0 = 1700.0[h]
Sárpilis (A)	1836	F	30-80 C 56.0 = 550.0[h]	-

China and Japan:

Qing Lin. [1691]	1644-1739	M	10-45	C	45.1 = 299.5	40-65	C'	20.2 = 436.8
" " "	" "	F	10-40	C	35.7 = 296.8	40-65	C'	32.7 = 277.7
Qing Lin. [1790]	1740-1839	M	5-45	C	51.3 = 350.6	35-75	C'	18.9 = 580.1
Taiwan	1920	F	10-45	C	44.1 = 315.9	45-75	C'	29.2 = 355.0
Qing Lin. [1865]	1840-1890	M	10-45	C	52.9 = 337.6	30-55	C'	22.1 = 564.2
Japan	1899	F	5-60	C	69.8 = 319.6	40-75	C'	36.5 = 560.9
Peking	1929-1933	F	10-60	C	68.4 = 267.2	40-70	C'	34.9 = 472.2
"	" "	M	10-55	C	88.1 = 259.3	35-70	C'	36.3 = 566.9

* = Fitted in Fig. 8.3a or 8.3b, others estimated; [1xxx] = middle year of long period; 25, 30.....[h] = year 25 or 30 = 1,000; (I) = Imhof; (W) = Wigglesworth (Vinovskis); (B) = Buffon (D. S. Smith); (A) = Andorka; (L) = W. R. Lee; (U) Uhlenberg, (r) = registration districts.

Sources: Figs. 8.3a and 8.3b; Wrigley 1968, 561; Imhof, ed., 1975, 2: 228, 259, 295, 331, 367, 400, 439, 460; Vinovskis 1971, 580-81; D. S.Smith 1999, 596; Andorka 1977, 23; Lee 1979, Tab. 4.13; Uhlenberg 1969, 419; Lesthaeghe 1977, 24; Preston et al. 1972, 726, 654.

Table 8.7

Some Approximate G-Related Trends in Changes of Height*

Population	Base (cm.)	Trend in Excess		
Sweden	163	1740-1780	D	1724 = 9.8
U.S., Slaves	170	1740-1790	D	1725 = 6.5
Northern Italy (Lombardy)	163	1745-1835	D	1760 = 3.6
Hungary	163	1745-1820	D	1766 = 3.8
Bohemia	160	1740-1790	D	1750 = 4.7
Bavaria	163	1700-1780	D	1764 = 3.5
France	163	1750-1785	D	1772 = 2.1
England	163	1770-1810	D	1770 = 4.5
" , Servants	163	1755-1815	D	1786 = 9.9
France	160	1675-1750	G	1692 = 2.8
U.S., Native White Males	168	1710-1765	G	1705 = 1.5
" , " " "	168	1765-1830	G	1720 = 1.9
France	162	1785-1825	G	1764 = 1.0
Bavaria	163	1720-1750	G	1764 = 3.5
England	163	1805-1840	G	1765 = 1.1
England	163	1841-1881	C	1920 = 3.0
U.S., Native White Males	168	1835-1892	D	1828 = 9.0
Limbourg (Eastern Belgium)	160	1805-1825	D	1825 = 1.8
Verviers " "	160	1805-1848	?D	1825 = 2.8
Tilleur " "	160	1825-1845	?D	1852 = 1.9
Polleur " "	160	1845,1855	?D	1847 = 3.5
Netherlands	163	1834-1864	D	1852 = 1.9
Sart (Eastern Belgium)	157	1825-1865	G	1844 = 5.4
Limbourg " "	160	1825-1865	G	1848 = 4.7
Verviers " "	160	1845,1875	?G	1866 = 3.6
Tilleur " "	160	1855,1885	?G	1805 = 2.4
Netherlands	163	1864-1924	G	1890 = 3.4
U.S., Native White Males	168	1882-1944	G	1904 = 2.5
Santiago (N.W. Argentina)	165	1917-1953	G	1893 = 2.4
Catamarca " "	163	1917-1953	G	1915 = 2.5
Jujuy " "	159	1917-1953	G	1924 = 2.8
Salta " "	160	1917-1953	G	1924 = 3.8
Tucumán " "	163	1917-1953	G	1925 = 2.9
Bavaria	163	1720-1790	G'	1758 = 5.5
Seraing (Eastern Belgium)	160	1815-1860	G'	1848 = 5.6
Limbourg " "	160	1825-1875	G'	1870 = 6.6
Sart " "	157	1835-1865	G'	1870 = 8.5
Tilleur " "	160	1845-1885	G'	1880 = 6.8
Northern India, Male Emigrants	62 (in.)	1845-1892	G'	1878 = 2.5
" " , Female "	57 (in.)	1845-1892	G'	1868 = 2.5
North Korea, Male Refugees	161	1935-1985	G'	1968 = 6.0
" " , Females "	147	1935-1985	G'	1974 = 6.7

* White male military recruits unless otherwise specified.

Sources: Komlos and Baten 2004, 194; 197-98; Haines 2000 B&S, 170-71; A'Hearn 2003, 272; Alter et al. 2004, 240; Haines 2004, 251-52; Salvatore 2004, 308; Brennan et al. 2004, 280; Pak et al. 2011, 147.

Table 8.8

Background and Senescent Erosion of Human Capabilities

Background Phase				
Life Expectation ($_{50}e_{21}$)	Scots	1750-1821	21-55	C 37
	Odd Fellows	1866-1870	25-55	C 38
	" "	1893-1897	21-55	C 36
	Britons	1983-1985	21-55	C 35
Actual Working Life ($_{50}w_{21}$)	Scots	1750-1821	21-55	C 36
	Odd Fellows	1866-1870	21-55	C 37
	" "	1893-1897	21-55	C 34
	Britons	1983-1985	21-55	C 33
Major Crime Rate	U.S., Native Parents	early 1900s	32-75	C 30
Minor " "	" , " "	" "	37-75	C 37
Sickness Expectation	Scots	1750-1821	21-55	C 98
" "	Odd Fellows	1866-1870	21-55	C 88
" "	" "	1893-1897	21-55	C 85
" "	Britons	1983-1985	21-55	C 50
High Mortality l_x	"Southern Europe"	life table	5-65	C 56
" " "	East Asia	" "	5-65	C 48
Grip Strength	?	1953	20-80	C 91
Arm "	?	1999	20-80	C 94
Leg "	?	1999	20-80	C 94
Farm Labor Wage	Durham & Gloucester	1833	35-65	C 94
Self-Estimated Health	United States	1972-2002	25-58	C 104
Senescent Phase				
High Mortality l_x	"Southern Europe"	life table	65-80	C' 26
" " "	East Asia	" "	65-80	C' 27
Major Crime Rate (alt.)	U.S. Native Parents	early 1900s	55-75	C' 24
Minor " "	" , " "	" "	27-75	C' 25
l_x after 65	U.S., Males	1982-1994	75-110	C' 30
" " "	U.S., Females	" "	85-115	C' 40
Farm Labor Wage	Durham & Gloucester	1833	50-75	C' 46
l_x (yrs. since arrival + 25)	Old South, Slaves	1850	35-50	C' 26
Earnings by Age	" " , "	1850	36-70	C' 21
Price by Age	" " , "	"	30-70	C' 14

* = All trends approximated.

Sources: Riley 1991, 181; Moehling and Piehl 2011, 814; Woods 2007, 379-80; Burnette 2006, 707, 702; Easterlin n.d., 30; Manton and Land 2000, 261-62; Fogel and Engerman 1974, supplement, 32, 82.

Table 8.9

${}_nM_x$, l_x, and T_x by Age in Selected Female Populations at Certain Dates

		${}_nM_x$ x 1,000	l_x per 1,000	T_x per 100,000
England & Wales	1861	30-70 E' 19.1 = 9.33	10-60 C 70.8 = 311.0	5-75 C 30 = 22
		70-85 E' 31.6 = 27.13	65-80 C 30.5 = 788.1	65-85 C' 15 = 32*
Italy	1881	25-75 E' 19.0 = 9.20*	10-65 C 70.0 = 240.0*	5-65 C 31 = 16.5
		65-80 C' 26.0 = 740.0*	65-85 C' 15 = 20*	
New Zealand	1881	25-50 E' 14.8 = 6.06	10-65 C 81.7 = 362.8	5-65 C 36 = 27
		55-75 E' 17.4 = 5.29	50-75 C' 43.1 = 686.6	70-85 C' 17 = 44*
Japan	1899	20-65 E' 19.0 = 9.42	5-60 C 69.8 = 319.6	10-70 C 31 = 21.5
		65-85 E' 27.3 = 18.15	40-75 C' 36.5 = 560.9	65-85 C' 14 = 34*
Taiwan	1920	40-65 E' 23.7 = 19.94	10-45 C 44.1 = 315.9	15-80 C 22 = 16
		65-85 E' 29.0 = 26.36	40-75 C' 29.2 = 355.0	
Chile	1909	35-70 E' 29.3 = 18.59	5-50 C 52.5 = 292.0	5-40 C 25 = 18*
		75-85 E' 60.5 = 69.78	50-85 C' 36.2 = 351.3	35-75 C 35 = 13*
				70-85 C' 32 = 55*
United States (r)	1900	25-60 E' 17.0 = 6.80*	5-60 C 74.5 = 336.0	5-70 C 30 = 23.5*
		65-80 E' 28.0 = 18.50*	45-75 C' 37.2 = 610.0	65-85 C' 15 = 30*
Canada (r)**	1921	25-65 E' 14.0 = 4.00	5-65 C 90.0 = 340.0	5-70 C 38 = 28
		65-75 E' 24.0 = 10.00	65-80 C' 42.0 = 760.0	70-85 C' 29 = 64
		75-85 E' 35.0 = 30.00		
West Cameroon	1964	30-55 E' 0.9 = 0.63	15-75 C 63.9 = 315.6	10-75 C 26 = 20
		65-80 E' 23.5 = 1.16	30-60 C' 23.3 = 616.8	70-80 C' 13 = 25*
Madagascar	1966	30-50 E' 34.0 = 1.66	10-45 C 54.5 = 342.6	10-75 C 29 = 19*
		50-65 E' 14.7 = 0.79	50-70 C' 35.1 = 457.6	60-85 C' 18 = 17*
		70-85 E' 42.3 = 5.49		
Mexico	1960	20-35 E' 0.3 = 2.45	10-55 C 95.5 = 340.0	5-70 C 38 = 28*
		35-55 E' 12.4 = 3.99	45-75 C' 42.7 = 742.5	70-85 C' 22 = 35*
		55-70 E' 19.6 = 6.71		
		70-85 E' 33.3 = 20.20		
Ecuador**	1965	20-35 E' -1.0 = 2.20	5-65 C 95.0 = 330.0	5-75 C 40 = 28
		35-70 E' 16.0 = 4.00	45-80 C' 44.0 = 740.0	65-85 C' 30 = 21*
		70-85 E' 37.0 = 24.00		

Table 8.9 (cont.)

${}_nM_x$, l_x, and T_x by Age in Selected Female Populations at Certain Dates

		${}_nM_x$ x 1.000	l_x per 1,000	T_x per 100,000
England & Wales	1985	5-45 E' -11.9 = 0.16	1-50 C 157.1 = 368.9	5-75 C 44 = 35
		45-60 E' 2.6 = 0.72	50-80 C' 49.4 = 962.2	75-85 C' 23 = 70*
		60-85 E' 22.8 = 5.08		
Italy	1983	15-45 E' -6.0 = 0.23*	1-60 C 118.0 = 390.0*	5-70 C 44 = 35
		50-75 E' 12.0 = 1.40*	50-75 C' 52.0 = 940.0*	75-85 C' 20 = 86*
		75-85 E' 20.0 = 4.30*		
New Zealand	1985	15-50 E' -4.5 = 0.40	1-60 C 132.6 = 374.5	5-70 C 44 = 35
		55-75 E' 17.9 = 3.11	50-80 C' 49.5 = 947.4	75-85 C' 21 = 80*
United States	1985	15-50 E' -5.0 = 0.37*	1-60 C 120.0 = 380.0*	5-75 C 46 = 34
		50-60 E' 8.0 = 1.40*	50-80 C' 50.0 = 940.0*	75-85 C' 27 = 50*
		60-80 E' 24.0 = 5.20*		
Japan	1980	20-45 E' -6.8 = 0.25	5-65 C 135.8 = 376.3	0-75 C 44 = 35
		50-75 E' 12.4 = 1.32	65-80 C' 50.1 = 1016.6	75-85 C' 22 = 72*
China	1981	20-60 E' 3.3 = 1.16	5-55 C 120.7 = 360.9	0-70 C 39 = 32*
		60-70 E' 16.7 = 4.37	55-75 C' 45.3 = 897.5	70-85 C' 17 = 76*
		70-85 E' 29.2 = 14.46		
Chile	1980	15-45 E' -6.2 = 0.52	1-60 C 120.8 = 371.7	5-75 C 40 = 35
		50-80 E' 17.6 = 3.72	50-75 C' 48.0 = 905.2	75-85 C' 22 = 62*
Tunisia	1960	20-70 E' 16.5 = 0.34	5-60 C 101.5 = 322.6	10-70 C 48 = 26*
			60-85 C' 50.9 = 664.8	70-85 C' 43 = 16*
Kuwait	1966	25-50 E' -0.8 = 0.13	5-60 C 107.9 = 366.0	0-65 C 39 = 31
		55-75 E' 8.2 = 0.15	45-75 C' 46.2 = 851.9	65-85 C' 19 = 50*
Malaysia, Malays	1966	30-60 E' 8.1 = 0.31	5-50 C 100.3 = 360.7	0-70 C 37 = 30*
		65-85 E' 33.7 = 2.07	45-80 C' 40.7 = 834.3	70-85 C' 26 = 86*
Fiji**	1966	10-60 E' 1.0 = 1.2	5-60 C 98.0 = 380.0	0-85 C 44 = 35
			45-85 C' 47.0 = 860.0	65-85 ?C' 31 = 21

** All tends for population estimated; * this entry estimated, others fitted.

Sources: Tables L.1 and L.4; Figures L.3a through L.3h; Preston et al. 1972, 386, 118, 726; Keyfitz and Flieger 1971, 368, 484; Keyfitz and Flieger 1990, 480, 348.

Table 8.10

Age-Specific Mortality Rates ($_{n}M_{x}$) per 1,000: Some Early Populations and Modern Comparisons

Durham Monks	(M)	1395-1529	25-60	E' 22.3 = 10.3	60-80	E' 34.3 = 19.4
England-Wales	(F)	1861	*15-45* 30-70	*G 15.8 = 7.1* E' 19.1 = 9.3	 70-85	 E' 31.6 = 27.1
Makeham	(F)	1851-1860	30-70	E' 21.8 = 9.8		
Urban Odd F.	(M)	1856-1860*	22-67	E' 16.0 = 9.5		
Rural Odd F.	(M)	1856-1860*	*22-47* 47-62	*G -10.0 = 4.2* E' 12.0 = 15.0		
Urban For.	(M)	1871-1875*	22-47	E' 12.0 = 8.0	47-67	E' 20.0 = 13.0
Rural For.	(M)	1871-1875*	22-47	E' 19.0 = 8.0	47-67	E' 14.0 = 7.5
7 N.Y. Co.'s	(F)	1850-1865[m]	*10-30* 30-60	*G 27.0 = 8.7* E' 16.5 = 8.5	 60-80	 E' 23.7 = 14.5
Sweden	(M+F)	1850*	*25-50*	*G 14.0 = 5.0*	57-88	E' 24.0 = 18.0
Sweden	(M+F)	2000*	27-50	E'-10.0 = 1.2	50-75 75-92	E' 16.0 = 18.0 E' 32.0 = 90.0

Qing Lineage	(M+F)	1640-1739[b]	30-65	E' 19.6 = 19.0	65-80	E' 36.0 = 53.3
" "	(M)	1740-1839[b]	15-40 40-65	E' -8.0 = 6.7 E' 25.0 = 33.9	65-80	E' 33.1 = 51.6
" "	(M)	1840-1890[b]	20-45	E' 0.3 = 8.4		
Taiwan	(F)	1920	40-65	E' 23.7 = 19.9	65-85	E' 29.0 = 26.4
Peking	(M+F)	1929-1933	30-60	E' 8.4 = 4.6	60-80	E' 22.7 = 15.6
China	(F)	1981	20-60	E' 3.3 = 1.2	60-70 70-85	E' 16.7 = 4.4 E' 29.2 = 14.5
China	(F)	2000*	20-60	E' 2.0 = 0.8	60-75	E' 15.0 = 31.0
India	(F)	1990*	27-62	E' 10.0 = 2.6	62-75	E' 23.0 = 11.0
S.E. Asia	(?)	U.N. model	20-60	E' 3.0 = 1.7	65-85	E' 28.0 = 18.0

[b] = Date of birth; [m] = *m* rather than *M*.

Sources: Figs. 8.4a and 8.4b; Tab. 8.9; Riley 1993, 37; Bongaarts 2005, 25; Bannister and Hill 2004, 72; Griffiths et al. 2000, 484, 486.

Table 8.11

Some Estimated Patterns by Age in Certain Causes of Female Mortality

		CDR	*Early Phase*	*Middle Phase*	*Late Phase*
<u>Other & Unknown</u>					
England & Wales*	1861	.00633	10-30 E' -8 = .00064	35-75 E' 13 = .00173	
Italy	1881	.00609		20-70 E' 14 = .00165	65-85 E' 34 = .00900
U.S.A. (r)	1900	.00354		25-75 E' 17 = .00125	
Japan	1899	.00993		30-65 E' 15 = .00350	65-85 E' 23 = .00700
Chile	1909	.00862		20-80 E' 22 = .00230	
Taiwan	1920	.00946		40-55 E' 10 = .00280	55-85 E' 20 = .00620
S. Africa (col.)	1941	.00513		10-50 E' 23 = .00090	
England & Wales*	1964	.00093		20-45 E' -1 = .00008	55-85 E' 20 = .00033
U.S.A.	1964	.00069	10-25 E' -11 = .00006	25-45 E' 3 = .00015	50-85 E' 28 = .00060
Japan	1964	.00129		25-85 E' 8 = .00018	
<u>Other Infections and Parasites</u>					
England & Wales*	1861	.00346		30-75 E' 34 = .00078	
Italy	1881	.00573		25-65 E' 22 = .00108	
U.S.A. (r)	1900	.00168		15-45 E' 44 = .00063	50-75 E' 29 = .00067
Japan	1899	.00154		30-65 E' 35 = .00090	70-85 E' 48 = .00120
Chile	1909	.00429		25-75 E' 32 = .00220	
Taiwan	1920	.00455		25-65 E' 32 = .00280	70-85 E' 49 = .00390
S. Africa (col.)	1941	.00223		15-65 ?E' 25 = .00060	
England & Wales*	1964	.00004		35-70 G' 90 = .000105	70-85 G' 118 = .00057
U.S.A.	1964	.00005	20-35 G' 65 = .00005	40-70 G' 87 = .000125	70-85 G' 115 = .00054
Japan	1964	.00008	5-45 E' 2 = .00001	25-65 E' 20 = .000054	65-85 E' 37 = .00015

Table 8.11 (cont.)

Some Estimated Patterns by Age in Certain Causes of Female Mortality

		CDR	*Early Phase*	*Middle Phase*	*Late Phase*
<u>Diarrheal</u>					
England & Wales*	1861	.00121	20-40 E' 5 = .00015	40-55 E' 19 = .00024	55-85 G' 114 = .01163
Italy	1881	.00293		20-75 E' 12 = .00036	
U.S.A. (r)	1900	.00142		25-55 E' 8 = .00013	55-70 E' 14 = .000225
Japan	1899	.00150		25-65 E' 12 = .00038	70-80 E' 13 = .00033
Chile	1909	.00164			40-85 G' 70 = .00220
Taiwan	1920	.00158		25-60 E' 18 = .00070	
S. Africa (col.)	1941	.00287		25-65 E' 9 = .000068	
England & Wales*	1964	.00007		40-55 G' 94 = .000121	55-85 G' 121 = .00195
U.S.A.	1964	.00004		35-70 E' 11 = .0000072	75-85 E' 34 = .000075
Japan	1964	.00016		40-60 E' 1 = .0000074	65-85 G' 135 = .07000
<u>Influenza, Pneumonia, Bronchitis</u>					
England & Wales*	1861	.00250		30-50 E' -1 = .00027	55-85 G' 107 = .02943
Italy	1881	.00388		20-70 E' 10 = .00095	
U.S.A. (r)	1900	.00242		25-55 E' 22 = .00058	70-85 G' 121 = .09400
Japan	1899	.00195		45-70 G' 96 = .05400	70-85 E' 35 = .00064
Chile	1909	.00624		20-70 E' 25 = .00038	
Taiwan	1920	.01080		15-30 G' 66 = .02500	35-85 E' 38 = .00850
S. Africa (col.)	1941	.00513		10-50 E' 23 = .00090	50-85 G' 107 = .08000
England & Wales*	1964	.00089	30-50 G' 94 = .00100	40-65 E' 2 = .000038	70-85 E' 21 = .000544
U.S.A	1964	.00028		25-45 E' 0 = .000020	45-85 E' 14 = .000057
Japan	1964	.00028		40-70 E' 1 = .000015	70-85 G' 136 = .09400

Table 8.11 (cont.)

Some Estimated Patterns by Age in Certain Causes of Female Mortality

		CDR	Early Phase	Middle Phase	Late Phase
Cardiovascular					
England & Wales*	1861	.00199	15-30 E' -9 = .00032	30-50 E' 0 = .00525	50-80 G' 103 = .03436
Italy	1881	.00295	20-35 E' -15 = .00014	35-55 E' -2 = .00042	50-85 G' 111 = .10000
U.S.A. (r)	1900	.00258	15-45 E' -6 = .00033	45-55 E' 4 = .00080	60-85 G' 102 = .10300
Japan	1899	.00242	20-55 E' 6 = .00076		65-85 E' 32 = .00580
Chile	1909	.00365	10-25 G' 63 = .00440	25-40 G' 80 = .01000	40-60 E' 24 = .00340
Taiwan	1920	.00058	10-45 G' 61 = .00084	55-65 G' 102 = .00680	65-85 G' 116 = .02700
S. Africa (col.)	1941	.00236		20-55 G' 74 = .01500	55-85 G' 102 = .18000
England & Wales*	1964	.00577	25-40 E' -20 = .000020	45-60 E' -1 = .00020	65-80 G' 126 = .33469
U.S.A.	1964	.00448	20-45 E' -18 = .000035	45-65 E' 1 = .00048	65-85 E' 21 = .00350
Japan	1964	.00251	15-45 E' -18 = .000030	50-65 E' 1 = .00029	60-80 G' 121 = .19000
Respiratory Tuberculosis					
England & Wales*	1861	.00267		25-55 C' 22 = .00496	55-75 C' 25 = .00457
Italy	1881	.00217		15-85 C' 32 = .00290	
U.S.A. (r)	1900	.00162		25-45 C' 13 = .00300	50-75 E' 45 = .00015
Japan	1899	.00126	20-40 C' 4 = .00240	40-65 C' 40 = .00125	65-80 C' 59 = .00088
Chile	1909	.00274		20-50 C' 21 = .00420	65-85 G' 84 = .00500
Taiwan	1920	.00139		20-65 G 46 = .00340	
S. Africa (col.)	1941	.00346		20-50 C' 13 = .00680	
England & Wales*	1964	.00006		35-80 E' 36 = .000023	
U.S.A.	1964	.00002		35-75 E' 28 = .000020	75-85 E' 40 = .000047
Japan	1964	.00015		35-75 E' 31 = .000125	

Table 8.11 (concl.)

Some Estimated Patterns by Age in Certain Causes of Female Mortality

		CDR	*Early Phase*	*Middle Phase*	*Late Phase*
Neoplasms					
England & Wales*	1861	.00049		35-70 G' 83 = .00314	
Italy	1881	.00065	15-35 E' -14 = .000064	40-85 G' 88 = .00420	
U.S.A. (r)	1900	.00087		20-85 G' 88 = .00620	
Japan	1899	.00044		35-65 G' 82 = .00250	
Chile	1909	.00052		20-75 ?G' 80 = .00200	
Taiwan	1920	.00022		30-70 G' 82 = .00135	70-85 G' 100 = .00230
S. Africa (col.)	1941	.00061		15-45 G' 88 = .00760	50-80 G' 96 = .01000
England & Wales*	1964	.00202	10-35 E' -20 = .00003	30-65 G' 92 = .00821	70-85 G' 108 = .03700
U.S.A.	1964	.00139		25-80 G' 82 = .01080	
Japan	1964	.00100		20-45 G' 85 = .00380	50-70 G' 97 = .01000
Certain Degenerative Diseases					
England & Wales*	1861	.00013	10-40 G' 62 = .00028		
Italy	1881	.00001		40-55 G' 86 = .00019	60-85 G' 112 = .00022
U.S.A. (r)	1900	.00101	10-30 G' 59 = .00100	30-45 G' 71 = .00210	45-85 G' 92 = .00780
Japan	1899	.00033	10-35 G' 51 = .00030	35-70 G' 92 = .00155	70-85 G' 118 = .00720
Chile	1909	.00025	15-25 ?E' -40 = .000054	25-60 E' 20 = .00030	
Taiwan	1920	.00102	15-45 G' 84 = .00115	45-70 G' 87 = .00450	70-85 G' 120 = .02700
S. Africa (col.)	1941	.00047		15-75 ?G' 79 = .00180	
England & Wales*	1964	.00024		35.50 G' 88 = .00035	50-85 G' 108 = .01884
U.S.A.	1964	.00037		20-55 G' 82 = .00090	60-80 G' 106 = .00450
Japan	1964	.00029	1-30 G' 54 = .00010	20-45 E' -2 = .00005	55-85 G' 110 = .00720

* Fitted in Figs. 8.5a and 8.5b; others estimated by template.

Sources: Figs. 8.5a, 8.5b; Preston et al. 1972, 226, 386, 726, 418, 146, 702, 618, 270, 770, 438.

Table 8.12

Approximate Trends for Particular Causes of Mortality (x 1,000)

Respiratory Tuberculosis

England & Wales	1861-1901 C 1891 = 1.40	1911-1940 C' 1908 = 0.96	
New Zealand	1881-1911 C' 1882 = 0.90	1911-1951 C' 1907 = 0.54	
Sweden	1911-1930 C' 1905 = 1.70	1930-1960 C' 1895 = 2.40	
Chile	1909-1940 C 1975 = 1.05	1940-1960 C' 1904 = 5.70	1950-1964 ?D' 2006 = 0.08
Japan	1899-1940 C' 1918 = 1.60	1940-1964 C' 1905 = 3.20	
Taiwan		1920-1964 C' 1915 = 1.40	
United States	1900-1940 C 1914 = 1.00	1930-1960 C' 1897 = 1.14	
Italy		1891-1964 C' 1905 = 1.20	

Other Infections and Parasites

England & Wales	1861-1921 C 1899 = 1.80	1921-1951 C' 1900 = 0.96	1940-1960 D' 1993 = 0.27
New Zealand	1881-1901 C' 1857 = 2.80	1911-1951 C' 1907 = 0.47	1936-1964 D' 1990 = 0.30
Sweden		1920-1951 C' 1892 = 1.80	1940-1960 D' 1999 = 0.13
Chile	1909-1930 C' 1908 = 4.50	1930-1950 C' 1923 = 2.50	1940-1960 D' 1985 = 0.28
Japan	?	1940-1964 C' 1894 = 8.00	
Taiwan		1930-1964 C' 1918 = 5.00	
United States	1900-1950 C 1918 = 1.20		1940-1960 D' 1996 = 0.22
Italy	1881-1901 C' 1856 = 8.00	1891-1931 D' 1933 = 1.50	
"		1910-1964 C' 1905 = 1.30	

Influenza, Pneumonia, Bronchitis

England & Wales	1861-1911 C' 1881 = 3.00	1911-1964 C' 1930 = 1.90	
New Zealand	1891-1921 C' 1886 = 1.30	1911-1951 C' 1916 = 0.70	
Sweden		1911-1951 C' 1914 = 1.30	1940-1964 D' 1966 = 0.50
Chile		1920-1950 C' 1911 = 7.50	
Japan		1908-1964 C' 1912 = 2.70	
Taiwan		1930-1960 C' 1904 = 7.50	
United States		1900-1950 C' 1898 = 2.20	1923-1964 D' 1973 = 0.27
Italy	1881-1921 ?C' 1898 = 3.70	1921-1964 C' 1920 = 2.70	

Diarrheal Diseases

England & Wales	peaks ca. 1866 and 1906		1911-1960 D' 1969 = 0.060
New Zealand	1881-1901 C' 1862 = 1.10	1911-1936 C' 1874 = 1.00	1946-1964 ?D' 1982 = 0.032
Sweden		1911-1940 C' 1882 = 0.65	1930-1951 D' 1988 = 0.070
Chile		1909-1930 G 1897 = 1.10	1940-1959 D' 1990 = 0.190
Japan	?	1940-1964 C' 1910 = 5.00	
Taiwan		1930-1964 C' 1910 = 5.40	
United States		1900-1930 C 1892 = 2.10	1950-1964 D' 1974 = 0.036
Italy		1881-1960 C' 1898 = 3.30	

Table 8.12 (concl.)

Approximate Trends for Particular Causes of Mortality (x 1,000)

Other and Unknown Causes

England & Wales	1861-1881	C' 1860 = 6.00	1911-1940	D' 1938 = 1.75	1940-1964	D' 1968 = 0.92
" " "	1881-1911	C' 1893 = 4.30				
New Zealand	1891-1936	C' 1906 = 2.10	1936-1964	C' 1938 = 1.80		
Sweden			1911-1960	C 1939 = 2.40	1951-1964	D' 1989 = 0.60
Chile	1909-1950	C' 1906 = 8.00	1950-1964	?C' 1942 = 2.40		
Japan	1899-1951	C 1939 = 5.20	1950-1964	C' 1929 = 2.90		
Taiwan			1920-1964	C' 1919 = 5.60		
United States	1901-1930	D' 1938 = 1.35	1920-1950	C' 1915 = 1.50	1950-1964	D' 1966 = 0.66
Italy	1891-1931	D' 1923 = 4.20	1901-1931	C' 1896 = 5.20	1931-1964	D' 1963 = 1.20

Degenerative Disorders

England & Wales	1861-1911	G' 1907 = 0.58	1921-1940	?G' 1936 = 0.60	1940-1964	D' 1979 = 0.20
New Zealand			1881-1926	G' 1925 = 0.50	1945-1964	D' 1982 = 0.16
Sweden			1911-1950	G' 1919 = 0.45	1930-1964	D' 1955 = 0.32
Chile			1909-1964	?G' 1941 = 0.45		
Japan			1899-1940	G' 1938 = 1.00	1940-1964	D' 1984 = 0.22
Taiwan			1930-1964	G' 1975 = 0.40		
United States			1900-1940	G 1858 = 0.45	1950-1964	D' 1972 = 0.35
Italy			1881-1921	?G' 1903 = 0.027		

Cardiovascular Issues

England & Wales	1861-1911	G' 1888 = 3.00	1921-1964	G' 1956 = 6.00
New Zealand	1891-1921	G' 1918 = 1.80	1921-1964	G' 1957 = 4.20
Sweden	1911-1940	E 1933 = 3.70	1930-1964	G' 1956 = 5.00
Chile	1909-1930	D' 1942 = 1.90	1930-1950	G' 1948 = 2.50
Japan	1908-1951	?G' 1927 = 2.70	1951-1964	G' 1974 = 2.60
Taiwan			1920-1964	G' 1953 = 1.10
United States	1900-1930	G 1858 = 1.12	1940-1964	G' 1959 = 4.50
Italy	1881-1910	E 1953 = 7.50	1921-1964	E 1992 = 8.00

Neoplasms

England & Wales	1861-1891	E 1894 = 1.00	1911-1964	G 1898 = 0.80
" " "	1881-1911	G 1876 = 0.58		
New Zealand	1881-1921	G' 1920 = 0.86	1921-1964	G' 1950 = 1.40
Sweden	1911-1951	G 1888 = 0.70	1951-1964	?G' 1965 = 1.90
Chile			1920-1964	G 1900 = 0.45
Japan	1899-1940	G' 1929 = 0.80	1908-1964	E 1984 = 1.70
Taiwan			1920-1964	?G' 1954 = 0.45
"			1920-1964	?E 1968 = 0.50
United States	1900-1920	G 1846 = 1.10	1920-1964	G 1886 = 0.54
Italy	1891-1921	G' 1916 = 0.75	1921-1964	E 1968 = 1.70

Source: Preston et al. 1972.

Table 8.13

Some Approximate Historical Trends in Specific Risks of Death

Plague Cases:	European Population	1585-1825 G' 1601			
Small Pox Deaths:	Geneva Population	1585-1675 G' 1616	1665-1745 G' 1698	1745-1805 G' 1768	
	London Population		1665-1735 G' 1702	1745-1785 G' 1768	1785-1845 C' 1783
	" "				1845-1880 D' 1880
Pock Marks:	London Convicts			1785-1825 G' 1788	
% Deaths:	Sweden			1755-1805 G' 1752	
Neonaticides:	New England Live Births	1650-1700 G' 1600	1710-1760 G' 1743	1760-1810 G' 1771	1810-1830 G' 1829
	" " " "		1830-1850 G' 1860	1850-1870 G' 1890	
Homicides:	New York Population	1800-1835 G' 1791	1830-1905 G' 1865	1890-1945 G' 1917	1955-1995 G' 2005
	Chicago Population			1887-1917 G' 1927	
	L.A. Population			1870-1955 G' 1874	1967-1995 G' 2004
	Combined Cities			1880-1950 G' 1905	
'Malaria' Deaths:	Punjab Population			1880-1940 G' 1892	
HIV-AIDS 15-49:	World Population 15-49				2000-2050 G' 2003
	Sub-Saharan Pop. 15-49				2000-2020 G' 1978
	Sub-S./All African Pop.				2010-2050 G' 1996
New AIDS 15-49:	World Population 15-49			1995-2020 D' 2027	2020-2050 C' 2017
Lung Cancer Deaths:					
	U.S. Men by Date				1957-1994 G' 1988
	U.S. Women by Date			1957-1982 E 1966	1975-1994 G' 2006
	U.S. Men by Cig.			1941-1987 G 1959	1987-2007 C 2023
	U.S. Women by Cig.			1929-1976 E 1964	1976-1996 G 1998
Overweight 20-75:					
Prevalence:	U.S. Non-Hisp. Whites				1989-2000 G' 2010
	U.S. Non-Hisp. Blacks				1989-2000 G' 2008
	U.S. Hispanics				1978-2000 G' 2007

Depth:	U.S. Non-Hisp. Whites	1989-2000	G' 2022
	U.S. Non-Hisp. Blacks	1989-2000	G' 2023
	U.S. Hispanics	1978-2000	G' 2010
Severity	U.S. Non-Hisp. Whites	1978-2000	G' 2027
	U.S. Non-Hisp. Blacks	1989-2000	G' 2031
	U.S. Hispanics	1978-2000	G' 2016

For level of curves see text.

Sources: Chenais ? (from Biraben); Livi-Bacci 2000, 8-9; Perrenoud 1997, 314; Oxley 2003, 636; Sköld 1997, 6; Roth 2001, 109; Zurbrigg 1997, 32; Monkonnen 2001, 63; Adler 2001, 30; Bongaarts et al. 2008, 210, 205; Harris 2001, 385; Pampel 2003, 56, 61; Joliffe 2004, 312.

Table 8.14

Comparing Patterns of l_x (per 100) among Primates and Certain Pre-Modern Human Populations

		Second Trend			Third Trend		
New World Monkeys[m]					1-20	C' -62.5 =	2131.0?
Old World Monkeys[m]		1-20	C 0.9 =	90.2	20-35	C' -29.5 =	273.4?
Wild Chimpanzees		10-35	C 11.6 =	35.6	20-60	C' -2.2 =	40.2
Pan[m]		5-45	C 35.0 =	43.2	50-65	C' -6.0 =	250.0
Prehistoric Humans		1-20	C 28.5 =	38.6	30-60	C' -11.2 =	110.7
London (M+F) 1661		26-46	C 22.6 =	27.3	46-66	C' 20.0 =	14.7
Yanomamo	FA	5-45	C 29.4 =	33.7	45-65	C' 25.9 =	24.3
Hiwi	HG	5-40	C 36.7 =	36.3	20-65	C' 28.8 =	35.9
Qing (F) 1644-1739		10-40	C 35.7 =	29.7	40-65	C' 32.7 =	27.8
" (M) " "		10-45	C 45.1 =	30.0	40-65	C' 20.2 =	43.7
Taiwan 1920		10-45	C 44.1 =	31.6	45-75	C' 29.2 =	35.5
Yanomamo Mocaj	FA	5-35	C 45.4 =	39.3	35-70	C' 36.7 =	50.4
Gainj	FA	5-35	C 51.1 =	34.5	20-60	C' 13.8 =	64.3
!Kung	HG	5-35	C 56.4 =	29.8	20-40	C' 15.3 =	58.0
Qing (M) 1740-1839		5-45	C 51.3 =	35.1	35-75	C' 18.9 =	58.0
Qing (M) 1840-1890		10-45	C 52.9 =	33.8	30-55	C' 22.1 =	56.4
Hiwi 1960+	AHG	5-40	C 56.4 =	23.5	40-65	C' 36.7 =	35.9
Chile 1909		5-50	C 52.5 =	29.2	50-85	C' 36.2 =	35.1
Breslau 1693 (M+F)		10-55	C 52.1 =	32.5	45-75	C' 29.0 =	44.7
Madagascar 1966		10-45	C 54.5 =	34.3	50-70	C' 35.1 =	45.8
Agta Peasant	AHG	10-35	C 60.4 =	20.8	25-70	C' 18.9 =	39.7
W. Cameroon 1964		15-45	C 63.9 =	31.6	30-60	C' 23.3 =	61.7
" " "					60-75	C' 37.3 =	32.2
Hazda	HG	5-35	C 63.9 =	25.6	35-80	C' 36.1 =	44.9
Agta Transitional	AHG	10-60	C 60.1 =	26.3		?	
Sweden 1750-59		10-55	C 64.4 =	28.2	40-80	C' 30.3 =	51.1
Ache	HG	15-55	C 63.4 =	30.9	35-78	C' 28.1 =	57.6
Tsimane	FA	5-60	C 64.3 =	34.7	40-75	C' 31.0 =	61.6
Peking 1929-33		10-60	C 68.4 =	26.7	40-70	C' 34.9 =	47.0
Japan 1899		5-60	C 69.8 =	32.0	40-75	C' 36.5 =	56.1
Italy 1881*		10-65	C 70.0 =	24.0	65-80	C' 26.0 =	74.0
England & Wales 1861		10-60	C 70.8 =	31.1	65-80	C' 30.6 =	78.8
Portugal 1920*		10-65	C 78.0 =	25.0	40-70	C' 38.0 =	50.0
Greece 1928*		5-50	C 76.0 =	31.0	45-70	C' 43.0 =	60.0
U.S.A. 1900 (r)		5-60	C 74.7 =	33.6	45-75	C' 37.2 =	63.1
Indonesia 1961*		5-60	C 78.0 =	32.0	50-75	C' 34.0 =	68.0
N. Territories Abor.	AHG	5-65	C 84.1 =	32.8	35-75	C' 35.1 =	70.9
Rural Taiwan 1966		5-60	C 103.0 =	37.0	45-75	C' 44.0 =	90.0

Settled Ache	AHG	5-65	C	111.4 =	32.7	35-75	C'	51.9 =	74.7
!Kung 1963-74	AHG	10-50	C	114.4 =	27.7	45-70	C'	43.2 =	65.9
China 1981		5-55	C	120.7 =	36.1	55-75	C'	45.3 =	89.8

Females unless otherwise indicated. * = estimated, [m] = primates from Gage; HG = hunter-gatherers; FA = forager-agriculturalists; AHG = acculturated hunter-gatherers.

Sources: Figs. 8.7a, 8.7b, 8.7c; Tabs. 8.6, 8.5; Gage 1998, 204.

Table 8.15

Patterns of l_x for Various Fauna, Standardized Approximately on Human Life Span

	Est. Span	Multiple	Second Trend	Extra Trend	Third Trend
Prehistoric Humans*	70	1	1-20 C 29 = 39		30-60 C' -11 = 111
*Pan**	70	1	5-45 C 35 = 43		50-65 C' -6 = 250
Wild Chimpanzee*	70	1	10-35 C 12 = 36		20-60 C' -2 = 40
Old World Monkeys[a]	80	2	2-40 C 38 = 45		40-70 C' 17 = 50
New World Monkeys[a]	80	3.6	4-36 C 1 = 49		54,72 ?C' 21 = 40
Dall Mountain Sheep[b]	80	6	6-48 C 73 = 35		48-60 C' 15 = 132
Fin Whales (catch)[b]	80	3.5	21-42 C 19 = 50[c]		49-70 C' -1 = 91[c]
Snowshoe Rabbit[d]	75	x	10,28 ?C -10 = 54		42-74 C' 10 = 46
Herring Gull[b]	80	x	16-48 C' 0 = 41		48-72 C' 21 = 15
Song Thrush[b]	81	9	9-36 C' -22 = 87	36-63 C' 6 = 9	63-81 C' 25 = 1+
Blackbird[d]	81	9	9-27 C' -17 = 66		45-81 C' 15 = 9
Song Sparrow[d]	80	x	15-43 C' -9 = 88		57-78 C' 26 = 8
Lapwing[d]	84	7	14-42 C' -8 = 50	42-56 C' 17 = 10	56-77 C' 32 = 5
American Robin[d]	80	9	11-33 C' -17 = 85	33-55 C' -5 = 24	55-77 C' 22 = 2
Barnacle[b]	75	31	8-43 C' 2 = 89		43-53 C' 21 = 37
Floscularia[b]	80	2,555	0-42 C' 1 = 97		42-70 C' 8 = 58

* Fitted in Fig. 8.7c with actual age span; [a] fitted in Fig. 8.7c but span adjusted here; [b] fitted in Fig. 8.8; [c] height adjusted to 0 = 200 for graphing; [d] trends estimated; [x] relative to unstated mean.

Sources: Figs. 8.7c,5 8.8; Deevey 1947 (in Smith and Keyfitz 1977, 62-72).

Table 8.16

T_X/100,000 for Females by Age in Selected Global Populations

AFRICA

Algeria 1965*	15-80	C	48 = 27
Tunisia 1960	10-70	C	48 = 26
Cameroon (W) 1964*	15-75	C	26 = 20
Madagascar 1966	10-75	C	29 = 19
Mauritius 1980	0-75	C	39 = 33
Réunion 1963*	10-85	C	37 = 30
Seychelles 1960*	10-75	C	43 = 30
C. S. Africa 1941*	10-70	C	29 = 21^5
" " " 1961	5-75	C	34 = 27

SOUTH AMERICA

Chile 1920*	10-70	C	26 = 16
" 1980*	5-75	C	37 = 11^5
Ecuador 1965	5-75	C	40 = 28
Guyana 1961*	5-70	C	36 = 31
Argentina 1964	5-70	C	42 = 32
Peru 1963*	10-75	C	42 = 28
Venezuela 1960	5-70	C	40 = 29

OCEANIA

Australia 1911	5-70	C	35 = 31
New Zealand 1881*	10-65	C	36 = 27
" " 1985*	5-70	C	44 = 35
Fiji 1966	0-85	C	39 = 32
Guam 1970*	5-70	C	43 = 33

EUROPE

England & W. 1861*	5-75	C	30 = 22
" " " 1985*	5-75	C	44 = 35
Italy 1881*	10-65	C	31 = 16^5
" 1983*	5-70	C	44 = 35
U.S.S.R. 1979	0-70	C	40 = 35
Sweden 1911*	10-65	C	38 = 27^5
" 1985*	10-70	C	43 = 35
France 1926	0-75	C	32 = 30
" 1985	0-75	C	46 = 35
Greece 1928	10-70	C	36 = 23
" 1985	5-70	C	44 = 35
Portugal 1920	10-65	C	33 = 18^5
" 1985	5-70	C	43 = 35

NORTH AMERICA

U.S.A. 1900 (reg.)*	5-70	C	30 = 23^5
" 1985*	5-75	C	46 = 34
Canada 1921 (reg.)	5-70	C	38 = 28
" 1985	5-75	C	46 = 35
Guatemala 1966	5-70	C	34 = 24
St. Chris.-N. 1970*	10-75	C	36 = 30
Mexico 1960*	5-70	C	38 = 28
" 1983	5-70	C	42 = 32
Dominican Rep. 1966	5-70	C	44 = 29

ASIA

Japan 1899*	10-70	C	31 = 21^5
" 1980*	5-75	C	44 = 35
China 1981	0-70	C	39 = 32
Taiwan 1920*	20-65	C	22 = 16
" 1985*	5-65	C	44 = 33
Singapore 1966-68	0-65	C	39 = 33
Indonesia 1961*	5-65	C	30 = 35
W Malaysia (IP) 1966	5-60	C	33 = 30
" " (M) 1966	0-70	C	37 = 30
Ceylon 1967*	5-70	C	38 = 30
Sarawak 1961	5-80	C	39 = 30
Ryukyu Is. 1965	0-70	C	40 = 33
Philippines 1960*	5-70	C	38 = 28
Cyprus 1980	0-65	C	41 = 35
Kuwait 1966*	5-65	C	41 = 35

* = Fitted in Figs. 8.9a through 8.9f; others estimated. ^{5} = 1/2. IP = Indians and Pakistanis. M = Malays.

Sources: Figs. 8.9a through 8.9f; Preston et al. 1972, 70, 118, 286, 326, 342, 578, 774; Keyfitz and Flieger 1971, 310, 312, 320, 324, 330, 362, 368, 404, 408, 412, 414, 416, 484; 1990, 296, 314, 338, 350, 358, 440, 458, 512, 580.

Table 8.17

Age Structure during Growth in Some Historical Populations

A. Patterns before 1900

	Date	Growth Trend(s)			Shape of Age Structure					
England (MF)	1561[a]	1561-1656	H	1461	10-42	C	39[b]	42-75	C'	29
	1656[a]	1656-1686	D	1587	7-65	C	48	42-75	C'	30
	1686[a]	1686-1726	H	1492	10-55	C	61	42-75	C'	29
	1726[a]	1726-1806	E	1822	10-55	C	54	42-75	C'	30
	1816[a]	1816-1861	H	1758	20-55	C	42[e]	42-75	C'	28
	1821*	" "	"	"	5-45	$e^{-.0274}$		45-75	C'	28
	1841*	" "	"	"	15-45	C	36	45-75	C'	28
	1861[a]	1861-1939	H	1794	10-42	C	40	42-75	C'	27
France (F)	1750	1752-1792	G	1702	7-42	C	48	32-82	C'	25
	1800*	1792-1827	E	1876	12-47	C	58	37-77	C'	28
	1825	1827-1939	G	1774	12-67	C	54	67-92	C'	18?
Sweden (MF)	1750*	1748-1783	G	1706	12-45	C	45	45-77	C'	31
	1790	1783-1818	G	1737	12-45	C	58	45-77	C'	28
	1820	1823-1848	G	1795	17-62	C	54	45-77	C'	29
	1850	1848-1943	H	1757	17-45	C	41	45-77	C'	28

B. C Then C' Patterns among 20th-Century Females

	Date	Growth Trend(s)			Shape of Age Structure					
Taiwan	1966*	1956-1992	G	1963	27-72	C	38[b]	47-87	C'	24
Sri Lanka	1967*	1921-1963	E	1957	17-32	C	22	42-82	C'	25
		1963-1990	G	1956						
Chile	1967	1940-1960	E	1967	27-57	C	45[c]	57-82	C'	30
		1970-1990	G	1960						
Argentina	1964*	1895-1970	H	1905	2-27	C	44	27-84	C'	26
		1970-1990	G	1959						
Mexico	1966*	1921-1960	E	1952	27-47	C	34[e]	52-87	C'	27
		1940-1990	F	-						
Costa Rica	1966	1920-1963	E	1946	27-62	C	28[e]	62-82	C'	28
		1963-1990	G	1973						
Tunisia	1960*	1946-1970	E	1976	17-52	C	39	57-82	C'	33
Philippines	1960*	1939-1960	E	1956	12-32	C	16	32-67	C'	16
		1960-1980	F	-						
Madagascar	1966*	1950-1970	E	1969	22-57	C	42[c]	52-82	C'	26
		1970-1990	F	-						
Chile	1980	1970-1990	G	1960	27-47	C	37[b]	47-77	C'	32
Madagascar	1985*	1970-1990	F	-	20-35	C	19[e]	40-65	C'	23
W. Cameroon	1985*	1970-1990	E	1983	15-35	C	21[e]	40-65	C'	27

Table 8.17 (cont.)

Age Structure during Growth in Some Historical Populations

C. Underlying C Then C' Declines with Bulges (xx,xx)

	Date	Growth Trend(s)			Shape of Age Structure					
France	1967*	1951-1990	G	1925	2-52	C	66	57-87	C'	43
					(17,42,62)					
Greece	1966-68	1951-1971	G	1912	2-27	C	68	57-87	C'	34
					(33,66)					
Norway	1967	1948-1990	G	1917	2-67	C	85	47-72	C'	41
					(16,48)					
U.S.S.R.	1979*	1959-1989	G	1937	2-77	C	72			
					(22,47#,67)					
U.S.A.	1966*	1940-1997	H	1888				42-87	C'	36
					(7,42)					
Japan	1966	1945-1965	G	1931	2-47	C'	18	47-87	C'	31
		1965-1990	G	1939	(20)					
W. Cameroon	1964*	1960-1970	E	1958	7-37	$e^{-.0362}$		37-77	C'	12
Algeria	1965	1948-1963	E	1956	2-22	C	-4	22-47	C'	10
		1970-1990	F	-	(2,24)			47-82	C'	32
Mauritius	1966	1944-1990	G	1953	2-27	C	7	32-82	C'	26
					(5,34)					
France	1985*	1951-1990	G	1925	17-62	C	82	52-87	C'	48
					(22,37,62,77)					
Norway	1985	1948-1990	G	1917	17-37	C	82	67-87	C'	46
					(20,32,62)					
U.S.S.R.	1987*	1952-1989	G	1937	2-62	C	86	42-87	C'	39
					(27,47,60,77)					
U.S.A.	1985*	1940-1997	H	1888	2-52	C	66	62-87	C'	40
					(27,62)					
Mexico	1983*	1940-1990	F	-	12-37	C	16	52-87	C'	29[e]
					(6)					
Algeria	1985	1970-1990	F	-	5-40	C	10	45-65	C'	27
					(2,24)					

China	1981*	1950-1990	H	1923	2-37	C	31	(12,27)	37-77	C'	31
Japan	1980	1965-1990	G	1939				(7,33)	42-87	C'	33
Taiwan	1985*	1956-1992	G	1963				(21)	42-82	C'	29

Timing of bulges (xx) is by the maximum point of the surge above the underlying trend.
* Age distributions fitted in Figs. 8.10 through 8.12b; others estimated by graphing.
[a] Estimated from *Population History* and GIP calculations combined; [b] Bulge precedes trend; [c] C trend precedes; [e] e^{-x} trend precedes; # center for sub-peaks at 42 and 52.

Sources: Figs. 8.10 through 8.12b; Keyfitz and Flieger 1971, 440, 456, 398, 364, 328, 308, 314, and 1990, 500, 374, 308, 115; Harris 2001, 27, 114, 148-49, 250-51, 280-81.

Table 8.18

Implied Dates of Birth for Bulges in Certain Age Structures, with Intervals

Population		*Peaks and Intervals (xx)*								
Taiwan	1966			1964						
	1985			1964						
China	1981			1969	(15)	1954				
Japan	1966					1946				
	1980			1973	(26)	1947				
U.S.S.R.	1979					1957	(25)	1932	(20)	1912
	1987			1960	(20)	1940	(13)	1927	(17)	1910
France	1967					1950	(25)	1925	(30)	1905
	1985			1963	(15)	1948	(25)	1923	(15)	1908
Greece	1966-68							1934	(33)	1901
Norway	1967					1951	(32)	1919		
	1985			1965	(12)	1953	(30)	1923		
U.S.A.	1966					1959	(35)	1924		
	1985					1958	(35)	1923		
Mauritius	1966			1961	(29)	1932				
Algeria	1965			1963	(22)	1941				
	1985	1983	(22)	1961						
Chile	1980			1965						
Mexico	1983	1977								

Sources: Keyfitz and Flieger 1971, 1990.

Table 8.19

Comparing Birth Bases for Bulges in International Age Structures

1	1900-08	France (2), Greece
2	1910-12	U.S.S.R. (2)
3	1919-25	U.S.A. (2), France (2), Norway (2)
4	1927-35	U.S.S.R. (2), Greece, Mauritius
5	1941-50	France (2), Japan (2), Algeria, U.S.S.R.
6	1953-60	China, U.S.S.R. (2), U.S.A. (2), Norway (2)
7	1961-69	Taiwan (2), China, France, Norway, Algeria (2), Mauritius Chile
8	1973-83	Japan, Mexico, Algeria

(2) = at two different dates.

Source: Tab. 8.18.

Table 8.20

Percentages of Total English Population in Certain Age Brackets (adjusted to 5-year equivalents)

Date	0-4	5-14	15-24	25-44	45-64	65-84
1541	13.30	10.61	8.73	6.40	[4.27]	[1.31]
1546	13.95	10.60	8.95	6.32	[4.13]	1.28
1551	[14.86]	10.86	8.89	6.24	3.91	1.25
1556	[14.13]	[11.64]	8.78	6.28	3.73	1.22
1561	9.81	[11.70]	[9.76]	6.67	3.89	1.24
1566	[14.25]	9.15	[10.41]	6.66	3.80	1.18
1571	13.59	9.82	[9.78]	6.84	3.81	1.13
1576	13.07	[11.44]	7.72	[7.15]	3.88	1.11
1581	[13.60]	10.90	8.26	[7.35]	3.87	1.11
1586	[13.88]	10.96	[9.47]	6.32	3.87	1.10
1591	12.52	[11.39]	9.22	6.43	4.01	1.10
1596	12.64	10.83	9.45	6.34	[4.22]	1.13
1601	12.39	10.38	[9.83]	6.47	[4.18]	1.14
1606	[13.12]	10.27	9.29	[6.98]	3.79	1.15
1611	[13.17]	10.48	8.83	[6.99]	3.85	1.19
1616	12.32	[10.86]	8.85	[6.92]	3.85	[1.28]
1621	12.97	10.49	9.03	6.84	3.93	1.22
Highs	13.68	11.41	9.85	7.08	4.20	1.295
Others	12.66	10.45	8.83	6.48	3.86	1.17
Ratio	1.0951	1.0923	1.1151	1.0923	1.0879	1.1026

[xx] = bulge years.

Source: Wrigley et al. 1997, 615.

Table 8.21

Approximate Peaks in Percentages of Children in Population

England 0-4	England 5-14	France 0-4	Sweden 0-4[p]	Sweden 0-4[t]
1551	1558	1776	1750	1770
(15)	(18)	(22)	(30)	(20)
1566	1576	1798	1780	1790
(20)	(15)	(23)	(20)	(20)
1586	1591	1821	1800	1810
(22)	(25)		(25)	(30)
1608	1616	-	1825	1840
(13)			(35)	(30)
1621*	(25)	1866	1860	1870
(12)		(20)	(25)	
1633	1641	1886	1885	-
(13)	(10)	(20)	(25)	
1646*	1651	1906	1910	-
(10)		(20)		
1656	(30)	1926	-	1940
(20)		(25)		(20)
1676	1681	1951	1950	1960
(15)				
1691	(30)			
(15)				
1706	1711			
(20)	(20)			
1726	1731			
(10)	(15)			
1736	1746			
(20)	(15)			
1756	1761			
(25)	(25)			
1781	1786			
(13)	(15)			
1794	1801			
(32)	(30)			
1826	1831			
(20)	(20)			
1846	1851			

[p] = peaks; [t] = troughs; (xx) = spacing; * = English peaks omitted in one analysis.

Sources: Figs. 8.13a, 8.13.b; Wrigley et al. 1997, 615.

Table 8.22

The Spacing of Bulges in Certain Age Structures, 1541-1985

A:	England 0-4 1541-1871	France 0-4 1776-1951	Sweden 0-4 1750-1967	E+F+S 0-4 1541-1967	20th Century 1965-1985	Total
n	17	6	6	29	21	50
Sum x	295	130	160	585	496	1,081
Sum x^2	5,659	2,838	4,444	12,941	12,800	25,741
Mean	17.34	21.67	26.67	20.17	23.62	21.62
s.d.	5.64	1.89	5.42	6.28	7.19	6.88
Median	15	20	25	20	25	20
Mode(s)	20	20	25	20,25	15,25	20

B:	England 5-14 1541-1871	France 0-4 1776-1951	Sweden 0-4 1750-1967	E+F+S 1541-1967	20th Century 1965-1985	Total
n	14	6	6	26	21	47
Sum x	293	130	160	583	496	1,079
Sum x^2	6,699	2,838	4,444	13,981	12,800	26,781
Mean	20.93	21.67	26.67	22.42	23.62	22.96
s.d.	6.76	1.89	5.42	5.92	7.19	6.54
Median	20	20	25	22.5	25	23
Mode	20	20	25	20,25	15,25	20,25

C:	England 0-4* 1541-1871	France 0-4 1776-1951	Sweden 0-4 1750-1967	E+F+S 0-4 1541-1967	20th Century 1965-1985	Total
n	15	6	6	27	21	48
Sum x	295	130	160	585	496	1,081
Sum x^2	6,231	2,838	4,444	13,513	12,800	26,313
Mean	19.67	21.67	26.67	21.67	23.62	22.52
s.d	5.34	1.89	5.42	5.57	7.19	6.40

Median	20	20	25	20	15,25	22
Mode	20	20	25	20	25	20,25

* Without 1621, 1646.

Sources: Tabs. 8.18, 8.21; Wrigley et al. 1997, 615.

Chapter 9

How G-Related Patterns Keep Appearing throughout Demographic Change: Explorations and Experiments

The casualty patterns of age-specific mortality (q_x's) carve survivorship into C then C' paths, which are in turn imprinted upon age structure, eventually smoothing out anomalies like baby booms, baby busts, or mortality crises. The fundamental C shape (G reversed with respect to time) of age structure throughout the active years between adolescence and senescence--infrequently C' instead--in turn shapes the number and proportion of dependent, productive, and fertile or mortality-prone individuals in a population. Some particulars of this process have been effectively determined in the development of modern demography. Others benefit considerably from further exploration and fresh understanding, exploiting insight from the system of G-based movements.

Central to the evolution of population theory since the 18th century has been the tenet that fixed birth and death rates will eventually produce fixed age distributions and log-linear change in the size of populations. How populations *approach* such stability, however--often over long periods of time--begs for more attention. These movements turn out to universally involve changes in G-related form, not only in the size of populations but in the age structures, vital rates, and fertility ratios that interactively shape demographic numbers.

Preceding chapters have demonstrated how both fertility and mortality in fact have *not* been constant historically.[1] They have instead repeatedly altered through time via curving G-related trends. The course of expansion or contraction that is determined by fixed vital rates, however--the momentum with which populations approach stability--is the simplest process to be considered.

It offers a basis of comparison for what happens when change in vital rates, either simultaneous for everybody or diffusing across birth cohorts, is introduced into demographic regimes. Do, for example, historically observed G-based patterns for fertility, mortality, age structure, and population size in fact result from arbitrary experimental changes in demographic systems?

Finally, how are temporary demographic shocks such as baby booms and mortality crises--or for that matter the migrations in or out of populations explored in Vol. II--related to the longer-term G-based trends of demographic change that are observed? Of interest are both the *shape* of the impact from such events and their *timing*. For example, are populations--which repeatedly alter in G-related patterns--particularly sensitive to shock or instability at certain stages or intervals which reflect the roots or waves of long-term fertility change?[2] How are such disequilibrating phenomena and their consequences affected by the ways that trends in both fertility and mortality have G-shaped forms imbedded in them?

MOMENTUM IN DEMOGRAPHIC CHANGE: THE LONG RUN VS. LONG APPROACHES TO IT

Since Euler in 1760, it has been clear that, without net migration, a population with fixed birth and death rates will eventually become ‘stable’--growing at a constant log-linear pace and having an age structure that is also log-linear. As valuable as this fundamental finding of stable population theory has been, especially when trying to work with incomplete data, insufficient examination has been made of the paths along which populations *achieve* stability. The conclusion of Ansley J. Coale four decades ago that "little attention has been given to the *process* of convergence from arbitrary initial circumstances to the stable form" seems still to apply (Coale 1972, 61). It can take a considerable amount of time, for instance, for log-linear growth or decline in the size of populations to appear. Volume I has shown, furthermore, that extended simple exponential change in population size has in fact been empirically a rather rare historical phenomenon. This observed log-linearity, moreover, tends to follow just the $e^{.03}$ path of the F curve, which is found in the exceptional context of frontier settlements and other societies enjoying for the time being otherwise relatively unrestraining environments.

Figures 9.1a and 9.1b illustrate, first of all, how constant rates of growth or decline do indeed eventually occur when the fertility and mortality schedules of several actual historical populations are held constant for 100 years (three to four generations) forward from the date of observation. The ten populations are selected to illustrate a variety of familiar transitions in expansion and/or contraction that have taken place historically, or that are occurring presently. Data for the base years in the 1960s or 1980s upon which forecasts are made come from the convenient international compendia of Keyfitz and Flieger (1971 and 1990).[3]

The trends that result once more reaffirm the initial insight of stable population theory: Namely, **1) if mortality and fertility are held constant, eventually age structures become fixed and populations will grow or decline in log-linear paths.**

More freshly insightful, though, they demonstrate how: **2) in actual historical populations with varying initial age structures, exponentially *curvilinear* change appears for quite a while *before* log-linear stability is achieved.** While this curvilinear phase can at times be brief, as the first 20 to 25 years in rapidly growing 1965 Algeria and 1966 Madagascar (Fig. 9.1.b), it lasts as much as 75 years in 1966 Japan and 1985 U.S.A. (Fig. 9.1a)

The figures demonstrate, moreover, that **3) these paths of *approach* to stable growth or decline consistently follow G-based shapes.** This is shown also by fitted projections for the

{Please note that the Figures and Tables referenced in Chapter 9 are not interleafed in the text but appear at the end of the chapter (notes). MSW 31 July 2015}

females of Mexico at 1966 (20 years, Fig. 9.4d) and of Italy at 1980 (70 years, Fig. 9.4e). Graphings of projections for females in 1983 Mexico, 1965 and 1985 Venezuela, 1961 El Salvador, 1967 and 1980 Chile, 1966 and 1985 Peninsular Malaysia, 1966 and 1980 Fiji, 1966 and 1985 Taiwan, 1967 Sri Lanka, 1980 Japan, 1966 U.S.A., 1985 Norway, 1967 and 1985 France, and 1966 and 1985 Yugoslavia--20 more populations--likewise indicate G-related trends followed by log-linear change. They extend and strengthen this insight of the 10 fitted cases.

4) These G-related projections of momentum in growth and decline pervade the patterns observed for hundreds of historical populations (Harris 2001: Vol. I). Actual historical trends since the 1960s or 1980s, however, frequently do not match exactly projections from those dates. For instance, in the United States at 1985 projection does not account for significant immigration that was taking place. It calls for growth via G rather than the H trend that really occurred into the early 2000s. In contrast, while the momentum for Norway as of 1967 accurately predicted extension of the G trend of the 1940s to the turn of the century (Harris 2001, 152), by 1985 the birth rate had dropped from 17.1 to 11.8 causing the observed natural increase of 8.4[4] to fall to 2.0 as the death rate simultaneously rose slightly. This shift makes projection for Norway from 1985 across the first half of the 21st century take declining C shape, not the E and e^x paths that appear for 1967 in Fig. 9.1a. For Mexican females in 1966 the projection of continued, robust log-linear growth (Fig. 9.1b) almost immediately failed to materialize as the female birth rate fell from 42.52 to 34.81, lowering natural increase from 33.49 to 30.00 already by 1983. Similar over-projection is likely for Algeria, while predictions for several European populations calling for C-shape decline may, like the United States at 1985, over-estimate loss by not including immigrants.

Among 10 populations whose paths of growth or decline are probed in Figs 9.1a and 9.1b or 9.4d or 9.4e (1966 Mexico and 1980 Italy), the ***G curve***--by far the most frequent trend historically (Harris 2001, 382)--is produced at once by the vital rates and age structures of 1967

Norway, 1966 Japan, and the United States at 1985 and constitutes a second phase of increase in 1964 West Cameroon. An extra plot for the United States in 1985, though, demonstrates how actual historical growth in H form through the second half of the 20th century exceeded the projected G path because immigration was significant.

As late as 1991, nonetheless, a G track appeared to be suitable for projecting U.S. demographic increase through 2025 (Harris 2001, 17, 28). Subsequent 1997 projections of the Census Bureau, however, can be seen instead to follow an H path from 2000 through 2050 (ibid. 27). For Norway, actual growth from 1948 through 1990 took G form only a little flatter than the projection from 1967 while similar G patterns in growth across the second half of the 20th century appeared in most countries of Europe as well as Australia, New Zealand, and Canada (ibid. 82, 66). In Japan, yet another developed country, projection from 1966 takes G shape based at 1927 while actual expansion from1965 though 1990 followed a G path with zero year at 1939 (Fig 9.1a; ibid. 251).

In contrast to the 1985 United States, an ***H trend*** is actually projected for 1981 China, with little net immigration, for the first third of the 21st century (Fig 9.1b). This H has a zero year at 1900, rather sooner than the 1923 for the path followed historically by the Chinese population between 1950 and 1990. Projection produces a short E phase of acceleration before 2001; but this runs fairly close to what would be the path of the H in these years. Together, China and the U.S. demonstrate how H trends in demographic expansion can appear both thanks to net immigration beyond the path of natural increase (the U.S.A.) and from natural increase alone (China).

This is a difference that, centuries ago, between 1514 and 1680 distinguished H growth in the labor-attracting maritime provinces of North and South Holland in the Netherlands from more internally generated H-form increase in contemporary Sweden (1570-1720) and Germany (1520-1618) or England from 1561 through 1656, where net *emigration* persisted (Harris 2001, 200, 148; 2003, 258). The differences likewise appear among countries with H-type increase across later centuries up to the present as this pattern of demographic expansion likewise significantly kept appearing, nationally and regionally, along with economic development in Europe (Harris 2001, 148-49, 159, 190, 198-99, 206-07, 213, 216, 220-22), the United States (17, 42), Latin America (114, 128-29), Asia (250-51, 258-59, 266, 271, 274-75), and even Africa (280-81) .

With projected, long-lasting log-linear rates of increase close to .03 (.0282 and .0289), meanwhile, 1965 Algeria and 1966 Mexico approximate the ***F form*** of demographic change first found in the United States between about 1675 and 1850 (Harris 2001, 17). Actual population gain in that .03 F slope has been identified between 1940 and 1990 in Mexico (ibid., 144-45), and between 1970 and 1990 in Algeria 1970-1990 (ibid., 280). Projections from the mid-1960s thus capture tendencies of growth that were taking place or about to appear in these two populations. Once one understands the movements in vital rates and age structure that generated these particular F growths, how well does one grasp the dynamics of such extreme .03 log-linear expansions in various historical populations that enjoyed, at least temporarily, relatively unlimited growth?[5]

Accelerating ***E-type increase*** is projected at first for the populations of 1965 Algeria, 1966 Madagascar, 1964 West Cameroon, 1981 China, and 1967 East Germany (Fig. 9.1b). In the last of these, it is a tendency that evolved only gradually, but did so over 60 years (Fig. 9.1a). The E-shape projected expansion of 1967 Norway, in contrast, follows 25 years of initial increase via G. Historical growth in Algeria, meanwhile, took E form from 1948 through 1963. In Madagascar, E was the path from 1950 to 1970. In Cameroon as a whole, the E shape of expansion occurred briefly between 1970 and 1990--and also from 1960 to 1970 (Harris 2001, 280-81). In China, actual increase from 1950 through 1990 involved no E phase; but such movement preceded later 20th century F trends in the Philippines and Taiwan and H trends in India, Pakistan, and Bangladesh. There and elsewhere, the dynamics that produced E growth served to launch long and relatively strong phases of increase.[6]

In the classic developmental phase of Britain, E-type population expansion from the 1720s into the early 1800s fostered the spread of labor-intensive industrialization before giving way to H-type demographic increase in the 19th century, in which technological development to a greater extent replaced cheap labor as the foundation of further economic growth (Ch. 10). This sequence, economic as well as demographic, subsequently appeared across much of continental Europe--and in the contemporarily industrializing regions of New England (ibid.). International shifts in manufacturing in our present time again entail exploiting the cheapest labor, made available by accelerating, E-shape population increase (?cite ?). Economies that in turn progress beyond this crude system with the help of their own continuous technological advance, meanwhile, display the familiar succession to H-type population growth (Ch. 10). Were the workings of age structure and vital rates quite similar among these historical instances of E then H expansion, or did they vary substantially?

Among developed societies, as in 1966 Japan, 1985 U.S.A., and 1981 Italy, ***C-shape decline*** begins to be projected by the early 2000s. Shrinkage in this accelerating form has previously been a very rare phenomenon historically--just 29 of 2,260 national and regional trends of population size identified in Vol. I (Harris 2001, 400).[7] Larger populations with such decline have included several Canadian provinces (4 before and 3 after World War I, p.66), 4 of 12 French departments examined (mostly across the years leading up to the Great Depression, 199;), 3 Caribbean sugar colonies facing failure during various periods between 1774 and 1917 (120, 123), Spanish baptisms in 5 of 8 regions before 1650, an era over which natural increase in England shrank comparably (186, along with Fig. 1,3 in the present volume), 5 provinces of China (mostly during parts of the 19th century, p.258), and 7 regions of Japan in the years after World War II (241).[8]

Some think this C-shape contraction is the tendency of the present and the future, not growth anymore.[9] In Japan, where net immigration has been insignificant, independent forecasting from 1980 produces C decline up to 2040 quite parallel with a trend of that shape based on 1965 shown in Figure 9.1a (Keyfitz and Flieger 1990, 374). In Italy, gradual C-shape contraction projected through the early 2000s may or may not be overridden by net immigration during those years. In the United States, however, assumption of a closed society since 1985 is clearly dubious, though recent attacks upon immigration may prove to have significant future consequences. In the late 1800s, the critique of census director Francis Walker--which set off a series of restrictions on immigration--recognized the power of recent immigration to keep population growing through greater reproduction than what occurred among the native born.[10]

The only one of six trends of change in population size (G, H, F, E, C, and D) not encountered in 10 projections (Figs. 9.1a, 9.1b, 9.4c, 9.4d; Tab. 9.2) is ***D decline***, in which initially rapid decrease slows sharply over time. The reason for this seems to be that movements in age structure and vital rates that might create such demographic decline require a fairly sudden unfavorable exogenous shock to initiate them. In modern societies, the floods, famines, epidemics, wars, and other adverse shocks that have produced D-shape decline in populations are less common. Their effects happen not to appear in the 10 populations studied.

Ten projections make only a small sample, of course. Yet these few cases already demonstrate how forms of change in populations size that capture over 3,000 historical trends (Harris 2001, 382) can result simply from the way that the interactions of fixed rates of fertility and mortality work their way through age structures over time. How are the few, recurrent patterns of momentum in populations generated? How do particular G-related movements in births, deaths, and age structure shape growth or decline into these distinctive ***G, H, F, E,*** and ***C*** paths?

INITIAL AGE DISTRIBUTIONS OF THE SELECTED POPULATIONS AND THEIR IMPACT UPON PROJECTIONS

First of all, there is an impact of the *age distribution* of the population being projected. Chapter 8, has demonstrated both continuities and variations in historical age structures since the 16th century (Tab. 8.17; Fig. 8.10). Most generally, older age cohorts taper off in C' shape. Where this path begins and what is the base year for the C' curve may shift through time and vary among populations, but the pattern is always there. Less universal is a tendency for this senescent C' decline to be preceded by the C shape contraction for earlier ages that is so common in survivorship. Nevertheless, the two successive curves together--integral followed by derivative--frequently resemble the two-stage pattern for l_x, which is identified for many diverse age structures in Chapter 8 (Figs. 8.11a and 8.11b vs. Tab. 8.17). The most significant discrepancies--found especially but by no means exclusively in modern populations--arise from a tendency for fluctuations to appear around the C decline that precedes the C' tapering of senescence or as this pre-senescent tapering takes C' rather than C shape (Figs. 8.12a, 8.12b; Tabs. 8.18 through 8.22).

The fitted trends in Figs. 9.2a, 9.2b, and 9.2c for the 10 representative historical cases that have been chosen for intensive study occasionally differ somewhat from the visual estimates made for these populations in Table 8.17. Mostly, the fluctuations are captured with a greater degree of accuracy. Also, some terminal C'-shape contractions of cohorts with age are displayed more precisely. In all, however, the selected cases suffice to illustrate the most frequent ways in which closed female populations with age-specific vital rates held constant might change size during projection simply because of the shape of their initial age structures. These patterns are presented for female populations with four disparate paths for projected trends in size (parts A through D of Table 9.1).

The apparently universal C' shape of senescent cohorts again stands out (in the rightmost column of Table 9.1). Before senescence, though, initial age structures for the ten examples shrink by 5-year cohorts in some distinctive ways. These patterns present some significant implications for how projected populations will start to expand or contract through time.

In ***1966 Mexico*** (Fig. 9.2a), cohorts before senescence shrink by age in log-linear decline ($e^{-.0364}$) from 0-4 through 50-54. At 1966, the population was in fact in the middle of a half-century of exponential growth for about 1940 through 1990 (Harris 2001, 114-15). By 1966, after 26 years or so of the fixed 30 per 1,000 net of birth- minus death-rates that produces F-type expansion, in other words, most but not yet quite all of the age distribution for females had assumed the log-linear tapering that is expected by stable population theory.[11]

The implication of log-linear age structure and log-linear growth is that birth and death rates retain a constant relationship. Looking forward in projection from 1966, the female population of Mexico departs ever so slightly from log-linear increase for the first 15 years (Tab. 9.2; Fig. 9.4d) as, even with age-specific mortality and fertility rates held constant, the crude birth rate (CBR)--Tab. 9.2 shows--rises for 25 years in C' fashion somewhat in advance of the crude death rate (CDR). The proportion of females who are of principal child-bearing age (CBA = 15-44) increases to a maximum at about projection year 12 in C' form, and though the ratio of children 0-4 to the number of these women (the child/woman ratio or CWR) dips in D' shape in response, the number of females 0-4 rises for 20 years via E', giving the projected population size ("Mom.") its initial 15-year E path. Thereafter, from year 25 through the end of projection, CBR and CDR each remain virtually stable--declining $e^{-.0001}$ and rising $e^{.0004}$, respectively, making the female population expand log-linearly (Tab. 9.2, part A).

In ***Algeria and Madagascar as of the 1960s***, two other populations assuming log-linear paths of growth after brief E-type expansion (ibid,), the *underlying tendency* likewise was for initial female age distributions as far as the 60s to shrink log-linearly--in Algeria at about the same rate of decline as for Mexico, in Madagascar somewhat less aggressively. *Across* this general tendency, however, after a brief D' start through age 10, successive C' movements represent pre-senescent or basic decline as well as the senescent drop-off into the 80s (Fig. 9.2a).[12] Unlike for Mexico, in these two other populations the mid-1960s--from where projection is made--represent not the midpoint of some 40 years of F growth but a period of transition from

E- to log-linear expansion (Harris 2001, 280-282). That implies changing rather than fixed vital rates at this point.

Most significantly, the D’ path for the age distribution of the youngest Algerians in 1965 says that just before this year of projection births had surged. Age structure and projection relate to each other in reverse with respect to time. In this case, the D’ in early age distribution reflects an explosive E’ surge in recent births. This surge generates the E-shape gain in projected population to year 20 or so, then in diminishing strength imprints its generational echo upon demographic forecasts for the next decades. Reproduction-related rates become fixed by about the 60th year, the crude death rate not before year 100 (Fig. 9.3a).

To a lesser extent, such imprinting of age structure at the beginning of projection is also evident in the vital rates of 1966 Madagascar.[13] An E’ rise in the number of recent births is again implied by the initial age structure (D’ in Fig. 9.2a), but the early birth rate surges in decelerating C’ fashion rather than accelerating E’. While the age structure suggests *past* fluctuations much like those of 1965 Algeria (Fig. 9.2a), this difference in pattern for the first few years generates much less fluctuation in the future (Tab. 9.2, part A). In addition, when it assumes log-linearity, the projected female population increases at the rate of 12.8 per 1,000, not more like the 30 of the F curve (Fig. 9.1b).

In ***1967 East Germany***, short-term swings across a long-term tendency for almost no decline with age before the 70s characterize the age distribution (Fig. 9.2a, bottom). Significant contractions among those born 1913-17 and 1941-45 reflect periods of low births in World Wars. The flatness of the initial age distribution for females helps launch the long E’ phase of projected growth for East Germany in its almost level path from the start. The actual total population of East Germany between 1946 and 1990 shrank slightly along a D’ path based in the 1880s (Harris 2001, 149)--quite flatly, but steadily, and almost in line with the virtually level path projected for females from 1967. The short-term demographic movements identified in part A of Table 9.2 did not shake that underlying tendency.

In short, precisely or broadly log-linear age distributions with significant tapering off during the pre-senescent years are found in populations that after some E' increase quickly settle into substantial exponential growth when projected (Mexico, Algeria, Madagascar). In contrast, the age structure of the female population of East Germany at 1967 at once forecasts faint E-shape increase that runs close to a level log-linear path. In each case, the taper of the initial age structure presages the log-linear pattern of growth that will be followed.

For ***1981 China***, the kind of brief initial projected expansion in E form found in Algeria and Madagascar in the mid-1960s again appears. It is followed, however, by some 35 years of H-type growth before becoming log-linear (Fig, 9.1b). The age distribution from 12 through 72 slopes off not unlike those for Mexico, Algeria, and Madagascar--and again along two C' paths except that, importantly, the second one lasts to age 72 rather than to 47 or 52 (Fig. 9.2b vs. 9.2a). Then, the third and terminal C' in China resembles the comparable trend for 1967 East Germany--reaching steeply back to a t_0 earlier than the one for the preceding C' curve, not coming after it as in Algeria and Madagascar (Tab. 9.1, sections B and A).

The actual Chinese population from 1950 through 1990 expanded in H form (Harris 2001, 243, 251). As in Mexico, the net of births over deaths had been doing the same thing for some time as of 1981. In the case of Mexico, the difference between vital rates remained the same. In China, that difference kept *changing* the same way, along the H path.

The distinctive feature of the Chinese age structure at 1981 occurs among the most recent birth cohorts (the youngest ages in the distribution). Rather than rising in recent years, from age 15 to age 0 numbers contract in a C' path (the reverse of G'), reflecting the restrictive demographic policies enacted since the 1960s. By the time these children on average reach mean reproductive age, around projection year 20 or 25 (a generational 30 minus 7.5 years for ages 0-15), the crude birth rate largely levels out (with fluctuations) and the rate of growth is mostly determined by the approximate H-shape increase of the death rate, which produces natural increase in that decelerating form--and H growth. The smooth D-form decline in the proportion of females who are of child-bearing age, like the rise of the death rate, underscores the significance of an aging population for these changes.

The age distribution for the females of ***West Cameroon in 1964*** is characterized by rather different patterning (Fig. 9.2b). Individuals 2 through 22 diminish via D'--a longer and stronger manifestation of the tendency observed in Algeria and Madagascar (Fig. 9.2a) for recent births to have surged in E' form. But then the cohorts from 22 through 67 shrink in C (not C') fashion, followed by the usual senescent decline via C'. This final pattern of declension in West Cameroon stands out for being exceptionally steep--anchored around age 5 rather than in the 20s and 30s of other closing C' movements (Tab. 9.1). Decadal data for the population of Cameroon as a whole from 1970 through 1990 in fact took the kind of accelerating E path projected for West Cameroon females from 1964 because of this recent E' in female births, who would soon in turn reproduce (Harris 2001, 281). The subsequent projected G growth from year 20 to year 50 arises because the birth rate rises via G' during this period while the death rate runs almost flat for a while in its E-shape increase.

The female population of ***1967 Norway*** projects to expand moderately, first via G then in E shape, before turning log-linear as of year 65 (Fig. 9.1a). With a base year at -28, or 1939, this G path is somewhat steeper than that taken by the whole population from 1948 through 1990, whose zero year was 1917 (Harris 2001, 149, 152). Overall, the original age structure tapers in C form through year 62 then drops away into the 80s via C' (Fig. 9.2b).

Interfering with this familiar age pattern for *homo sapiens,* however, a "wedge" is cut out of the C trend between age 22 and age 47. This minimizes at age 32, meaning among women born in the vicinity of 1935, while the cut as a whole occurs among those born between 1920 and 1945--from the end of World War I through the end of World War II, minimizing in the depths of the Great Depression (Fig.9.2b; Tab. 9.1, part C). The C decline in the age distribution through year 22 implies G increase in females born 1945 to 1965. This supports the G path found in projected demographic growth through 1997 or year 30 and to 1990 or later in the history of the Norwegian population (Fig. 9.1a; Harris 2001, 149). Women born during the recovery years of the ‘wedge’ in the 1967 age structure (cohorts 22 through 32, more precisely the age range 20 to 34) increased in E’ fashion (D’ reversed in time), raising the CBR this way as their deaths contribute to the accelerating G’ decline of the CDR. Together these generate the projected E-type demographic increase that follows (Fig. 9.3c).

Projection of ***1966 Japan***, as for contemporary Norway, begins with female population growth in G form (Fig. 9.1a). This predicted G has its base year at 1927 (-39) compared with 1939 for the G increase for both sexes that in fact appeared historically between 1965 and 1990 (Harris 2001, 251, 249). G-shape growth since the 1920s is supported by a 1966 age structure that increased in G’ form (C’ backwards) from age 47 through age 2, a pattern interrupted by a spike among females of about 17 years, or born in the vicinity of 1949 and a correcting low a decade later (to the left in Fig. 9.2c). The initial age distribution for Japanese women in 1966 mostly tapers in successive C’ paths that are less steep than those of Algeria, Madagascar, and China, but display deeper erosion with age than patterns found for East Germany and Norway in the same decade (or in Italy and the U.S.A. during the 1980s).

The outstanding feature of projected demographic change for 1966 Japan is the way that the population ages from 1966 forward. The proportion of females 65 and over, for example, increases in H fashion from 7.1 percent at year 0 through 25.8 percent at year 55, then via G’ from 35 through 75, before leveling out (graphed but not fitted and shown). The crude death rate rises in largely parallel form (though most precisely via G’ through year 20 then a C’ path that resembles an H trajectory through year 70, where it levels out with a D’ dip through year 95 (Fig. 9.3d). With CDR rising this way and CBR decreasing in swings around an underlying D path largely generated by decline in the proportion of females of child-bearing age, shrinking natural increase turns negative about the 25th year of projection and takes an accelerating downward path to about year 75, where birth and death rates thereafter parallel each other, making subsequent contraction in the number of females log-linear.

The female age distribution of ***Italy in 1981*** (Fig. 9.2c), is generally more level--and approximately level for longer--than that of 1966 Japan or the populations of less developed societies (Figs. 9.2a, 9.2b, 9.2c). In this general respect, it more resembles the populations of 1967 Norway and 1967 East Germany (or the 1985 United States). In developed societies people live longer, pushing the broadly level phase of the age distribution further on through the life cycle. As in many other populations, the number of Italian women born from 1943 through 1963 (ages 37 through 17 in 1980) surged significantly--here in E' form (D' reversed) before tapering off.

Thus in the case of 1981 Italy, overall through age 67 rather than the C' and C' trends of Japan, G'and D' patterns delineate the age distribution. The triangles at years 32 and 62 identify outlier values omitted from the curve-fitting. Those born 1947-1951 rise above trend, thanks to the postwar 'baby boom.' The markedly low exception for those born 1917-1921 is due to World War I and the devastating 'Spanish 'flu' that followed). The senescent C' drop from age 72 through age 87, however, comes just one cohort later than in Japan (Fig. 9.2c; Tab. 9.1).

The female population of Italy is projected to expand for 20 years via G then to decline for half a century in C fashion before taking up log-linear decrease at a rate of $e^{-.009}$--close to that for Japan. Indeed, the whole projection of population *size* closely resembles the one for Japan in spite of marked differences in initial age distribution (Tab. 9.2, Fig. 9.2c). Furthermore, the projected G trend for 20 years to 2001, with base year at -70 or 1911, matches almost exactly the *historically observed* G path for Italy (both sexes) from 1950 through 1990 (or later), with its zero year at 1910 (Harris 2001, 148, 151).

Along with Japan at 1966, Italy in 1981 holds an aging population. Like the proportion of all females who are 65 or older between projected years 20 and 60, the crude death rate from year 30 through year 70 rises in E form. With zero year at 96, this upward-accelerating increase in mortality--with the birth rate virtually fixed by this point in projection--imprints nearly perfectly reciprocal C-type contraction with target year of about 104 on the number of females--a simpler dynamic than in Japan (Tab. 9.2, part D). From projection year 20, furthermore, the E rise in death rate and the roughly D decline of the birth rate carry negative increase further and further into negative territory and population numbers therefore into faster and faster decline via C (Tab. 9.2).

The United States of America at 1985, another developed society, holds a female population whose age distribution likewise contracts relatively modestly overall, in this case between years 2 and 62. The decline was steeper than that in 1967 East Germany and Norway or 1980 Italy, but less than the contraction in 1966 Japan. Between the 0-4 cohort and those of the 60s, the succession of E’ then C’ movements into the 40s resembles the patterns of 1966 Japan, though in the U.S.A. the E’ is longer and more gradual while the C’ decline cuts more steeply. The brief G’ that follows, in contrast, is reminiscent of the longer and 15 years earlier G’ for Italian females (Fig. 9.2c; Tab. 9.1).

The first tendency is for the projected U.S. female population of 1985 to grow in G form with base year at 1939 (1985 minus 46)--historically along with G expansion in Norway (1939) but later than in Japan (1927) and Italy (1910). This G trend conforms almost exactly in base timing (1938) with G growth identified for the United States between 1950 and 1990 (Harris 2001, 27-28).

Through projection year 35, the U.S. birth rate exceeds the death rate. But this margin dwindles as through year 15 the CBR shrinks in C’ shape based at year -7 while from year 5 through year 35 the CDR increases via C’ with zero year at 32. This combination differs somewhat from the movements of CDR and CBR in producing initial G expansion for females in Norway, Japan, and Italy. Yet in all four cases a more substantial and lasting rise in CDR continues past where a lesser increase in CBR fades away. In the U.S.A., like Japan and Italy, the change is strong enough to turn natural increase negative and make the population decline (via C) rather than continue to grow.

By year 40, CBR for the U.S.A. falls below CDR. The population declines in C fashion as the death rate rises through year 67 in C’ form while the birth rate becomes fixed by year 45 after falling via C since year 15. Though perceptible short-term movements in the child-woman ratio and the proportion of females of child-bearing age are shown in Table 9.2, they depart from long-term underlying tendencies by very little. That is, the CWR is basically fixed from the base at 1985 through projection year 100, while the CBA generally declines in D form from about year 10 forward and CBR takes this kind of path for several decades from year 0 (or 1985). Japanese females at 1966 likewise project movements of this D shape in CBR, CBA, and CWR. Projections for Italian women as of 1981 display much the same trends as for the Japanese and the Americans, but with somewhat less movement.

Thus all three sample populations which enter into C-shape population decline have birth rates that largely level out via D by about year 40 and death rates that rise. This particular divergence makes their populations age in line with their increasing death rates. C-shape contraction of the population in each case results from aging, which in turn is the product of an increasing advantage of death rates over birth rates even when age-specific schedules of mortality and fertility are held fixed, as in these explorations.

HOW THE SIX CHARACTERISTIC TRENDS IN POPULATION SIZE ARE GENERATED

Only ten cases have been examined. Nonetheless, their iterated projections from particular initial age structures, holding age-specific schedules of mortality and fertility fixed, begin to demonstrate how the six basic G-related patterns sufficient to represent over 3,000 historical trends of growth and decline in Volume I can be generated, in the present and future as well as in the past (Harris 2001, 382).

D, a pattern of decline, does not occur in these projections for selected populations of the 1960s and the 1980s. It requires an externally originating downward shock, whose effect in population loss diminishes over time. In modern, largely developed, national populations this phenomenon is rare, though sub-Saharan African societies recently ravaged by AIDS and warfare might provide examples. Though an example is absent in our sample, one can expect the dynamics of D to follow in inverted form those of G, its vertical mirror image.

G is by far the most frequent form of change in population size found historically (Harris 2001, 382). In all 5 appearances of G among 10 sample populations (at the beginning of projection in 1967 Norway, 1966 Japan, 1981 Italy, and the 1985 United States; and following two decades of E growth in 1964 West Cameroon), it consistently occurs when the interplay of birth rates and death rates generates a dip in the rate of natural increase that follows the path of log_{10} of G upside down. (Unless indicated to the contrary, logs to the base 10, the common log) are the vertical scale for figures in this study.)

In the figures G is presented in logarithmic form (to the base 10). In the calculus, the first derivative of *ln G* (or "*ln G prime*") equals *1/ln G*, *ln G* being the natural log of G (log_e, to the base *e*, or about 2.71828). Logs on other bases (log_a), such as 10, will curve differently in semi-logarithmic scale, but sagging $1/log_a G'$ will remain imbedded in the first derivative of *G'* when it is presented in the scale of log_a:

$D_x(ln\ u) = 1/u\ D_x u$, therefore **<u>if</u>** the semi-logarithmic scale were based upon *ln* (or log_e),

$D_x(ln\ G') = 1/\ G'\ D_x G'$.

<u>But</u> since the scale of the graphs is instead to log_{10},

$D_x(a^u) = a^u\ ln\ a\ D_x u$, and in the case of log_{10} ($a = 10$),

$D_x(log_{10}G') = log_{10}G' \bullet ln\ 10\ D_x G'$, and because the derivative of *ln 10* is *1/10*,

$D_x(log_{10}G') = log_{10}G' \bullet 1/10\ D_x G'$, and the first derivative of G' in the scale of $\log_{10}$ has the same upside-down relationship to $\log_{10}G'$ as found in the scale of ln or $\log_{2.71828}$ ($\log_e$).

This upside-down relationship in calculating the first derivative of $\log_{10}G$ for graphing may at first seem counterintuitive and confusing. As the path of $\log_{10}G'$ in natural increase drops through time, however, the *rate* of population growth slows fast at first, but then slower and slower so that by year zero the dip passes through a bottom and begins to rise. Thereafter, G' converges upward toward a slope of $e^{.03}$.

In Volume II *log$_{10}$G*--actually the vertical reciprocal of *log$_{10}$G* or G presented in $\log_{10}$ scale--was called G' to emphasize the difference in *bend* between the various growth curves and their derivatives, especially G. This labeling was incorrect calculus. But, avoiding the upside-down relationship of the true derivative, it compared in the simplest way the different *curvatures* involved and their significance for migration and urbanization, the objective at that point in the evolving discussion, which focused on additions to the receiving population more than losses to various homelands or regions. In previous chapters of the present volume, too--and also in prior sections of this chapter--so far what is, for example, really $\log_{10}$C for senescent survivorship or age structures has likewise been called C'. Beginning with Table 9.2 and Figures 9.3a through 9.3d, however, G' for a pattern on a graph is given as D' i.e. 1/G', the true first derivative of $\log_{10}$G--and so forth for the derivatives of D, E, and C.

As some stimulus multiplies births and/or reduces deaths, and the results of this shock with time work their way through the demographic system, the G' sag in the *rate* of natural increase can be caused in more than one way: by a decline in CBR, by a rise in CDR, or by some combination of both. A significant subset of the last possibility entails a lag between the timing of a bulge in the CBR and that for a crest in CDR, which makes net natural increase (CBR - CDR) first fall then rise in true G' form.

Of the 4 initial bulges (omitting West Cameroon) in the projected crude birth rate, whether they take D' or more gradual E' form, 3 crests come at about 1980, 1979, and 1978 (omitting 1980 Italy's opening E' high, which arrives only at 1991). Given a modern generation of about 30 years, these surges mostly echo the great international baby boom that followed World War II, a well-recognized positive shock in births. Then, after about two more decades, a second echo of this shock in CBR tops out in the vicinity of 1996, 2008, and 2004, along with Italy's opening surge at 1991 (av. = 1999.8 for all four). The amount of variation around the underlying tendency in these swings of CBR (their amplitude) tends, like their frequency, to diminish as projection advances--established characteristics of fertility fluctuations (Coale 1972, xx).CHECK

In *Norway* during G growth from year 5 through year 30 of projection, CBA for women runs flat along with CWR and CBR. It is the rise of the crude death rate in D' pattern to a high at year 24 while the birth rate tapers off slightly from year 13 via D', which gives the rate of natural increase the vertical opposite of D', sagging via G' and shaping the growth of the population into a G path (Fig. 9.3c; Tab. 9.2, part C).

The female population of *West Cameroon* at 1964 forecasts G growth only later in projection, from year 20 to year 50 (Tab. 9.2, part B). The E trend shown for CDR, with its zero year as late as 98, rises only slightly during this segment of projection.[14] Meanwhile, CBR falls off in a G' path for years 15 through 40. As in Norway, at the beginning of projection there, a resulting G'-shape sag in natural increase (G' CBR minus flat CDR) makes the population grow ever more slowly in G form for three decades. On the other hand, forward from the peak of its opening bulge, it could be said that from year 15 through year 50 an underlying D path captures the decrease in CBR for the females of West Cameroon. This longer-term course of decline in the birth rate (shown in brackets) mostly results from a D-shape drop in the proportion of females who are of child-bearing age because the child/woman ratio runs level from year 15 through year 100 of projection (Tab. 9.2, part B; estimated).

During the G-shape expansion of *Japan's* 1966 females to year 25, CBR rises via E' to maximize at about year 10 of projection while CDR surges via D' to a high rather later--at year 20. The *lag in timing* between the two crests makes the rate of natural increase decline via G', first across the first 10 years of projection (zero year about -20) then fall via E' for the next decade (t_0 in the vicinity of -40), before turning negative by year 25 as the population begins to shrink. Over the longer term, after its early rise, CBR in Japan (as in West Cameroon) decreases in roughly D shape along with the proportion of females who are of child-bearing age while the level child/woman ratio from year 10 through year 100 (short dashes) indicates constant fertility.

During the G-shape expansion of 1980 *Italian* females to year 20, CDR rises via D' as in Japan (to year 24) and CBR falls in E' fashion after a peak at about year 11. Natural increase through year 10 declines in G' form, then even further to turn negative by year 20. Again, meanwhile, the transition from the E' bulge in CBR to the G' sag that follows makes the birth rate, like that of Japanese females, broadly take D shape over the longer haul. This happens, once more, because the proportion of females of child-bearing age contracts this way while the child/woman ratio remains basically constant.

As growth through year 15 takes G shape for *United States* females at 1985, once more CBR falls via E' while CDR rises in a D' path (through year 30), resulting in a G' sag in natural increase and G growth. Still again--as in Italy and Japan--the transition from the E' start at year 0 to the decline that follows gives the long-term projection of CBR general D shape. That tendency again reflects an aging of the population which sees the proportion of females who are of child-bearing age contract in such a D manner while the child/woman remains closely constant.

In all 5 instances of G-type expansion, most of the long-term path for the crude birth rate (in Norway level rather than via D) is determined by the proportion of women who are of child-bearing age. Another long-term feature of these 5 projections that produce G growth is the way that the *number* of young children 0 through 4 very quickly becomes essentially log-linear (Figs. 9.3c, 9.3d; tab. 9.2, parts B, C, D--frequently in brackets). This happens often considerably before log-linear growth in the total population appears. The fate of the young foreshadows the experience of the whole as demographic systems churn along through time. Movement in the child/woman ratio, meanwhile, indicates that it is the current fertility level of these women that gives the CBR its shorter-term swings around any long-term tendency.

G growth can be generated in at least three ways: In the Norwegian case, D' increase in the death rate while the birth rate runs level imprints G' shape on the rate of natural increase, the pattern necessary for G growth. In the example from West Cameroon, a D' drop in the birth rate combined with a relatively flat E trajectory for the death rate shapes natural increase into G' form. In Japan, Italy, and the U.S.A., birth rate bulges that have peaked and are falling combine with death rates rising to a later crest to mostly generate the G' pattern in natural increase (two E' drops occur instead in Japan).

In 5 G-shape segments of growth projected in the sample of 10 populations, the average high point for CBR, along whatever path it is achieved, comes 9.8 years into the projection including the U.S.A. as an outlier at year 0 (12.25 years without it). The comparable average crest for CDR arrives about year 23.2.[15] Adding China, where a second phase of growth takes H form rather than G, the average for the *first* crest in CBR is again about 9.8 years into projection. The initial high in CDR comes in the vicinity of 23.2 years. The mean lag becomes 13.4 years.[16]

In contrast, for the 4 projections of part A of Table 9.2, where *E-shape* increase rather than G growth opens the projected numbers for females, followed soon by log-linear expansion CDR lags CBR by just 1.6 years. The early maxima are virtually simultaneous, averaging 17.6 for CBR and 19.2 for CDR.

H-type growth among the 10 sample populations is projected only in China--from years 20 through 55, following brief E-shape expansion (Fig. 9.1b; Tab. 9.2, part B). As in the 5 G-form increases just examined, the proportion of females of child-bearing age again imprints its long-term D-type decline upon the birth rate while fluctuations of the child/woman ratio about a level baseline generate movements around this underlying tendency of the CBR. These waves decrease in amplitude with time and tend to come about 30 years, or a generation, apart. From year 25 through year 70, meanwhile, CDR rises in H shape as the proportion of females who are 65 or older swells comparably. This H tendency in the death rate results from how in the vicinity of year 40 increase in G' shape leads into E' expansion.

Together, the D-shape decrease in the birth rate and the H-form rise in the death rate makes the rate of natural increase decline from year 20 through year 55 fluctuating around the underlying path *1/ln H*, or *H'*, which is the expected first derivative of H.

It will take more examples to understand reliably the role of the birth rate in generating the H path of expansion and to determine just how H growth occurs. For example, projections with G growth from Japan and the U.S.A. share this combination of H expansion in CDR and D decline in CBR without producing natural increase in the form of *1/lnH* and H growth.

As of the mid-1960s, near-***F*** ($e^{.0300}$) expansion is forecast for the females of Mexico ($e^{.0282}$) and Algeria ($e^{.0289}$) (Fig. 9.1b). Projections for Algeria's demographic trends display more movement around this long-term tendency (Tab. 9.2, part A). By the 1966 base year of projection the age distribution for Mexican females was virtually log-linear into their 60s. The total population of Mexico had already been expanding at the $e^{.03}$ rate for a quarter of a century--since about 1940 (Harris 2001, 114-15). In Algeria, in contrast, it was not before about 1970--a few years *after* the beginning of projection at 1965--that demographic growth shifted from E-type increase to an F path (ibid. 280).

The essence of the shared almost-F trend in these two populations is that before, or shortly after, the year of projection, the birth rate *constantly* exceeds the death rate by about 30 per 1,000 and the age structure is log-linear or approaching it (in Mexico, already long expanding in F growth; in Algeria, just entering it). Any small demographic fluctuations evident tend to wash each other out, keeping the rate of natural increase approximately fixed.[17] The ever-faster E-type increase in population shifts to log-linear when something like $e^{.03}$ or 30 per 1,000 is reached. At this rate, the size of a population doubles every 23.1 years.

Comparably, females in 1966 Madagascar quickly project 75 years of log-linear expansion. But the rate of this increase is only $e^{.0128}$. The projection for just females is for some reason much flatter than the F growth for both sexes that is reported for Madagascar at 1970 (ibid.), and is clearly forecast for 1966 Mexico and 1965 Algeria.

For 4 brief opening segments of ***E* growth** among 7 instances in which this form of expansion is projected, a recent, accelerating surge in the age structure is imprinted upon the size and age distribution of the female population at time of projection. In Algeria, Madagascar, and

West Cameroon, G' declines at the beginning of the initial age distribution (still labeled D' in Figs. 9.2a and 9.2b) from youngest forward through the early years, become recent "E'" (C') gains in number with time (Figs. 9.2a, 9.2b; Fig. 9.1b). The age distribution of 1966 Mexico, meanwhile, is log-linear, while the very brief E movement in the first years of projection for the female population is virtually so (Figs. 9.2a, 9.4c). In 1981 China, however, the peak in the age distribution comes at 12 and numbers *contract* through year 2. "D'" (G') patterns that appear in the initial age structures of Norway and East Germany occur among age groups too old to shape projections of female numbers.

For 1967 Norway, 30 years of E-shape growth are expected to follow three decades of initial G-type expansion. Here E grows out of another trend, which has often occurred historically since England in the later 1700s (Harris 2001, passim). In 1967 East Germany no less than 60 years of E-form expansion is projected at the start. In Norway, during its E-form increase the CDR shrinks along a D' slope while the CBR remains level, pushing up natural increase faster and faster (Fig. 9.3c; Tab. 9.2, part C). In the case of East Germany, at the start a D' surge in the CDR is stronger than the E' rise in CBR to age 20. After an abrupt jump in the first 5 years (as in Norway) the CDR comparably takes D' form.

In 5 short E-shape growths expected at the beginning of projection, CDR maximizes on average at 22.4 years, ranging from 20 to 26 (Tab. 9.2, parts A and B). This timing resembles that of early CDR for 5 G-growth populations (23.2)--and adding China with second-phase H-type growth (av. = 23.1). In the 3 African countries this local high is reached along a D' path. In Mexico it tops out via E'; for Chinese females, the trend takes C' shape instead. In all 5 cases, too, the CBR again crests some in advance of the CDR--on average about 9.8 years, ranging from 10 to 15 years. Ranging from 10 to 17.5, the 5 projections of birth rates maximize on average at 15.1 years. This makes them precede the highs for CDR by only 7.5 years, compared with 13.4 for the 6 populations with G and H growths. With Norway, where E growth is only secondary, the averages for six projections are 14.7 years for CBR, 22.8 for CDR, and 8.1 for the difference between the vital rates.

Natural increase rises briefly in accelerating shape in the 5 short, early cases mostly because the initial age structure imprints the E pattern on demographic increase. In the longer E growth of East Germany, deaths decline slightly *before* births, making populations “explode”--though only a little--in the accelerating E fashion of ‘demographic transition. For the females of Norway, E-type expansion emerges out of preceding G growth because fading CDR through year 50 becomes accompanied by a D’ surge in CBR during the 30s and 40s of projection.

C*-shape *decline appears in the three projections within 20 to 40 years. Running through some relatively weak waves around the underlying tendency (especially in 1980 Italy), the crude birth rate shrinks from about year 10 through year 70 in D form--with base year in the vicinity of year -17 on average. CBR decreases this way because, as seen elsewhere, the proportion of females of child-bearing age shrinks in such a manner while the number of children under 5 per fertile woman generally remains constant (Fig. 9.3d; Tab. 9.2, part D). Meanwhile, in each case the crude death rate multiplies by about 1.5 to 1.8:[18] Japan, via E’ for projection years 20-70; Italy, via E for 30-70; and the U.S.A., via E’ for 35-75 (ibid.). As the birth rate flattens out in its D-shape decline and the death rate rises, natural increase turns more negative in D’ paths as far as year 70 or so where both CDR and CBR both run roughly level and further contraction becomes log-linear.

Waves in the vital rates are slight, and there are only three cases for evidence. Nonetheless, as C decline appears high points in CDR consistently lag crests in CBR by 30 years, averaging 66.7 and 36.7 respectively, whereas prior to C decline averages of 26.7 and 6.7 left an average lag of some 20 years, which is closer to the gap for G growth--in turn longer than that for E expansion.

In all, there is considerable insight into how the recurring G-related trends of demographic growth or decline come about:

G increase, with its characteristic steady $e^{-.03}$ deceleration in rate of growth, is by far the most common pattern historically for change in population size. It is generated in several ways: The death rate can rise in D' form while the birth rate remains level. The birth rate can sag in G' fashion while the death rate remains steady. Some combination in these derivative-shape changes in CBR and CDR can create the required G' dip in the rate of natural increase.

Where a lag between the early crests in CBR and CDR produces G' movement in the rate of natural increase and G-shape growth, furthermore, particular rhythms seem to be followed: The initial crest in CBR on average comes about year 9.8 of projection while the first peak for CDR arrives in the vicinity of year 23.2, or some 13.4 years later. The sample numbers are only half a dozen, and the fits are just approximate. Still, a useful mathematical patterning is suggested as to how birth rates and death rates typically interact to generate the G form of demographic increase.

For ***H***, the 10 cases provide only the one example from 1981 China. There, during that form of growth from year 20 through year 55, the proportion of women who are of child-bearing age falls in D form, taking the crude birth rate along with it--as in G expansion, the other form of decelerating increase. Over the long haul, from year 20 through year 80, however, the crude death rate projects G' then E' phases of increase. Successively, from year 25 to year 70 these two movements together closely approximate an H path, while CBR is now for all practical purposes level. The result, in this one example, is to generate natural increase in *1/lnH* form and, since *1/lnH = H'*, H growth.

F-type demographic expansion occurs when prior population increase reaches approximately $e^{.03}$ in rate. In the 2 cases found among 10 projections, Mexico and Algeria, it is brief E-shape expansion that increases the growth rate to that level, where the gap between birth rate and death rate becomes fixed. The approach to F-type log-linearity has, however, also followed other paths.[19] It does not matter what form of G-related pattern moves the rate of increase to $e^{.03}$. When it reaches this point, it does not rise further, but takes the log-linear F route. As suspected in Volume I (Harris 2001, xxxxxx), there is some kind of upper limit on human increase at work here at about 30 per 1,000 (doubling every 23.1 years) that is not exceed by much or for long.

In the short initial cases of ***E*** growth projected, for the most part a recent accelerating bulge in births (surge in the age structure) shapes growth in its image. In the 2 longest and clearest instances of E-type expansion, East Germany for years 0 through 60 and Norway between years 35 and 65, numbers accelerate upward because, while the birth rate runs basically level, the death rate *decreases* in C' pattern. This discrepancy expands natural increase, and growth, in the ever-faster fashion of E.

Including Norway, where E-type expansion follows an initial period of G growth, for 6 cases the first crest for CBR tops out on average about year 14.8, the initial high for CDR at 22.7--leaving a lag of 7.9 years, or appreciably shorter than that found during G growth (13.4). While the timing for CDR closely resembles that for G growth, the high for CBR arrives 5.0 years later. In the 7th case, East Germany, the peak for birth rate instead *follows* that for death rate, the order that historically has generated E expansion in demographic transition.

C-shape decline in the size of populations occurs when, after a preceding phase of slowing growth, deaths begin to exceed births. Cutting through some fluctuation, CBR once more shrinks for several decades in a D tendency because, though the child/woman ratio mostly remains steady, the proportion of women of child-bearing age similarly contracts via D. The death rate, meanwhile, rises in approximate E fashion.[20] In these three aging populations, in short, contraction occurs ever faster in C form because the death rate rises in accelerating E manner while the D trend of the birth rate becomes almost level by the time that C-shape decline in size appears. Evidence of waves is slight, but during C decline the lag between crests in death rate lengthens to follow those for the birth rate by as much as 30 years.

In other words, for both C and the more lengthy and substantial E patterns of change in population size--the two *accelerating* forms, one down one up--it is movement in CDR that shapes the distinctive path of natural increase while CBR remains relatively constant. For C decline, the death rate rises approximately via E; for E growth, CDR contracts along a C' trajectory.

The ***D*** form of contraction does not appear when our 10 recent historical cases are projected because it starts with a demographic crash, which is unusual in modern populations like these--but is found quite often historically. One can imagine, however, the dynamics of a *negative* shock transmitted across the generations much in the way of the positive surge underlying G.

For G and H, the *decelerating* forms of increase, the behaviour of CDR is likewise crucial. In G growth, CDR rises while CBR falls in successive waves of decreasing strength, making the rate of natural increase contract. For H increase, CBR runs level while CDR climbs in H fashion.

These are *some* ways in which the G-related forms of change that have recurred so often historically come about. There is no indication that they are the *only* ways, but useful evidence has been acquired into just how movements in fertility and mortality interact to generate these common forms of demographic change, into just why these patterns appear over and over again. It remains to be seen if other combinations of movements in birth and deaths can create the G, H, F, C, E--and also D--trajectories of expansion and contraction.

DEMOGRAPHIC SYSTEMS WHEN FERTILITY OR MORTALITY CHANGE

In reality, rates of fertility and mortality *change*. These shifts, not simple momentum, is what demographic analysts typically confront. What demographic patterns result under these altering conditions?

Mathematical experiments can demonstrate the impact of historically noted G-related forms of change in fertility and mortality upon demographic systems. They also show the consequences of brief shocks, instantaneous lasting shifts, and other likely shapes that modifications not involving the G curvature might reasonably take. The first step in such investigation is to select representative populations upon which to impose such changes, examples whose manipulation will demonstrate reliably and insightfully how familiar patterns are generated by particular modes of experimentation.

Choosing Typical Historical Populations to Manipulate

The historical peoples examined in this study for the most part fall into four general categories: 1) pre-modern, pre-'transition' populations with high birth and death rates and very little growth; 2) populations entering transition, with death rates that have begun to lessen but whose birth rates have declined relatively little so far, and therefore are expanding at a significant rate; 3) populations at or near the peak of modern 'transition'--with death rates already well down, but birth rates little reduced as yet--which are therefore growing very rapidly (in the vicinity of the $e^{.03}$ trajectory of F); and 4) populations that have already gone through 'transition,' whose birth and death rates are now both low, and which exhibit very little increase--or even presage decline in the near future. Moving chronologically backwards across this sequence of demographic development saves the more complicated selections of representative cases for last.

To begin, the particulars of ***Italy at 1980*** serve to represent several recent, later-20th-century populations of type 4 that have been observed. With a CBR for females at 10.68 and a CDR of 8.98 there is a current crude rate of natural increase of just 1.70 per 1,000, while projection with fixed schedules of fertility and mortality indicates (absent net migration) some actual contraction by the early 2000s. The age structure tapers via C from 7 through 57, with target year around 90, then in C' fashion from 57 through 82 with t_0 estimated in the vicinity of 40--not unlike the long-term patterns that underlie age distributions in the 1980s for France, Norway, and the U.S.S.R. in Table 9.1 (cutting through 'baby boom' bulges, which appear more markedly in those other populations). Indeed, the reason for choosing Italy at 1980 among several comparable possibilities is that the age structure displays less fluctuation than is often the case elsewhere--though for ages 57 through 87 some such concentration exists among those born between 1893 and 1923, years of massive emigration from domestic population pressure (Harris 2003, 28). Survivorship as of 1980 tapers from 1 through 60 in C form, targeting about 118, then from 50 through 75 via C' with base year around 52--again much as for females in the U.S.S.R., Cyprus, Chile, Japan, China, New Zealand, and the U.S.A. from 1979 through 1985 (Tab. 8.5).

Mexico in 1966 then serves to represent populations in category 3, observed at the peak of 'demographic transition.' With a birth rate of 42.5 but a death rate already all the way down to 9.0, the number of females projects to expand to 2066 at about 32.8 per thousand ($e^{.0328}$, or somewhat above the pace of F). Historically, from 1953 into the 1980s natural increase peaked in the vicinity of 1964 in C' fashion (Tab. 9.2), the pattern that Chapter 3 has shown for growth when decline of fertility in C shape lags behind decrease of mortality in comparable form. The mid-1960s was when the crude birth rate and gross reproduction finally began to atrophy and slow growth down. As of 1966, from 2 through 27 the age distribution for females declined log-linearly, at a pace of about .037. Tapering via C through age 47 followed, with zero year around 34, then further contraction in C' fashion based about 27 (Tab. 8.17). Meanwhile l_x fell from 10 through 55 with t_0 around 96 followed by C' type tapering from 45 though 75 based about age 43, much like patterns for several rapidly growing Latin American, Caribbean, African, and Asian populations in the 1960s (Tab. 8.5).

Particulars for the females of ***Madagascar in 1966*** resemble properties of group 2 populations, in which prototypical 'demographic transition' had begun with some substantial decline in crude death rates but birth rates as yet remained very high. These characteristics make it possible to simulate change in populations as ‘transition’ began to appear in the 18th and 19th centuries.

Part A of Table 9.3 compares particulars for Madagascar females at 1966 with those for the peoples of England and Sweden (both sexes) in the 18th and 19th centuries. Survivorship can be patterned for England at 1861 and for Sweden in the 1750s, though not at 1820. Tapering for l_x in Breslau in 1693, however, provides another, and somewhat closer, two-stage comparison with Madagascar’s females in 1966. In all, though crude birth rates in early modern Sweden and also in England by 1861 had come down rather more, the particulars for Madagascar females in 1966 were not unlike those for the five much earlier European populations in part A of Table 9.3. The closest comparison was with England at 1816.

Females in ***1966 Madagascar***, if their ***age-specific death rates*** are ***magnified by 1.4***, can also serve as the basis for experimenting with the impact of demographic change upon category 1 or ***pre-‘transition’*** populations, those in which fertility and mortality were both very high (somewhat over 43 per 1,000) and growth was minimal.[21] As one might expect by the early modern era, some familiar populations of the 16th, 17th, and 18th centuries[22] had lower vital rates of both types and somewhat more growth (0.2 to 4.0 per 1,000). Among these cases, the closest comparisons of Modified Madagascar (ASDR x 1.4) were in vital rates with France at 1750, in age structure with 1750 France and 1561 England, and in survivorship with Breslau at 1693.

Overall, the closest match with the Madagascar population once its age-specific mortality rates are raised to make increase insignificant appears in the French population at 1750 (assuming that something like the 1693 pattern of survivorship for Breslau applied). At this point, the French people had been multiplying slowly in ever-flatter G fashion for half a century and were about to commence four decades of new, but only slightly steeper G-type growth (Harris 2001, 148, 152). In the other early European populations of part B of Table 9.3, CBR and CDR were also closely equivalent, but at a somewhat lesser level--mostly in the low 30s.

While the modified particulars for Madagascar's 1966 females do not exactly match those for any of the six early European examples, the model does provide a population--with high fertility and high mortality, very little growth, and at least comparable age structure and survivorship--upon which to simulate the effects of certain demographic changes in pre-'transition' populations.

These four cases, in short, serve to illustrate how populations with distinct but historically common characteristics have consistently digested various forms of change with results that over and over again take G-related shapes. Whether arriving as an abrupt shift or as a gradual transformation, a variety of changes in vital rates produce results that take G-based shapes. In each case, this is demonstrated through 20 iterations of replacement in 5-year steps over 100 years. Consequences for population size serve as the principal illustration. Some effects on age structure and vital rates are also demonstrated.

Consequences of Increasing Mortality in Some Historically Familiar or Likely Ways

Figures 9.2a through 9.2e illustrate what happens to population numbers when mortality is increased in forms that have been observed in this historical survey or is elevated in certain arbitrary ways. Table 9.4 summarizes these consequences.

By the 100th year of projection, or 80 years from the time where age-specific mortality is first increased, in 16 of 20 manipulations the size of populations assumes constant exponential gain or loss (e^x or e^{-x}) as the analysis of Euler demonstrated some three and a half centuries ago. Before that point, however, several G-related patterns of change appear. Some of these significantly reflect the type of population being considered. Others seem to be produced instead by the kind of increase in mortality that is applied.

An H form of demographic expansion, for example, occurs among these experiments only when fertility remains high while mortality has been reduced to the low level of contemporary societies--at the peak of demographic transition, in fast-growing populations like that of Mexico at 1966. In Italy at 1980, on the other hand, momentum to *decline* is strong enough to make its C-shape pattern appear when all five means for increasing mortality are employed. In both populations mortality is so low that doubling it makes little impact upon the momentum of the original population.

In contrast, G or closely similar G’ increase (in the pre-transition case) appears after abrupt decline whenever a shock in a single quinquennium is imposed (whether doubling the mortality schedule or, in the case of Italy, multiplying it by 10 for clarity). This is the path back to normalcy. Similarly, in most types of populations D-shape decline results when doubling mortality in G’ form starts only at t_0. In the exception, Mexican females as of 1966, the sag takes E shape instead. If this E curve is examined as a *proportion* of the $e^{.0289}$ slope of the basic momentum of this population, however, the ratio declines in D shape from a zero year at -21. In other words, in Mexico at 1966, too, D very generally captures the impact of mortality increase in this form upon the projection of population size. Finally, while the particular local trends vary (C’ in pre-transition conditions, G’ in 1966 Madagascar, H in fast-growing 1966 Mexico, but C in post-transition Italy at 1980), the first results of mortality increase in G form and full G’ fashion in each case take the same shape. Other results of these manipulations seem more idiosyncratic.

Do these buds of generalization bloom when fertility is changed or mortality lowered rather than raised? Do comparable insights for different patterns appear?

Some of the forms employed for increasing mortality experimentally are familiar from the historical record. A mortality shock in just one 5-year period for the four prototypical populations, summarized in Table 9.4, represents a frequently encountered phenomenon among historical populations, particularly pre-modern ones. Famines, floods, epidemics, and wars have tended to strike populations in this concentrated manner (in various temporary multiples of currently typical death rates), often time and time again--with some shocks much greater than others (for example, Livi-Bacci 1992, 107-08; 2000, 82; Dupâquier 1997, 448). Thus, one way that the G form of population increase appears over and over again in so many historical populations in Volume I is due to the sudden mortality crises that have been so frequent, particularly before the modern era. These disasters can return, as Malthus pointed out, wherever and whenever demographic expansion exceeds what human ingenuity can milk from current natural resources.

Examples abound in Volume I of such sudden brief demographic contraction due to a mortality shock followed by G-type rebound in numbers. For instance, local and regional disasters in the Thirty Years War, the Seven Years War, and other conflicts dot the 17th and 18th centuries. In more modern times, under the bombing of the mid-1940s Tokyo and Osaka sharply lost population but then regained it in G fashion. Also scattered across several centuries and many parts of the globe are cases where population was shocked suddenly more by famine or disease than through war (which further both). Examples include famine in parts of England during the 1320s (Harris 2001, 360-61), a local disaster for some reason in Tuscany about 1480 (354), and crises in the Kamimichi district of Japan (357), the Calabrian commune of Borgia (370), and the atolls of Sikiana and Nukuria in the South Pacific (375) during the 1700s and 1800s.

Longer lasting losses of population are even more frequent in Volume I. These take D shape, which is so usually the result of experimental mortality increase following G' after its t_0. Many such cases reflect the initial impact of the Black Death in 14th-century Europe across communities, regions, and nations. Others come from the 15th-century decay of Ming China and several of its provinces (243, 266). Various decimations of native peoples in the Americas when confronted with biological and military-economic intrusion during the 1500s and 1600s crashed in this pattern, as did populations of Pacific islanders and native Canadians in the 1800s and early 1900s when confronted with invaders (ch. 4; p. 66). Lingering (as opposed to readily reversible) demographic effects of European warfare in the 17th and 18th centuries were also shaped this D way, as were regional and local demographic losses for a variety of reasons in southern Italy, China, and Japan during the 18th and 19th centuries (370-71, 375). When the transition to sugar shook the West Indies during the 1600s, the number of whites--whose small-scale agriculture with servants could not compete with heavily capitalized slave-manned plantations--shrank via D (71). So did populations overwhelmed by economic change in the 20th-century United States, whether Great Plains states likewise once full of small farmers (53) or core populations of many once leading industrial cities (297, 299).

In considering the workings of mortality increase in this form of G’ after t_0, think of a disease that is brand new to a population or a deterioration in resources that arrives suddenly but whose negative effects then gradually peter out (like the local devastation spread by the armies of the Thirty Years War). One clear example of such a change in mortality over several decades--embellished with brief shocks of less and less magnitude as mortality reapproached its former level after a devastating initial blow--is available from plague deaths at the Dominican monastery in Sienna between the 1340s and the 1450s (Pinto and Sonnino 1997, 491). In modern times, in spite of growing evidence about its deep historic roots, the spread of the recent scourge HIV-AIDS seems to resemble the truncated G’ way in which the invading Black Death first struck population after population in Europe some 650 years before (Tab. 8.13).

The full G’ pattern in mortality, rising before falling, has on the other hand repeatedly appeared in surges of endemic disease. In the early modern era, for example, the loss rate from smallpox--no longer a new threat in Europe--repeatedly built to a crest this way in Geneva in the vicinity of 1616, 1698, and 1768, and around 1702 and 1768 in London (Tab. 8.13). In modern times, across the later 1800s and the first half of the 1900s, deaths from neoplasms, cardiovascular issues, and degenerative disorders became more frequent in G’ fashion in 8 countries spanning the globe (Tab. 8.12). Overall population deficiency in London, created by excesses of deaths over births, swelled then shrank in G' manner between the early 1600s and the early 1700s, topping out in the vicinity of 1660. About a century earlier, contracting deficits from 1562 through 1612 suggest a previous crest in the vicinity of 1560 (Harris 2003, 187). That was about the time of "Jack Fisher's 'flu" (cite ch. 1) and the hump in the crude death rates for all of England from 1541 through 1581 (Fig. 1.1).[23] For England as a whole, furthermore, an up-and-down G' pattern in mortality (rather than just an abrupt increase to a maximum followed by G' tapering) appears for children from 1 to 4 and for all under 15 three times between the later 1600s and the early 1800s. Such a series of G' surges is also evident in loss rates for English adults from 25 through 50--though with a slightly different timing, which keeps the overall crude death rate from displaying such patterns (Figures 1.9a, 1.9d, and 1.10 vs. Figure 1.1). Local G' bulges in deaths of infants and/or children have similarly been found in several communities and regions of Germany in the 18th and 19th centuries (Tab. 5.9, Fig. 5.11).

In the Atlantic slave trade, death rates also frequently swelled in G' fashion, whether from the dissemination of disease that accompanied extensions of intercontinental contact or because of crowding and poor provisioning during periods of particularly inept or greedy slaving practices. G' bulges of mortality crested in Dutch and British (and perhaps French) shipments in the middle 1600s, then again in the vicinity of 1730. Later death surges in G' form appear in French, Portugese, and Cuban operations--peaking in the vicinity of 1790, 1825, 1835, and 1860 (Harris 2003, 396). Death rates for slaves while 'seasoning' after arrival in America, meanwhile, crested around 1700 (ibid., 394). In short, G' rises and declines in mortality are another frequently identified historical phenomenon. But these have distinctive results for different types of populations.

In all, when mortality is raised in several ways that are familiar historically, G-based patterns repeatedly appear in the trends of four diverse types of populations. Some trends are shared, others depend upon the nature of the populations selected. Interested readers can experiment with the impact of still other types of mortality increase.[24]

Some Results from Reducing Mortality

The transition to modern demographic regimes, in contrast, began with *improving* death rates. Previous chapters have displayed repeated declines of mortality in C shape--from some European nations, regions, and communities beginning in the second half of the 18th century to recently developing countries of several continents in the second half of the 20th. Still earlier contraction of mortality in this form occurred among English infants and young children in the years around 1600 and perhaps also among most English adults under 60 during the century after 1650 (Figures 1.9a and 10; Tables 1.4 and 1.5). Back in the later middle ages, during recovery from the Black Death, estimates suggest that improvement for the crude death rate of England took long-term C shape between 1374 and 1475 (R. D. Lee 1973; fitted in Harris 1997, Figure 12.2).

Figure 9.3a demonstrates what happens to the number of females when schedules of age-specific mortality are reduced in C form following the 15th year of extrapolation while the fertility schedule remains unchanged. The C path is set so as to reduce numbers by half between there and the 55th year of projection. From that point, the rates are held at half the base level on through the 100th year. That patterning approximates how C trends have often followed each other historically within populations, the first years of each new movement being very flat (for example, Figures 2.1a and 2.1b).

Where the projection begins with a relatively high death rate--as in the pre-transition model and, to a lesser extent, 1966 Madagascar--numbers clearly swell in accelerating E form for a few decades before growth settles into a new, elevated exponential path. In 1966 Mexico, whose population was already expanding thanks to robust birth rates and well-reduced death rates, the change in eventual exponential rate is slight, from .0321 to .0344, and E-shape transitional movement between the 20th and 40th years of projection is barely perceptible. In the contracting conditions of 1980 Italy, on the other hand, the effect of the C-shape modification of age-specific death rates is just to extend the C pattern of demographic decline another two decades or so before log-linear attrition appears.

Population increase in E form as during modern demographic transition (with birth rates still high but death rates already declining) is first observed in England and Ireland (and perhaps the Belgian provinces of Antwerp and Brabant, Dutch Friesland, and the Rhineland principality of Mark) about the 1720s. Denmark, Scotland, the Netherlands, and Iceland (also Württemberg and possibly East Flanders) display the pattern within the next few decades, as does France briefly between 1792 and 1827, with it lasting longer in certain departments (Harris 2001, 148-49, 198-99, 208, 337; Tab. C.9; "Figure 6.2" for Belgium). Subsequently, in the middle of the 19th century, E-type accelerating expansion appears in Germany, Austria, Spain, Portugal, and Romania--and rather later (between 1880 and 1910) in Switzerland, Bohemia and Moravia, and Hungary (Harris 2001, 148-49). Certain regions of Russia also experienced this E pattern of population growth in the 19th century (ibid., 220-22), though the underlying movements of birth and death rates are not known.

In Latin America (Harris 2001, 114), in a few islands of the Caribbean (122-23), in Asia (250-51, 258-59; noticeably soonest in Japan, some regions of China, and Hong Kong), and in Africa (280-81; first in Algeria) E-form population increase can be linked to reduction in death rates before birth rates also contracted, the familiar 20th-century phenomenon of 'population explosion' with the onset of 'demographic transition.' Earliest of all, E-shape growth may have occurred in certain provinces of Ming China between 1491 and 1578 (Harris 2001, 266), though the role of relative changes in birth and death rates during this era is unknown. E-form expansions of the populations of some parts of Mexico from the later 17th century into the 18th, however, are indeed likely to reflect improvement in mortality accompanying relatively steady fertility as adjustment to the biological and economic consequences of Spanish invasion worked itself out (105, 109)--a recovery also observed for several island populations of the Pacific in the

1900s (133). In all, E-type expansion resulting from C-form decline in death rates without matching decrease in birth rates, as projected by the experimental manipulations of Figure 9.3a, has been a very common historical phenomenon,.

In all, the most significant changes from reducing mortality appear for populations in which the death rate is still high--in contrast to Italy at 1980 (where both vital rates had already declined) or Mexico in 1966 (where the CDR had fallen to modern levels even though the CBR had not). Generally the more sensitive populations of the four being manipulated is the pre-transition model (with fully pre-modern death rates) and Madagascar at 1966 (which represents an intermediate case, with already partially reduced CDR). Figure 9.3b depicts some of the more prominent results from them. Table 9.5 displays the results of certain ways of reducing mortality in addition to the C method, compared with base projections from initial vital rates.

If mortality rates in the pre-transition model at all ages are cut in half for just one five-year segment of the century-long projection, at year 20--the “shock” experiment-- the size of the population jumps somewhat at that point but thereafter increases via two flat successive E movements that closely resemble overall the $e^{.003}$ path anticipated from the characteristics of the initial population (Tab. 9.5, Fig. 9.3a). Nothing changes much. (This form of brief relief on a significant scale also appears to be a rare historical event.) If, on the other hand, such a reduction of age-specific mortality rates is kept in force from year 20 forward (a more likely phenomenon), then demographic increase takes G shape through year 40 before climbing via $e^{.0217}$, the pace for actual 1966 Madagascar, whose mortality schedule was doubled to create the pre-transition model in the first place. On the whole, mortality reduction in either of these forms seems less likely than more gradual improvement in death rates.

While not so common as decrease in C shape, temporary but protracted historical reductions of CDR in D’ pattern have occurred fairly often in two kinds of historical settings. Preceding modern demographic transition in various countries, and also during recent decades as death rates have bottomed out, the D’ form has not infrequently appeared. In England between

1681 and 1731, then again between 1731 and 1761, CDR dipped in D' fashion (Figure 1.1). Comparable movements occurred in Sweden between 1693 and 1743, Finland, Norway, and Denmark slightly later, local and regional German populations between 1755 and 1795, and Bohemia and Moravia at the end of the 18th century (Figures 2.1a through 2.1d). In recent years, D' movement has also characterized the ending of mortality declines in countries like Mexico, Venezuela, El Salvador, Chile, Fiji, Taiwan, Malaysia, China, Japan, and Sri Lanka, but also France and Yugoslavia, as the impact of further health improvements has slowed and populations have aged along with declining fertility.

The third and fourth plots in Figure 9.3b represent results when, after the 15th year, age-specific mortality is reduced in D' fashion by just under a third, .312, bottoming around the 40th year of projection and returning to the original level at year 75. This experiment captures the typical depth and duration of D' movements observed in several populations of northern and central early Europe during the early modern era.[25] In the D' projection for the pre-transition model (which was designed to mimic conditions like those in France under the *ancient régime*) population size first multiplies in accelerating E manner through year 40, then increases to year 85 or so in G fashion before reacquiring the $e^{.003}$ log-linear slope that is inherent in the base population that is used for projection. The females of Madagascar as of 1966, on the other hand, have a CDR that more closely represents levels found in pre-1825 England and Sweden--and France around 1800--where D' patterns in the crude death rate are at times well documented. For these Madagascar females, whose properties collectively resemble those of a population that has begun to enter transition, some continuation of inherent upwardly accelerating E-type growth from year 15 on to year 35 is followed by expansion in H (rather than G) form to year 80 before the $e^{.022}$ path of the base population is rejoined.

In historical reality, H-type growth has, as Figure 9.3b predicts, occurred with mortality reduction of D' form which appeared in certain early modern populations that were on the threshold of demographic transition. Most neatly, in England between 1681 and 1731, a D' dip in CDR that bottomed out at 1704 contributed to H-shape population increase between 1681 and 1726. Earlier, beginning around 1561, the people of England began to multiply in H fashion as their crude death rate sagged in D' form for about four or five decades starting in the 1540s. The GIP procedure of the Cambridge group shows this later conjunction more clearly than the method of the *Population History* (Figures 1.1 and 1.2; Harris 2001, 150). In Norway, too, what seems to be a shallow D' dip in CDR between 1743 and 1773 (Figure 2.1a) helped set off H-type population increase that unfolded between 1748 and 1818.

Elsewhere, D' sagging of CDR in Sweden from 1693 through 1743 can be documented overlapping only the very end of a long era of H-type population growth from 1570 through 1720. For earlier years, however, the crude death rate there is simply unknown. D' dips in CDR for some locales in Germany and for the Czech lands of Bohemia and Moravia, meanwhile--between the 1750s and the 1790s and the 1780s and the 1810s, respectively--significantly precede documentable H trends of demographic expansion--but because information on growth only begins in the 19th century, not due to any contrary evidence that expansion had followed a path other than H.

On the other hand, D' sags of CDR in England from 1726 through 1761 and in Denmark from 1737 or earlier through 1762, definitely appeared as population growth in E, not H, shape unfolded (1726 to 1806 and 1735 to 1801).[26] H growth that occurred in England from 1816 to 1861 and from 1861 to 1939, and in Denmark from 1801 through 1845, from 1850 to 1890, and between 1890 and 1845, furthermore, was not accompanied by D' dipping of the CDR (Harris 2001, 148; Figures 2.1a , 2.1c, 2.1d). D'-shape sagging in the CDR, in other words, has been neither necessary nor sufficient to produce H-type population increase. It has, however, been one way that the H pattern of expansion can appear historically, evident especially among populations in the midst of modern demographic transition.

Still another type of experiment in the consequences of reducing mortality ("Young to Old") cuts death rates for infants and for children under the age of 5 by half. Then, at every subsequent interval the next older group is also affected by the reduction until at year 85 of projection females of all ages benefit from halved age-specific mortality relative to the base population at year 0. With this kind of manipulation, population size for the pre-transition model swells in accelerating E fashion through the 45th year. By this point, females up through age 49 have reduced mortality. That is, the reduction has advanced through the fertile portion of the life cycle. From this point in the experiment forward, the population expands at an exponential rate of $e^{.0226}$, or about the rate for Madagascar females as of 1966, whose mortality was doubled to mimic pre-transition conditions of high fertility plus high mortality.

As resulted from increasing mortality, reducing it in various ways--some historically familiar, some arbitrary--not only shapes population size in G-related forms. It also leaves imprints of this type upon crude birth rates and age structure. In summary:

The least effect appears for the percentage of the female population under 15. For all practical purposes, in the pre-transition, 1966 Madagascar, and 1966 Mexico cases this proportion remains level when mortality is reduced in C shape, when it dips in D' fashion, and when it is pared back progressively starting with the young. A relatively constant proportion in this age bracket has also been found in the base populations for these experiments.[27]

In the case of 1966 Madagascar, with its partially reduced death rates, slight G-shape increase over time in the CBR with the original projection disappears both when mortality rates are lowered in C form and when they are made to sag via D'. Both trends become virtually level. Whereas temporary reduction of mortality in D' fashion retains the flat trend of the CBR, to cut death rates via C from their high starting point in this population pushes down the birth rate in D manner between the 15th and 60th years of projection as older females constitute more and more of the population. A similar effect appears if mortality is reduced first among the young, then diffused up the age scale.

The percentage of females 65 or older, a relatively small part of populations, alters most of all with reduction of age-specific mortality rates. Even in comparatively imperturbable 1980

Italy, while the sagging D' pattern does not change the G trend for the elderly found in the original, aging population, to cut back death rates in C form turns G-type accumulation into accelerating E-shape expansion of the percentage 65 or older. A similar result occurs from projecting 1966 Mexico. In 1966 Madagascar, meanwhile, though a G' surge for the elderly over four decades of projection in the base population is retained when mortality is reduced in C form, when age-specific death rates are made to dip in D' manner, C-shape decrease in the percentage of females 65 and over occurs instead for a substantial period. In the pre-transition model population, on the other hand, original G' movement for the share of the elderly in projection becomes C-shape decline when mortality is sagged in D' form or expanded from the very young on up through older age groups, while, if cut back via C, makes the percentage of females 65 or more rise increasingly in E manner.

In all, whether one raises or lowers mortality schedules shapes trends of population size, age distribution, and even birth rate in familiar G-based forms. Holding age-specific fertility constant, simply iterating alterations in mortality of arbitrary or historically observed shapes through demographic systems over and over again produces G-related forms of change in populations. This is because these systems constantly include the underlying G-based C and C' distributions of age structure and survivorship identified in Chapter 8.

Consequences of Reducing Fertility

Raising or lowering levels of age-specific fertility while holding death rates constant also makes imprints of G-connected form upon population size, age structure, and even crude birth rates. Certain historically familiar or imaginable ways of *reducing* reproduction, first of all, generate such patterns. Using the same four populations for illustrations, Table 9.6 summarizes the impact upon numbers of females that results from different ways in which fertility has declined historically or can be expected sometimes to do so. Figures 9.4a and 9.4b fit certain of these trends, others--denoted by "*"--are estimated by template.

For the historical populations, most of which first appear on the record as pre-transition peoples with almost equally high birth and death rates, the most frequently observed pattern for fertility decline has been of C shape--starting downwards slowly but progressively accelerating until some lower threshold is reached. This is the way that fertility has actually contracted, following or accompanying decline in mortality, as ‘demographic transition’ diffused across human societies. Many examples have been observed during the 19th and 20th centuries: for crude birth rates and, more specifically, for overall, marital, and extramarital fertility (Chapters 2 and 4). Meanwhile, C patterns for several local, regional, or national instances reach back into the 18th century (Chapter 5). In England, C-shape declines in crude birth rate, gross rate of reproduction, overall fertility, and age-specific marital fertility appear as early as between the 1550s and 1660s (Figs. 1.1, 1.2, 1.4, 1.6), long before reemerging there with modern transition after 1850.

Figure 9.4a (upper middle) and Table 9.6 show, first of all (with hollow circles), how for a pre-transition population, which projects slow inherent growth (“base”) because of near balance in births and deaths, to cut births in half, step by step, between the 15th year of projection and the 55th in C fashion,[28] produces contraction in C form for over five decades before log-linear decline begins with the 75th year. In the example of *post*-transition Italy at 1980 (Fig. 9.4a, top), where some shortfall of births relative to deaths already promises a little C-shape contraction from the base population, the effect of C-type reduction in age-specific birth rates for 40 years is to steepen the C-form decrease in numbers of females, reducing the zero year for the curve from 106 to 86 before exponential shrinkage takes over only about year 80.

In *early*-transitional Madagascar (Fig. 9.4a, lower middle), in whose base population at 1966 births exceeded deaths sufficiently to produce projected growth at a pace of $e^{.0216}$, reducing fertility by half via C over 40 years drags increase down from this exponential path into G form before virtually flat log-linear movement appears around the 80th year. For Mexico as of 1966, meanwhile, with the maximum excess of births over deaths that is historically typical of the peak of demographic transition, comparable C-shape decline in fertility slows increase in population from its $e^{.0321}$, or approximate F, pattern into H-form expansion instead as far as the 80th year of projection, where relatively slow exponential growth finally replaces it.

For each of these last two types of shift into decelerating expansion of G or H form there are many examples among the international populations examined in Volume I. Typically, such change has occurred as birth rates began to fall only considerably after death rates during modern transition, in a contraction of fertility that--as noted--demonstrably took C form. If death rates, on the other hand, did not decline before birth rates, the pre-transition model in Figure 9.4a indicates, such populations would have declined. This in effect happened to the English population in the 17th century, as between 1556 and 1661 the CBR shrank via C while the CDR rose somewhat via E rather than falling. This combination pushed the rate of natural increase into C-shape decline until it went negative between 1666 and 1681, when a dip in death rates at last provided relief. Population size during the second half of the 17th century contracted slightly via D rather than in C shape. Though the crude death rate peaked in E fashion, which would foster C-type contraction, fertility as of 1660 began to increase after a long fall and net emigration collapsed, together making decline of the population decelerate rather than accelerate (Figs. 1.1, 1.2, 1.3).

Certain other types of trends in reducing reproduction have been observed less frequently. D-shape movement has occurred for crude birth rates in late 20th-century Austria, Ireland, and Fiji (Figures 2.2f, 2.2c, 2.2j). Previously, decline in this form appeared in the Paris basin for marital fertility from 1790 through 1880 (Figure 5.1a) and for the crude birth rate and gross reproduction in England during the first half of the 19th century (Figures 1.1 and 1.2). Dipping in reversible D’ form, furthermore, emerges for crude birth rates in Denmark and Sri Lanka in the late 1900s, and--more specifically--for marital and overall fertility in England across the second quarter of the 19th century. Reduction of fertility beginning with older women and spreading to young ones, meanwhile, has been identified from the later 17th century to the present. It is conceivable, on the other hand, that younger women might curb fertility first in a change of sexual norms, spreading the practice to older cohorts only as they themselves matured. The results of projecting two other hypothetical types of reduction are also reported in Table 9.6: reducing age-specific fertility by half all at once and leaving it at this lower level, and cutting it this much only once (for a single five-year period) at the 20th year of projection, as might happen in a war or a brief depression.[29]

The main insight from these different ways of lowering fertility is that variations in just how fertility is reduced make little difference in the nature of the path for population size. Over several decades of projection, all methods produce for 1980 Italy C-shape declines in numbers that are to varying degrees somewhat steeper (have earlier target years) than the trend of this shape that is inherent in a projection of the original population. The almost level log-linear basic trajectory of the pre-transition model, meanwhile, is with just one exception likewise transformed into C shape decline.[31] For early-transitional 1966 Madagascar, furthermore, all projections of numbers commence with G trends of considerable length rather than the fairly strong exponential growth expected from the base population. For Mexico at 1966--at the peak of transition--finally, uniformly H-type increases taper off below the original F path.

In four instances, a second trend whose shape differs from the usual one for this type of population appears before log-linear change is reached. For the two populations with relatively equal birth and death rates--the pre-transition model (high, high) and Italy at 1980 (low, low)--just a D path in population from the D’ type of fertility reduction results following 35 years of C-shape projection. For the two populations with birth rates significantly in excess of death rates, the D’ reductions again generate exceptions. These now take E shape following the usual G and H patterns. In a final exception, a permanent downward shift in 1966 Madagascar creates C-type contraction following G increase in population. The significant general finding, though, is how consistently the same path of change emerges for each method of reducing fertility in a given type of population.

It should be remembered, finally, that a change in age-specific fertility rates does not automatically entail a comparable trend in crude birth rates. For example, cutting fertility in half for women 20 through 24 reduces the CBR much more than a comparable reduction for females 40 through 44. As the imposed change comes to bear upon women of different ages the birth rate is differently affected. Table D.1 in Appendix D presents estimated movements in CBR that result from altering age-specific fertility in various ways for the four representative populations.

The general observation is that after three decades or so of reflecting the impact of some particular change, the crude birth rate--excepting only 2 of 24 experiments (in the “shift” for the pre-transition model and in the D’ modification for 1980 Italy)--after a few decades of projection the CDR converges upon a constant long-term level from above via D.

The movement that precedes this D approach can take several different forms--sometimes more than one. Historically insightful similarities and differences appear among the four illustrations. The C pattern of decline in CBR, for example, has been observed as a very common feature of modern ‘demographic transition’ (Chapter 2, for instance); and limitation of offspring that begins with older females has played a characterisitic role in this reduction (Chapters 1, 5, and 6). During the earlier decades of manipulation, halving fertility rates starting with older women then moving step by step across younger child-bearing ages in fact does produce C-shape decline in CBR for all four types of populations. An arbitrary, and rather exaggerated, diffusion of cuts in fertility by age from older to younger females at risk, of itself produces the kind of C-shape contraction in CBR that has been so historically prevalent and significant. Perhaps because the base population already has low birth and death rates and is inherently declining via C, a sudden shift downward in age-specific fertilities for 1980 Italy likewise reduces the CBR over some time in C fashion--as does D’ curtailment in that population.

The same C type of trend in birth rate appears if the modification is reversed from young to old in the cases where fertility in the base population for projection is still high--in the pre-transition model and in 1966 Madagascar. In 1966 Mexico and 1980 Italy, in contrast--where fertility is already down to modern levels--D' or D trends result by the 20th year instead. Cuts passing from young to old might be expected to result from an abandonment of traditional family norms by certain cohorts who then carried their reproductive changes along with them as they aged.

In contrast, to cut back all age-specific fertilities simultaneously via C, except in Italy, temporarily *increases* CBR a little in E manner before after the 55th year it falls in typical D mode as the changes pass through growing populations. These are the sequential patterns of the CBR found in England between the 1720s and 1810s then from there to the 1840s (Fig. 1.1).[32] The E pattern also appears (more briefly) with D and D' reductions where the gap between births and deaths is substantial at the start of projection, as in Madagascar and Mexico, and with the D form of manipulation in the pre-transition model. G-type increase in CBR, meanwhile, occurs only with D' alteration in the pre-transition population, or temporary relief. A simple, lasting downward shift in the level of age-specific fertilities, however, generates G' swelling in the CBR in all populations but post-transition Italy.

Increasing Fertility

{Please note that Harris indicated to provide more detail at the beginning of the section but I could not find the intended section in his notes – MSW 31 July 2015}

Leads to economic and social impact English and possibly a few related examples.

SOME MATHEMATICAL CHARACTERISTICS OF G-RELATED MOVEMENTS

1) Constant, if shifting, G-based (C then C') vector of age distribution in renewal matrix.

2) Sensitivity to shocks at root?

3) Cumulative G close to cumulative normal.

Along with the continual and pervasive, in origin biological, imprint of the C shape that is contained in survivorship upon many aspects of demographic change, certain properties of G-based curves as a class (including simply reoriented C, D, and E) should be noted: especially 1) the tendency over long periods for the bending or change in acceleration to resemble the curvature found in the cumulative normal pattern of transition; and 2) the nature of the roots and powers of G, which turn out to relate insightfully to the best fit of G to the normal distribution and to the roots of the renewal equation in stable population theory. These connections help steer many kinds of demographic movements into G-based paths, and hold them there, as populations digest lasting shifts or cope with temporary shocks.

Though if both curves are given the same zero year of inflection (t_0) and the same height or y range from 0 to 1, the arithmetically presented shapes can at first look quite different, across the heart of its total span G representing a proportion follows a trajectory very similar to that of a **cumulative normal** curve that has certain dimensions. The cumulative normal pattern is the integral of the normal ("bell") curve from minus infinity to year x, the way that G is the integral of rather differently rising then falling G'. True, the cumulative normal follows a path in which the segments of the 'S' pattern are symmetrical whereas for G the second or upper arm is considerably larger than the first or lower part of the 'S'. If, however, one allows the parameters of the cumulative normal to float in order to fit G with the best possible pattern of that type, for about 150 years the arithmetically expressed paths become very similar (Fig. 9.1, left panel; G is represented by hollow circles with an 'X' at t_0; the best cumulative normal follows the dashed line, pivoting at the solid square).

From roughly year -60 through year +100 the G curve is closely captured by a cumulative normal trajectory. The latter curve has a *z* of approximately 37 years; its range from bottom to top of just under 1.00 runs from about -.05 to .95 (rather than from 0 to 1); and the point of inflection lies in the vicinity of .475 some 8.4 years after t_0 for G (rather than at .500 for year 0). The residual error (G - CN) fluctuates around zero between about +.018 and -.016 with a frequency of approximately 90 years (the bottom plot in the figure magnifies it by 10).

In a function that constantly increases, however, *proportional* fitting of change weighs the error around low expected values equally with those at the high end of the trend rather than letting the latter dominate the whole comparison. In the right panel of Figure 9.1, the best G (a dashed line) is fitted logarithmically for -60.3 through 101.7 to a cumulative normal curve (-2.6 *z* to +4.4 *z*) in which *z* = 23.1 years (the hollow circles). There are obvious bulges of proportional error in this fitting: high around -40 and low in the vicinity of +20. However, in spite of these zones of visible difference G with a value of .479 at year -3.34 does tend to converge in waves toward the cumulative normal (.500 at 0) over a considerable span of time (bottom plot).

The cumulative normal curve is given a *z* value of 23.1 in the right panel of Figure 9.1 for a reason. The two curves most resemble each other through the middle years of transition. The early and late tails diverge from each other. The range from -2.0 *z* through +2.0 *z* covers 95 percent of the transition and 72 to 104 years of G for cumulative normal curves with *z* values of 18 through 26. Standardizing the curve segment being analyzed to always embrace this identical dominant proportion of total change without comparing the extreme tails of the two curves (where least change takes place), the best proportional or logarithmic fit in fact appears empirically when z equals about 23.1. Table 9.1 shows, for selected *z*'s from 18 through 26, how the overall norm for the G fit, the standard error for *x* (the year), and the standard error for *y* (the height of the curve, or value of G, at t_0) all attain a minimum when *z* is in the vicinity of 23 years, while x_0 moves closest to the cumulative normal's 0 year and y_0 best resembles the .500 height of the cumulative normal at that point. A slightly smaller norm (.219) for the fit and standard error of timing or y (.317) appear when z = 22.5 rather than 23.1, but at the cost of somewhat more error for the height of the curve (.00931) and poorer values for year and for G (+2.78 and .520). The best z span of 23.1 years is shorter than the 37.4 for the best arithmetic fit of the cumulative normal to G for the particular time range from -60 through +100 (the left panel of Fig. 9.1) because of the different method for assessing error that is employed in its proportional comparison.

As Figure 9.2 indicates, it is especially between about year -41.6 and year +27.7 (-1.8 z and +1.2 z, the curve with the stronger line in the graph) that G most closely follows the cumulative normal (for 3 z spans rather than the 4 enclosed by -46.2 through +46.2). In all, a change that takes G shape tends to converge with the cumulative normal about year -50.8 (briefly overshooting somewhat around -46.2, but adjusting back). During previous years, the ratio of G to the cumulative normal increases in what seems to be G' manner, targeting 1.629 at -24.5 years--or approximately $e^{1/2}$ (1.6487) at -z (-23.1049). Then from about -50.8 through +27.7, for almost 8 decades, the ratio holds very close to 1.0. Finally, after about year +27.7 G pulls away, its ratio to the cumulative normal gradually rising from here onward in G shape (pivoting on .512 at year -11.18, or roughly -z/2, headed toward a maximum of 1.3918 (roughly $e^{1/3}$, or 1.3956) as the latter effectively flattens out. In Figure 9.2 one sees not only where G most tightly follows the path of the cumulative normal but how it initially joins that pattern and with time eventually then pulls away from it.

In all, a budding tendency to change in G form soon converges on a cumulative normal ceiling, is thereafter along its G path closely compatible with normal transition for almost 80 years, but then has to push upwards independently in order to sustain its particular, higher trajectory as the cumulative normal decelerates faster. When z = 23.1, making the best fit between the two curves, first the convergence with the cumulative normal and then the departure from it occur in G-based patterns whose parameters, are roots of e and multiples of z. These close mathematical relationships to a normal pattern of transition would seem to affect how random disturbances to a population, certain to occur in historical phenomena, are channeled to support rather than disrupt change in G-connected fashion for long periods of time. For an extended and centrally significant portion of the total change, when z = 23.1 years any relationship between randomness and the aggregate path that is imbedded in the cumulative normal distribution works to support the trajectory of G . In contrast, systematic exogenous stimuli of G' then G shape are required to start a G-shaped change or, eventually, to sustain it above the normal past a certain point.

Empirical findings that G resembles the cumulative normal for about 46 years before and 46 years after t_0 (or from -2z to +2z), and most closely models that curve when z equals about 23 years connect insightfully with certain **mathematical properties of G** itself. Most simply, $e^{.03}$ (the rate of change in the pace of increase for G) has a doubling time of 23.1049 years (*ln* 2--or .69315--divided by .03). G^2, furthermore, equals e times the value of G with t_0 coming 23.1 years later, while $G^{1/2}$, or the square root of G, equals G x $(1/e)^{1/2}$ with t_0 23.1 years sooner. Figure 9.3 first of all plots these patterns for the square and the square root of G relative to the basic trend. It also displays the timing of the zero years of other powers and their values at t_0 relative to these particulars for G.

The bottom plot in Figure 9.3 shows how other powers and roots of G from $G^{1/6}$ through G^6 tend to trend in E (G^I or G inverse) form via multiples of 23.1 and powers of e. The hollow squares represent year relative to t_0 and height at that point of inflection relative to 1 (graphed as 1/1,000) for five powers and five roots of G as determined by multiplying G the requisite number of times by itself and fitting the G model to the results. The timing (x) and height (y) at the zero points for each of these curves, plus G itself (1.0 at year 0), appear in the first two columns of Table 9.2. The third column displays the E curve that this series approximates (the dashed line in Fig. 9.3), with a y value of 1.0016 at year -.05--or almost exactly the expected 1 at year 0. The 4th and 5th columns contain estimates of the years and values at t_0 for the various roots and powers of G as modeled by the power equation for *y* and the third spacing formula for *x* in part B of Table 9.3. Columns 6 and 7 express the fitted values of columns 1 and 2 as a multiple of the modeled estimates in columns 4 and 5 (i.e., indicate the proportional error of the dimensions of Model 3 at each point).

First, it should be noted that 23.1407 is the result of e^{π} (the natural logarithm, 2.71828, to the power of 3.14159), a rather basic and provocative value. This very closely resembles the 23.1049 years for the doubling time of $e^{.03}$ or the -23.1053 and +23.0955 year shifts of t_0 for the empirically fitted square and square root of G, and suggests that both *e* and π are fundamental in trying to construct formulas for the roots and powers of G.

The values at t_0 for empirically fitted powers (*p*) of G from 1 through 6 all equal almost exactly the value at this base point for G itself (G^1) times the (*p*-1)th power of *e*. For example, for G^3, the height of the curve at t_0 becomes 1 x $e^{(3-1)}$ or 7.3891 (1 x e^2), compared with 7.3908 for the empirically determined value (col. 5 vs. col. 2, Tab. 9.2). For roots (*r*) of G, quite effective approximation of the levels at t_0 is attained through the formula $G_r = (r\text{-}1)^{-.25}/e^{-.5}$, or the 4th root of *r*-1 divided by the square root of the natural logarithm, $e^{-.5}$ or $\sqrt{e}$ (Tab. 9.3, part A). For the cube root of G, G at $t_0 = (3\text{-}1)^{-.25}/1.6487$, or .5100 vs. the empirically fitted .5134. This modeling is very accurate from G through the cube root of G (Tab. 9.2, col. 7), but then errs progressively more through the 6th root (2.5, 4.8, and 7.2 percent). Nonetheless, from $G^{1/6}$ through G^6 the estimation in column 5 of Table 9.2, based upon powers of *e*, closely resembles the fitted values at successive t_0's and the E path that they follow (cols. 2 and 3). The model results are graphed as the X's along the bottom plot of Fig. 9.3.

More than a single method closely reconstructs how the *zero years* for the roots and powers of G are distributed. These estimations are shown in Table 9.3. One approach (Model 1) sums the steps from one power or root of G to the next, spacings that are based upon roots of π. The other (Model 2) multiplicatively compounds each successive timing via powers of the square root of $4/\pi$. This happens to be the ratio (1.27324) of the side of a square to the diameter of a circle that contains the same area. Model 3 modifies this approach slightly to obtain a better fit with the empirical evidence.

In all models, the **height** of G at year zero, y, is:

for powers (p), $y = \mathrm{G} \times e^{p-1}$;

for roots (r), $y = \mathrm{G} \times (r - 1)^{1/4} / \sqrt{e}$ [the 4th root of $r - 1 \div$ the square root of e].

Three methods approximate the **spacing** of zero years, x, for both roots (negative) and powers (positive) relative to t_0 for G:

In **Model 1**, the series $e^{\pi}/\sqrt{((p - 1)\pi)}$ for the spacing of t_0's accumulates additively for the intervals between powers 1 through n,so that for G^6, for example, t_0 is the sum of the lag between G (0) and G^2 (e^{π}) plus the intervals between all other pairs up to G^6.

In **Model 2**, to obtain t_0 for higher powers of G, e^{π} for G^2 is accumulatively *multiplied* by successive powers of the square root of $4/\pi$, beginning with the 4th, in which the square root of the last *power* applied to $\sqrt{(4/\pi)}$ becomes the next power in the series, for example from $(\sqrt{(4/\pi)})^4$ to $(\sqrt{(4/\pi)})^2$ [more simply, from $(4/\pi)^2$ to $4/\pi$] as the next term.

In **Model 3**, the same multiplicative series as for **Model 2** is employed, except that $e^{\pi}/1.03$ replaces e^{π} as the base.

Table 9.4 compares the zero years for roots and powers of G which are obtained from empirically fitting the curves that result from these mathematical operations with the estimates that the three models of timing generate, including ratios of the fitted values to the modeled ones. The average ratio, or timing relative to the empirical fits, for Model 1 is quite small, 0.80 percent too low. The average ratio for Model 2, on the other hand, is a substantial 2.62 percent too high. A reduction of Model 2 by .03 (the $e^{.03}$ or $e^{-.03}$ rate of acceleration or deceleration imbedded in the G, C, D, and E functions) to construct Model 3, however, best approximates in average ratio the empirical findings--only 0.04 percent high. Also, when fitted via E, the t_0 for this model comes nearest to the empirical finding of -.05. (that is, +.34 vs. -.72 for Model 1 and +2.24 for Model 2).

The .03 correction, however, reduces the t_0 for G^2 (and for $G^{1/2}$) to 22.4667, a rather shorter interval relative to G than the 23.1407 of e^{π} or the 23.1049 doubling time for $e^{.03}$. (The latter comes closest to the actual fitted values of 23.1053 and 23.0955.) This variation, though balanced by high values for $G^{1/5}$ and G^5 to average out closest to the fitted results, makes the mean squared error for Model 3 as a predictor of the empirical findings amount to .0171 compared with .0106 for Model 1 (but .0316 for Model 2). The underlying path for Model 3 resembles that for the empirical evidence more closely; but there is more offsetting fluctuation around it. The reduced base at 22.4667, nonetheless, is reminiscent of how the best proportional fit of G with the cumulative normal curve, judging by the norm for the overall fit (Tab. 9.1) is derived when *z* for the latter is somewhere in the vicinity of 22.5, slightly below 23.

The top plot in Figure 9.3, finally, shows how according to Model 1 (hollow circles) and Model 3 (plus signs) given the spacing in time that is indicated in each case the ratios of the zero years for successive roots and powers to the base t_0 for $G^{1/2}$ or G^2 increase in C or G fashion (with zero year at -34.71 or +34.68). There (denoted by the solid squares), these curves for relative timing have a value of about 1.50 times that at $G^{1/2}$ or $G^{2.}$ The timing of this inflection point in years, meanwhile, represents almost exactly 1.5 times the 23.1407 first interval between G and G^2 according to Model 1 or 1.03 × 1.5 times the alternative 22.4667 first gap for Model 3. It is also virtually equivalent to $e^{\pi\sqrt{(4/\pi)}}$ (34.6365). At the zero year, moreover, projections of these C and G curves call for a level of .24104 or almost precisely the natural logarithm of $4/\pi$ (.24156). The $4/\pi$ element is decidedly imbedded in the mathematics of G-based patterns.

In all, zero years for roots and powers of G as multiples of G are spaced according to combinations of *e* and π that work from a base of about 23 years or slightly less. This fundamental first interval, meanwhile, simultaneously represents the *z* score or standard deviation of the cumulative normal curve that best fits G-type change. On the one hand, the very basic and unusual mathematical relationships with normal accumulation and their connection to the roots and powers of G would seem to help change take G-related shape and hold it. On the other, does the approximate 23-year span upon which the spacing of roots is based make shocks or impulses upon G-type trends more consequential at this kind of interval than elsewhere in the course of their unfolding?

The mathematics of the G pattern seem related to several previous findings about stability and disruption in demographic change. In his pathbreaking exploration of stabilization and fluctuation in demographic properties (1972), for example, Coale observed that, internationally, the proportion of females cohabiting maximized between about age 23 in societies with early marriage and high rates of widowhood and 37 years where marriage came late and little widowhood and divorce took place (p. 6). While $e^{\pi} = 23.14$, about the lowest mode found, $e^{\pi} \times 4/\pi = 29.46$, or about the mean female generation or age of fertility for humans, while $4/\pi$ times 29.46 equals 37.51, or an apparent upper limit for the mode of female cohabitation. As observed, 23.1 years is the interval of time separating the inflection or zero points of both the square and the square root of G from that for G. The value $4/\pi$ (more exactly its square root), meanwhile, has been shown to be a fundamental element in the spacing of t_0's for the roots and powers of G (Tab. 9.3).

The ability to bear children normally runs from about 15 through 45 and the international average for mean fertility tends to focus a little under 30, its range extending from slightly less than 26 to a somewhat over 33 (Coale 1972, 5).[33] The practical limits for the range of mean female fertility among human populations, in other words, are approximately $23.1 \times 1.1284 = 26.06$ and $37.51/ 1.1284 = 33.24$, or those for the mode of cohabitation multiplied or divided by the square root of $4/\pi$ (1.1284). The full range of 7.18 years, meanwhile, is almost exactly half of the 14.37 year spread for the maximum proportion of women 'at risk' in cohabitation. It should be noted, generally, that to divide each end of a range by the square root of $4/\pi$ is to cut the full spread in half while $2 \div (4/\pi)^{1/2}$ reduces to $\sqrt{\pi}$ or 1.7725.

In analyzing how populations with arbitrary characteristics approach the stable condition when fertility and mortality remain constant over time, to determine the path of births one can either use conventional population projection or decompose the birth sequence beginning at $t = 0$ into the eventual exponential trajectory of the stable form plus a series of oscillatory terms: r_0 plus complex roots of the form $r = x + iy$, where x is the real part (which must always be less than r_0) and iy is the imaginary part (Coale 61-62, 64-65). Coale noted how for the lowest frequency oscillation, the first complex root, the period is the mean (μ) of the net fertility function or $\phi(a)$, typically about 30 years. The effect of the cosine component upon $\phi(a)$ is negative below $3/4\mu$ and above $5/4\mu$, making the bulk of fertility occur between 22.5 and 37.5 years for women in a universe of populations with mean age of fertility at 30 (Coale, 72; assuming symmetrical distribution, which is usually not the case).[34] The particulars of this critical span compare closely with the 23.1 to 37.5 limits around a mean of approximately 30 found for maximum cohabitation among international populations (Coale, 6). Fertility, like the proportion of the female population ‘at risk’ to bear children, has a mean of about 30 years and concentrates within a range of $\pm 4/\pi$ x around that mean, with a lower bound of some 23 years and a higher bound of about 37.5.

The maximum fertility rate for cohabiting females, furthermore, occurs between ages 20 and 25 (ibid.). This is the case whether no contraception takes place or the practice is widespread, though these extremes produce very different means and skews for the fertility schedule. In spite of such differences in the shape of distribution, generally 75 percent of total fertility in practice occurs within a span of about 16 years (ibid.), or only half the rough biological range of 15 to 45 (not necessarily at the center of this span because of the skew in most fertility schedules). In other words, maximum individual fertility (statistically speaking), occurs at the beginning age for the 23-to-37.5 range for a symmetrical concentration of aggregate fertility in a population between 3/4 and 5/4 times the mean age.

The relationships of age structures also display values observed in these basics of human fertility but also in the nature of G-shaped change. When the age structures of two stable populations are compared, if they share the same mortality but one has higher fertility, from the beginning of life into the 80s the proportions at each successive age for the one with higher fertility start out greater than those for the compared population and decline comparatively in linear fashion, becoming lower (< 1.0) around age 30, the average female generation or the mean age of fertility (Coale 1972, 38).

If the second population has the same fertility but lower mortality than the first one, then the ratio at successive ages declines in linear fashion only between about age 5 and age 55 or 60 (ibid.). This persistently linear reduction in spite of an alteration in the mortality schedule, again passing through a ratio of 1.0 about age 30, reflects how from later childhood to around 55 or 60 survivorship very generally erodes in C form in population after population (Ch. 8). Both life tables will behave in that C manner for this particular segment of the life cycle, and thus will relate to each other linearly. Lower mortality especially entails less loss of babies and young children. That has the counter-intuitive effect of relatively enlarging later portions of the population (Coale 39-40). Reducing early mortality, in the Swedish example provided by Coale, makes the proportion just after birth in fact about 1.12 or approximately $(4/\pi)^{1/2}$ lower than in the base population (roughly 1.11/.99). After about age 60, meanwhile, lower mortality progressively increases the proportions of older individuals in the altered population. By age 85 the ratio reaches about .92/.82 or roughly $(4/\pi)^{1/2}$ as much.

The proportions of particular populations found at successive ages themselves erode in accelerating C fashion from about age 10 or less into the 40s or later (compare Coale 1972, 42, if the graph is re-scaled logarithmically--with the findings of Ch. 8). In Coale's examples, the distributions for two stable populations increasing at the same rate (r = .010), one with lower mortality and another with higher fertility cross each other about age 28. There, the example with higher fertility falls below its competitor. Both distributions, however, drop considerably earlier--around age 23--through the stable age structure for a population that does not grow (r = 0) but has fertility comparable to the one and mortality comparable to the other (ibid.).

Age-specific mortality rates, on the other hand, tend to have much the same “U” shape whether life expectancy is high or low (Coale 1972, 10). The difference between two age-specific mortality schedules, however--“West” model for females with life expectancy of 20 at birth minus the same type of life table with 50-year expectancy in Coale’s example (1972, 154)--rises in decelerating manner from age 12.5 through 47.5 via G’, or through the most active span of life, to about .019 around age 48 (or, perhaps, via G based near age 23 at a level of .012 for the same ages). A second, surge through later life, however, from 32.5 through 72.5 takes accelerating E shape upward from about .020 around 44.

Indeed, the effect of declining mortality (in Coale’s example, equivalent to a 0.01 percent annual rise in fertility) is to lower the proportions of population to be found at young ages relative to the stable population and raise the fractions of older people. The comparison passes through equality about age 30 after a few years of development (15, for example) but more like age 35 once a generation or more has lapsed (1972, 162). Early on, after just 15 years, from age 22.5 though 62.5 the difference rises via G based upon a back-projected ratio of about .44 in the vicinity of -18 years. But by the time 45 years have elapsed, from age 12.5 to 62.5 or a little later the age distribution with declining mortality increases relative to the stable one in accelerating E fashion targeting a ratio of about 2.3 about age 87 according to the formulas of Coale and 2.4 near age 99 by conventional projection methods. In between, after 30 years, a short G trend is followed by a short trend in E form as the eventual effect of the transition begins to show itself.

Evident here, significantly, is a way that not only the ubiquitous G but the E shape can enter population change. Modern ‘demographic transition’ in the 18th, 19th, and 20th centuries, for instance, has typically begun with reduction in mortality, and many populations at this stage (Harris 2001)--and their births (Tabs. 2.3a, 2.3b)--have expanded in E fashion.

??In calculating the first complex root of a net fertility function--$\phi(a)$--for the Swedish population of 1946-50, Coale began by normalizing by 1/1.1372 to make $\int_0^{\beta} \phi(a)da = 1$. That is, in this population the sum of fertility through the highest age of fertility was 1.1372 times the norm.(77-78)??? Peculiar to this population or more general?

Assuming symmetry and zero alteration via the real root (x) of the underlying exponential path, the lowest frequency oscillation (y_1) in the way that fertility converges on a stable trajectory must satisfy both a cosine integral equation equal to 1 and a sine integral equation equal to 0. It has a period of μ_1. At this frequency sin y_1a is negative at ages below μ_1 and positive above it. The sine minimizes at about age 23 and maximizes about age 38. Cos y_1a, meanwhile, attains 1 at μ_1--empirically on average just under 30, as opposed to about 32 years in Cole's illustration--and is negative only below $3\mu_1/4$ and above $5\mu_1/4$, or about 23.1 and 37.5 years if (assuming symmetry) the cosine equation reaches maximum at μ_1 (Coale 1972, 71-72). Once again 23.1 years and multiples of it by $4/\pi$ structure demographic change.

The less the concentration of fertility around the mean age,, however, the greater the decrement of the lowest frequency oscillatory term. That is, the greater the damping (difference of amplitude between r_0 and the real component or x of the first complex root) becomes. Outside the range from $3\mu/4$ through $5\mu/4$ the effect of the cosine element upon net fertility is *negative* (ibid., 73). The more dispersal in an actual net fertility schedule, in other words, the weaker the wave effect of the first complex root becomes.

In 47 mostly European populations studied by Coale, F--the proportion of net fertility or $\phi(a)$ occurring between $3\mu/4$ and $5\mu/4$--varied from .599 to .791 (1/1.2642 to 1/1.6695). That is, approximately $1/(4/\pi)^2$ to $1/(4/\pi)$ (1.2732 to 1.6211). Assuming symmetry, the implied mean and median for F would be about .695 (1/1.4472). [or 1.0233 times the square root of 2?] Assuming symmetry, concentrations of fertility between $3\mu/4$ and $5\mu/4$ in the first complex root of stabilization, in other words, are structured internationally relative to an observed group mean by $4/\pi$ or its square root, like modes for cohabitation, the mean age of fertility schedules, and net fertility schedules or $\phi(a)$'s (Coale 1972, 74; 6; 19; 72, 74).

Fertility schedules, however, rather than being symmetrical, are at least somewhat skewed. V, the ratio of the median age of the net fertility function to its mean, ranges from .956 to .995 in the 47 populations studied by Coale (74). From one approximate empirical extreme to the other, that is, the ratio changes by a multiple of 1.0408. This is almost exactly the cube root of $(4/\pi)^{1/2}$ (1.0411) or $(4/\pi)^{1/6}$. The formula for skewness is SK = $\sum x^3/N\sigma^3$ (Harshbarger 1971, 100). The range of imbalance for median relative to mean for at least 47 populations is likewise framed by a third power, in this case the cube *root* of the now familiar value $(4/\pi)^{1/2}$.

The next, or fourth, root of $(4/\pi)^{1/2}$ also plays a central part in demographic change. Its value is 1.0307 or $e^{.0302}$ or almost exactly the rate of change in the rate of change for the G, D, C, and E functions. While Coale's models (1972) assume log-linear developments in fertility, mortality, and growth, previous chapters have instead demonstrated trends that *decelerate* or *accelerate* proportionally. As this tendency is added to Coale's framework of analysis, as it must be (by someone with much more mathematics than this author), one can expect that further shaping based upon the roots of $4/\pi$ will appear.

According to the Swedish example of 1946-50, the initial phase of the first damped oscillatory component of the birth sequence that results from a population element at age *a*, $\theta_1(a)$, from ages 10 through 45 rises in G' shape toward a crest of about 6.3 in the vicinity of 45 (Coale 1972, 93). Perhaps relevantly, 6.2842 = 2π, while 46.28 = $2e^{\pi}$. The equivalent phase for the 6th oscillatory component increases to age 23, then levels out around 21, never breaching 7π (21.991). In each case the limit is about $\pi(i + 1)$ for $\theta_i(a)$. How general are these characteristics for other case of convergence upon a stable population?

Once again for the Swedish example of 1946-50, $M_2(a)$, one of the key elements in calculating the 2nd complex root of the fertility integral, is negative around age 23 and again around age 43, reaching maximum about age 33 (above the international average for Coale's sample of populations). $N_2(a)$, another basic component, hugs 0 until just under age 20, bottoms out at about 29, peaks around 38, and returns to 0 at approximately 46 (Coale 1972, 65-66, 95). A composite of the two waves together would pass through zero around 22 and then around 46.

In contrasting fast and slow convergence of fertility upon stability with examples, respectively, from Sweden 1891-1900 and Yugoslavia 1960, Coale (1972, 98-99; by projection) found initial drops that bottomed out around 13 and 10 years. The ensuing upswings peak about 32 and 26. In other words, on average the opening decline maximizes around 11.5 years or approximately $e^{\pi}/2$ while the first upward fluctuation on average crests around 29, the global average female generation or approximately $e^{\pi} \times 4/\pi$ (or 29.46). The adjustments toward stabilization, in other words, start close together from a common human demographic structure. The differences expand with time. As evidenced by the highs and lows of the first two waves, however, years for the slower Swedish convergence at each turning point run roughly $4/\pi$ times those for the faster-converging Yugoslav example: approximately 13:10 L; 32:25 H; 47:36 L; 63:52 H, for an average ratio from these four comparisons of about 1.274 vs. the 1.273 for $4/\pi$. If these two examples were the extreme cases encountered by Coale, the range for rate of convergence to stable conditions for human populations seems to entail a spread of about the familiar $4/\pi$.

Coale compared projected births for four populations, all given the net Swedish fertility function of 1946-50 (1972, 100). (1) When with the stable age distribution for 1946-50 fertility is made to decline 2 percent annually, there is very little departure from the log-linear path plotted by the real root for births. The projection just rises above this trajectory slightly between about years 8 and 23,with a maximum variation from the log-linear base in the vicinity of 16, and falls below even less markedly between about 23 and 36, with a relative low about 30. Further crossings occur about 38 and 58. (2) If the base population under the age of 2 in the stable age distribution is reduced by 50 percent, appreciably more fluctuation about the log-linear appears. The first wave rises to a relative high in about 12 years before falling to a low around 23; the second peaks about 40 before dipping to something like 57. The fluctuations cross the underlying trajectory in the vicinity of years 4, 19, 33, 50, and 60. (3) Projecting the actual Swedish population conditions of 1946-50 without modification, in contrast the fluctuations reverse those of example 2. Lows occur around 11 and 42, highs about 28 and 58. The waves traverse the baseline around years 5, 20, 36, 50, and something like 63. (4) The strongest wave movement appears, however, when the stable population has its cohorts under 5 reduced as in Germany during World War I, "one of the largest short-term reductions of fertility on record." These fluctuations resemble those where the population under 2 is cut in half, but are stronger. The highs arrive about 11 and 40, the lows appear in the vicinity of 21 and 53. The crossing points for the fluctuations come around 3, 17, 30, 47, and 58.

These are just rough visual approximations from movements in Coale's Figure 3.9. But, as Table 9.4 indicates, they allow some general comparison of the effects of three different kinds of manipulation of fertility upon an actual population: Two ways of reducing the very young in the initial age structure (Coale 102-03), examples 2 and 4, generate much the same waves around the trajectory of the real exponential root though the amplitude is somewhat greater and the period a little shorter using the age reduction under 5 based upon German experience in World War I (example 4) rather than just cutting the population under 2 by half (example 2). Both these experimental alterations, however, roughly turn the waves of the original Swedish population (example 3) upside down. This happens because in the initial age structure as of 1946-50 the 'baby bust' of the Great Depression imprinted a sharp drop for proportions of females who were roughly age 10 through 25, in contrast to the reductions under age 5 in examples 2 and 4. Upside down, however, the spacing of how a shock to the age structure makes waves remains much the same. If fertility is reduced 2 percent per year (example 1) rather than containing a ‘cut’ that passes through the system, the age structure smoothly and consistently becomes younger than the stable distribution for 1946-50, the amplitude of the fluctuations are made very small, and the early high and low points and crossings over the underlying trend are stretched out most of all. The waves, nonetheless, are lengthened versions of those found in examples 2 and 4, other ways to reduce fertility, and are again inverse to the projection of the original Depression-generated population conditions. A cut in the age distribution focused around 15 rather than 2 flips over the wave pattern for birth projections but largely retains the period. Gradual, persistent reduction tends to suppress the amplitude of fluctuations while shock early in the life cycle does not.

Coale illustrated how population elements at different ages combine to produce aggregate fluctuations that diverge from the wave patterns of each component (1972, 107). From the fertility schedule of Swedish females 1890-1900, with a life expectancy of 70 at birth, he chose those at 0 and 16.7 years (about half a generation). The waves for those 16.7 years old at the start crested after about 15 years, dipped to about 31, and then peaked again after about 48 years of projection. The offspring of those only just born at the start maximized after approximately 30 years, and bottomed out after about 47, roughly opposite to births from the 16.7-year element. In a population where the 16.7-year element was 1.4363 times the size of the newly born, combined projected annual births would crest after about 23 years, fall to a low after about 30, peak again near 39 years, then minimize after about 46. The period amounts to 16 years or about half a generation. The first and strongest peak comes at about 23 years, but at twice that time a low rather than a high occurs as the period of the wave is 16 years rather than 23.

The age distribution of a population with the current fertility and mortality of 1946-50 Swedish females but with a history of fertility declining constantly at 2 percent (Coale 1972, 112) from age 0 through 40 follows the findings of Chapter 8 in that it takes C shape (with zero year at about 12). Its net fertility schedule, $\phi(a)$ maximizes (has its mode) at about age 26 for at least the first 25 years of projection (Coale 1972, 113). Its low frequency oscillation crests about 14 and 45 years around a bottom of approximately 29, crossing the underlying exponential birth sequence in the vicinity of 7, 15, 22, and 38 (ibid., 114).

When fertility declines at a constant rate, the ratio of births to those in a comparable population with constant fertility shows signs of stabilizing through fluctuations of successively lesser amplitude over 120 years but in periods repeatedly close to 33 years, all around a level of approximately 1.03 (Coale 1972, 139). Coale's estimate for the ultimate greater flow of births that would result from a history of declining fertility is $e^{-kT/10.5}$ (140). Eventually, he calculated with $e^{kT/10.67}$ for years greater than $3T/4$, where T is the female generation or beginning just under 24 years. This results in a ratio of about .9715 or 1/1.0293, the underlying level of the ratio after a century or so of fluctuations (139), whereas to employ the originally estimated 10.5 rather than 10.67 would produce a level of more like 1.0312.

After 50 years of development, the ratio of the age distribution of a population with steady 1 percent decline in fertility at ages under 45 exceeds that of a comparable population with constant fertility. Above 45 the ratios fall increasingly short of 1.0 (Coale 1972, 146). The curve for this ratio from age 15 through 80 takes C shape with a target around .47 near age 86. If the divergence were to continue "forever," the C trend is virtually identical, while under 50 years the shorter the period of change, the flatter the comparison, especially at older ages (147). Conversely, when fertility *stops* declining, the longer that it as ceased, the flatter the ratio becomes for the formerly altering age structure relative to the stable one (148).

Coale also addressed the possibility of demographic changes when fertility fluctuated rather than altering at a constant rate. He argued, however, that empirically such waves have been observed only for very short seasonal movements, too brief to shape significant developments in births and age structure.

He analyzed 45 net fertility schedules for the amplitude and phase of birth cycles produced by fertility cycles with a wide range of frequencies (1972, 171-73). For U.S. females as of 1960 (with NRR set to 1.0), as the duration of the fertility cycle approaches about 16, amplification (amplitude of birth cycle/amplitude of fertility cycle) falls somewhat below 1.0 (about .86 = 1/ 1.1628, approximately $1/((4/\pi)^{1/2} \times e^{.03})$ or 1/1.1627 . Between there and a fertility cycle of some 25 years (or the median of the net fertility function,[35] the amplitude ratio surges to 1.56. This value closely resembles $(4/\pi)^2 \div e^{.03}$ or 1.5732. The ratio then dives to a two-century minimum at a frequency of roughly 60 years ("twice the mean age of the net fertility function, or about one cycle every two generations," p.173, though the generation was actually 26.37 years in 1960, Keyfitz and Flieger 1985, 81). This minimum level is about .55, or the maximum of 1.56 minus 1.0. Simultaneously, it for some reason almost exactly resembles $1/(4/\pi)^{2.5}$ or $1/((4/\pi)^{1/2})^5$ = .5467. Thereafter, frequencies in fertility through the next 140 years produce amplification that increases arithmetically roughly .006 a year, for a multiple of 2.2727. For the long term, this generates a net proportional result of $e^{.01623}$, about e to $.03000/(4/\pi)^{2.5}$ or $e^{.01640}$, in other words $e^{.03 \times \min}$.

For about the same span, the phase of birth cycles lags behind fertility cycles about .257 years more every additional year of duration for the fertility cycle. When fertility cycles last between about 23 and 53 years birth cycles lead rate than follow them, pulling farthest ahead for fertility frequencies in the vicinity of 32 years. When the duration of fluctuation in fertility is less than 23, the birth cycles are generally coterminous with them (Coale 1972, 172-73). Something of an early crest appears of lags when the duration of the fertility cycle is about 20 years compared with the much stronger peak for amplification about 25.

The components c_f and s_f are cosine and sine elements that help determine the frequency response of a net fertility function (Coale 1972, 170). For U.S. females 1960 with NRR set to 1.0, their joint positive effect, $(c_f^2 + s_f^2)^{1/2}$, begins about 1.0 at one very long cycle every 500 years , then progressively falls to 0 as cycles shorten to about 6 years (ibid., 176). Viewed from the perspective of *length* of fertility cycle (not frequency per century as graphed by Coale), as the fluctuation lengthens from about 12.5 to 50 years $(c_f^2 + s_f^2)^{1/2}$ rises in G' fashion toward about .80 in the vicinity of a 60-year frequency. Two generations are considerably less than 60 years for this population (more like 53); but 23.1 × e = 62.9 years ($e^{\pi} \times e$, or $e^{\pi + 1}$).

Fluctuations of both c_f and s_f contract significantly with length of cycle. Crests of s_f attain about .95 when the cycle is around 111 years, approximately .25 for a cycle in the vicinity of 19 years, and roughly .10 for cycles close to 9.5 years. The interval between these peaks, meanwhile, narrows from some 90 years to more like 9. The troughs arrive for frequencies around 36, 13, and 8 years, reaching about -.42, -.16, and 0 at these points. For c_f, meanwhile, the highs come about 1.0 at an ultra-long frequency of over 500 years, approximately .33 around 25 years, then roughly .10 near 9.5 years. The lows appear around frequencies of 57 (-.78), 15 (-.20), and 8.5 (-.02) years. Collectively, the troughs for s_f and c_f together tend to flatten (lose amplitude) for cycles at least between 57 and 13 years in C fashion based about .50 around 42 years. For peaks, between frequencies of at least 111 and 19 years the path seems to be C with .37 at a t_0 of approximately 30.[36] For frequencies within these ranges, meanwhile, the zero years of the trends and the levels at t_0 seem to maintain a ratio of highs to lows for s_f and c_f combined of about 1.375 (actually 1.4 for frequency, 1.35 for level). Given the rough approximations from Coale's graph from which these patterns are estimated, that ratio could easily be √2/1.03 (1.4142/1.03 = 1.373). These fluctuations of s_f and c_f, however, through their different timing offset each other so as to produce an interacting cumulative trend, $(c_f^2 + s_f^2)^{1/2}$, that from frequencies of about 50 through 12 years declines very smoothly via C with .80 at a base cycle of approximately 60 years.

The phase difference between the current periodic fluctuation of births, h_1, and the weighted average for the fluctuation of births one generation before, z_1, with fertility concentrated at the mean age of the stable population increases in multiples of π along with the frequency of cycles per century (Coale 1972, 175, 177-78). It therefore *decreases* with the length of these fluctuations in *years* as shown in Table 9.5 (cols. 1, 2, and 3). This makes the difference in phasing rise from frequencies of 26.3 through 7.5 again in an E' path based upon a level of about 3.6 in the vicinity of a frequency of some 56 years (Fig, 9.4). For the female population of the United States as of 1960, the E' curve again appears for cycles of roughly 24.3 through 5.6, but based with a level of more like 4.0 at a frequency of some 52 years. This similarity exists in spite of the manner in which, expressed as cycles per century rather than in years, the two trends diverge as graphed by Coale (177).

Table 9.5 indicates how close, for the actual 1960 U.S. population, the timing at which successive multiples of π arrive is to the successive *intervals*, in years, between zero points for the fitted powers or roots of G (spans between entries in Tab. 9.2, col. 1). On average, the 5 new estimates are 1.1026 higher (col. 4). A multiple of $(4/\pi)^{1/2}$ (1.12838) would run about 1.0233 times more than that. This extra difference amounts to approximately $e^{.03/(4/\pi)}$ or $e^{.0236} = 1.0238$. Meanwhile, the ratio of frequencies for a population with its fertility concentrated at the mean age to those of the actual United States females of 1960 (Tab. 9.5, col. 1/col 2.) generally increases from one value of π to the next in E fashion (across the middle of Fig. 9.4) toward a target level of about 2.5 in the vicinity of projected year -23--or into cycles of infinitely small frequencies in years and large repetitions per century.

The *frequencies* for Coale's illustrative 1960 U.S. population at successive multiples of π, furthermore, decline closely parallel with the *intervals* between successive zero years for the fitted powers and roots of the G function (cols. 2 and 3 in Tab. 9.5; the spans for col. 3 come from the spacing of entries in col. 1 of Tab. 9.2 plotted as the E trend in Fig. 9.3). The bottom plots of Fig. 9.4 compare the mid-points between powers or roots from 1 through 6, whose x values are in fact multiples of e in powers/roots of G (Tab. 9.3), with frequencies at successive multiples of π for Coale's phase differences. For graphing, both e and π are given a width of 10 arbitrary units. On this scale, the approximate frequency in years for each multiple of π in the phase lag of h_1 and z_1 declines from π through 7π in D shape based on a frequency (vertical) of about 10 years at a zero point (horizontal) around 4.4π (or 13.82). The intervals between the t_0's for the powers of G, in multiples of e, meanwhile, contract also via D but with a y of more like

8.4 in the vicinity of 4*e* or 10.87. The estimated horizontal unit value, 13.82, for the zero point in the phase lag is 1.271 times that for the power/root interval for G or 10.87. That ratio almost exactly represents the 1.273 of $4/\pi$. The ratio of 10 to 8.4, the approximate *y* values in years for the two series, meanwhile, comes to 1.1905. This result very closely resembles π/e, the ratio of the base units for the two sequences compared (1.1557), times 1.0304 or $e^{.03}$, the underlying accelerator (positive or negative) of the G function and its family of curves--in all, 1.1909.

?? In short, the imaginary components (*iy*'s) of the successive roots or powers of G are simply and systematically related to the phase differences between h_1 and z_1 in at least one illustrative population. This indicates........

Given the fertility of U.S. females in 1960, amplification of fertility cycles in birth cycles rose from a low of about .58 for cycles in the vicinity of 70 years to 1.0 around 3.1 (approximately π) cycles per century or a frequency of some 32 years (Coale 1972, 180). It continued increasing, however, to maximize at a frequency of about 26 years (the female generation at that time) at a level of 1.56 or $(4/\pi)^2/e^{.03}$. The ratio of where the maximum was reached to where the trend transcended 1.0 amounted roughly to 32/26 or 1.2308, which approximates $4/\pi \div e^{.03}$ or 1.2357. The phase differences, meanwhile, declined from 90° through 0° linearly, mostly like those for phase differences with fertility concentrated at the mean--to turn increasingly negative until reaching a minimum of about -30°, also around π cycles or about a frequency of 32 years before heading back to 0 at roughly 4.1 cycles per century or around 24 years (close to $23.1 \times e^{.03}$ or 23.8 years).

The ratio of the amplitude of birth fluctuations to the amplitude of fertility fluctuations based on Swedish women 1891-1900, itself fluctuates strongly at low frequencies, reaching a minimum of under .6 in the vicinity of 1.5 cycles per century (some 67 years) and a high of over 1.6 for approximately 3.0 cycles or 33.3 years. As of about 4.3 cycles or 23.3 years, however, further movements in the ratio become minor and it tends to hover around 1.0. Likewise, some comparative narrowing in swings of amplication for comparatively greater amplitudes of fertility (g = 0.5) disappear. The amplification resulting from harmonics at 2f and 3f, meanwhile, become negligible (around 0.15 and 0.02) already by cycles of 100 years and are virtually absent for cycles shorter than 23 years (Coale 1972, 186).

ADD/INSERT articles?????

Has been a recurrent if controversial literature on 20-25 timing. Paragraph summary. Any relevance of findings here?

Section on waves? roots?

Tie to imaginary numbers in stability and waves????

Substantive conclusions of relationship to normal?

On the other, even roots with 23.1 spans

[Approximately 23.1 years is not just an arbitrary choice for z in comparing the cumulative normal curve with G. It is indicated empirically. Through the middle of its distribution the best arithmetic fit of the cumulative normal to G indeed tends to have a standard deviation for the time variable of about 23 years. For the range from -30 to +30 years in G the standard deviation for the cumulative normal is 21.60 years. For -30 to +40 it is 24.50 years. The average for these spans is 23.05 (for an implied range of about -30 to +35). This fitting, due to the options for *Tablecurve*, is done with the arithmetic rather than the logarithmic version of the data. For an increasing trend such as G or the cumulative normal, absolute error in later years has a disproportionate weight (unlike the use of *proportional* error for most G-related fits in this study). That effect shifts the best-fitting range between the two curves forward in time from roughly -46 to +23 (Fig. 9.x [8GF]) to more like -30 to +35.

Figure 9.c illustrates the excessive amount of arithmetic error after about +14 years in G relative to the cumulative normal as fitted proportionally for the range of -32.3 through +13.9 in Figure 9.GF. After fluctuating around an average of merely .00135 for seven decades, this soars more than 200-fold in a G' path through about year +60.1. Here, or a few years sooner, further increase shifts into more gradual G shape.

The *proportional* difference between the two curves, however, is less than 2 percent from -27.7 through +18.5 and virtually level (av. = .997) from -9.2 through +13.9. It then gradually accelerates in E fashion to about +41.6, where it swings over into a decelerating G trajectory to reach 1.37 in the late 70s. It requires an absolute stimulus in G' shape to push the G curve relatively above the normal via E. To hold it in proportional further gain via G a G trend in the arithmetic difference suffices, though this G must be markedly stronger--with a base year about 50 years later than the G for relative difference. At the early end of Figure 9.GF, on the other hand, the G curve converges upward to the cumulative by about year -20 through gaining proportionally for some 40 years in G' manner. Very little absolute difference as both curves low, but swings around cumulative normal - + -, picking up its path..

If a population, for example, begins to grow via G or a fertility reduction spreads within it in G fashion, by about 35 years before t_0 the trajectory will converge from below on the cumulative normal distribution. For over half a century random variations in the process will then add up in G form and support a G trend for demographic change. To continue thereafter, the G trend will have to exceed random accumulation by-------]

Consequences for G growth and other G (or D) change.

C as in lx or E

What might be the significance of these findings for changes that curve in G or G-transposed shapes (C, D, or E)? Discussion of roots and waves.

Another is the way that through about 50 years around its zero point G (or C in reverse) converges with the cumulative normal distribution. This convergence, finally, is most evident if the standard deviation of the normal curve is about 23 years, the imaginary component of the second root for the G function.

??The convergence of C on the reverse of the cumulative normal curve through the 'active' middle years of the human life cycle will assist in reducing random variations in attrition to the underlying curve. A similar smoothing process will be facilitated by the resemblance to the normal distribution in other trends that bend like G.

The consequences of the root. Fluctuations there most effective (cf. Coale)? Tie between secular trend and fluctuation.??

Notes

1. Producing log-linear change in population size as modeled by Ansley Coale (1972, Ch.'s 4 and 5).
2. As explored notably in Coale 1972.
3. In projecting, the number of female children at year 5 is estimated by female l_5 (proportion surviving to age 5) x 5 (the years 0 through 4 in the 5-year cohort) times the sum per year of females' births for each cohort of mothers.

4. Which closely resembles the long-term growth of 9.0 projected from 1967 (Fig 9.1a).

5. Thcse cases are included, continent by continent, in the same summarizing tables of Vol. I just cited for H-type increase.

6. The same sources as for H in Harris 2001.

7. And only 8 of 808 trends for smaller and more local populations (ibid.).

8. The Spanish movements, based on baptisms, are not counted in the sum of 29; but C trends in the Russian provinces of Minsk and Mogilev 1833-1857 and in the Mexican state of Colima from 1850 to 1900 fill out the total.

9. Van de Walle critique. It may be for some more developed countries, as in Europe; but the large majority of world populations are still expanding, many quite robustly.

10. citation and elaborating comment

11. By 1983, the duration of log-linearity had shortened rather than lengthened toward completion, because vital rates had altered (Keyfitz and Flieger 1990, 314).

12. The two "X's" in the sequence for Madagascar for visual convenience represent averaging of adjacent cohorts. The numbers for the separate cohorts, however, are employed in the curve-fitting.

13. Unlike the case for Algeria, whose rates are fitted in Fig . 9.3a, particular trends for Madagascar in Tab. 9.2 are estimated visually with template from the projection results.

14. As does what might be an alternate G path for years 10 through 60 (Tab. 9.2, part B; in italics and brackets).

15. For Japan, Italy, and the United States CBR crests via E' and CDR via D'; in Norway both vital rates first maximize in D' paths. During West Cameroon's later G growth, weak D' increase in CBR peaks about year 32, while CDR maximizes in a E path about year 45. During the later H growth of China, meanwhile, the second bulge in CBR peaks about year 43 while the maximum for CDR comes at year 70.

16. The second lags for China and West Cameroon, during their H and G growth, are about 27 and 25 years respectively.

17. In both Mexico and Algeria by about year 25 CBR runs near 45 per 1,000 and CDR at about 8.5 or 9. This implies natural increase of approximately 36 per 1,000 rather than the 28 or 29 projected by iterations or the 30 of F. The observed CBR for 1965 females in Algeria was 43.0, the CDR 9.3; the comparable rates in 1966 Mexico were 42.5 and 9.0, implying natural increase of 32.7 and 33.5 respectively (Keyfitz and Flieger 1971, 308, 344).

18. U.S.A. 1985 1.52, Italy 1980 1.58, Japan 1966 1.80.

19. A survey of national populations finds almost as many instances in which a G-shape rise carries increase to the F level, while in a few cases the .03 rate of expansion is reached via an H path. Of 30 cases in all for national populations, 15 times F is reached via E and 12 times is attained in G form. The E approach to F occurred 7 times in Latin America, 5 times in Africa, and 3 times in Asia. The G way to reach $e^{.03}$ log-linearity appears 7 times in Africa, and in Paraguay, the Dominican Republic and Iraq. It first is observed as about 1675 colonization of New France and the British colonies of North America stabilized and began to grow through natural increase (Harris 2001, 17, 66, 114, 120, 250-51, 280-81). Not a single instance of F-form expansion appears for European nations since the 1500s (ibid., 148-149).

20. In Italy, E is the most exact path. In the U.S.A., E' is somewhat more precise. In Japan, the E' form best captures the rise of CDR between years 20 and 70, but CBR falls more between about 15 and 40 than in the other two populations, making net natural increase accelerate downward here, too (Tab. 9.2, part D; Fig. 9.3d).

21. The birth rate was 43.55 and the stable rate of growth from year 25 or later through 100 just $e^{.00095}$. Therefore the death rate had to be about 43.4.

22. The dates chosen approximate transition points from one trend of growth(or decline) to another in the French and English populations (as do those for England and Sweden in part A of the table).

23. Though a G' curve is not fitted there.

24. The crude death rate in England, for example, rose in E fashion between the 1560s and the 1680s. This change, however, entailed only about 40 percent increase over 120 years. E-type advances of comparable extent for infant and early childhood mortality occurred in parts of Germany during the first

half of the 19th century--and to a lesser degree for the CDR's of Cyprus and perhaps Jamaica in the early 20th century (Figs. 1.1 and 1.2; Fig. 5.11, Tab. 5.9; Figs. 2.1g and 2.1i). On the other hand, some worsening of crude death rates or losses of children in relatively flat G form appears in Japan, Costa Rica, and Chile in the late 19th century, in Lombardy and New Castile during the late 18th, in some German communities and European countries in between, and in many international populations during the decades following World War II--probably now related to aging (Figs. 2.1a through 2.1h, 5.11, and C.10; Tabs. 5.9, C.8). Advances of mortality in this G fashion have tended to be even smaller than those of E shape.

25. The precise .312 amount of maximum reduction within that historical range is chosen for ease of calculation.

26. While in Finland from 1723 or sooner D' movement of the crude death rate is evident (parallel to that in Sweden), the population expanded along successive G paths, not via H. G-type demographic expansion with D' sagging in CDR, however, is expected from totally pre-transition demographic regimes. In Finland the death rate was already well under 30 by the 1720s, making the situation clearly more like 1966 Madagascar than the pre-transition model.

27. The exception comes with D-type contraction for 1980 Italy from each of the three kinds of modification lowering mortality. In the case of Italy, however, D' atrophy is inherent in the original population being manipulated. The exceptional shape of change in the size of the population comes from that, not from various ways of reducing mortality. The trends in birth rates for experiments on 1980 Italy also reflect the D shape characteristic of projection from the original, unaltered population.

28. As described for reducing mortality.

29. All experiments commence following the 15th year. To move from old to young, age-specific fertility for those 40 to 44 is halved at year 20. Similar reduction is also made for those 35 to 40 at year 25, and so forth, until all females of child-bearing age are affected. Moving from young to old, conversely, starts with those 15 to 19 and moves up the life cycle. Births to mothers under 15 and over 45 are sufficiently infrequent to be ignored. These procedures in fact exaggerate the effect of movement

across age cohorts, where the record more typically shows successively lagged C patterns of decline in fertility (for example, Figs. 5.7, 5.8, and C.7; Tab. 5.6), which sum into total contraction taking that same C shape.

31. For 35 years in the one-time shock modification a very flat G segment appears instead.

32. Though marital fertility declined in C form toward 1800 only among wives in their 30s and upper 40s (Fig 1.6) and as a whole rose slightly via E (Figs. 1.6, 1.4).

33. In 47 fertility schedules with which Coale worked closely, the mean age of $\phi(a)$, the net fertility schedule or $p(a)m(a)$, ranged from 25.8 to 32.2 years (1972, 74).

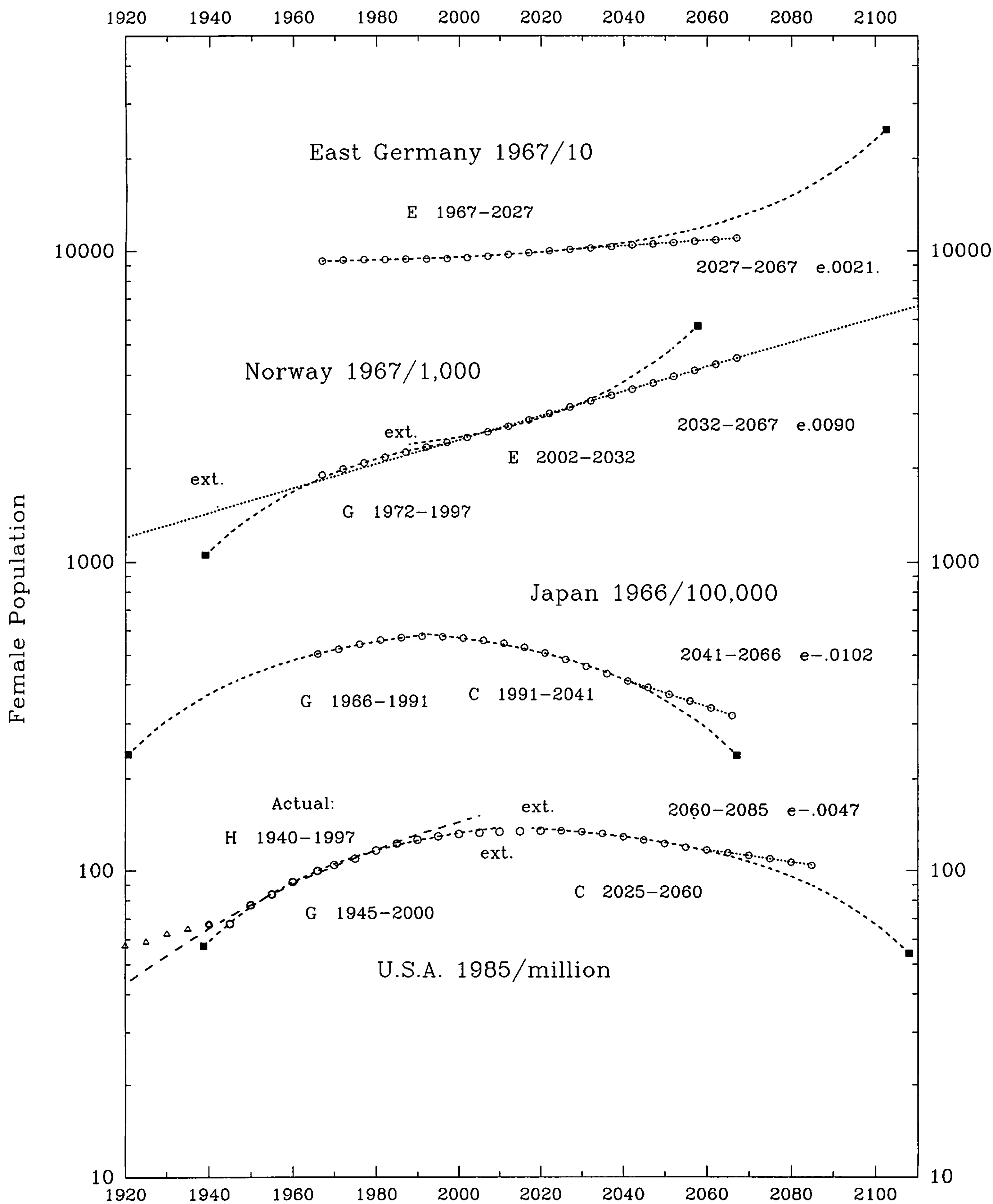
34. Coale's illustration is in fact for a female population with a mean net fertility function of about 32 years.

35. The mean being about 26 (ibid. 22; Keyfitz and Flieger 1985, 81).

36. For a much shorter span (from 25 through 9.5 years), the combined highs seem to follow a C trajectory anchored near .82 in the vicinity of 48 years.

Figure 9.1a

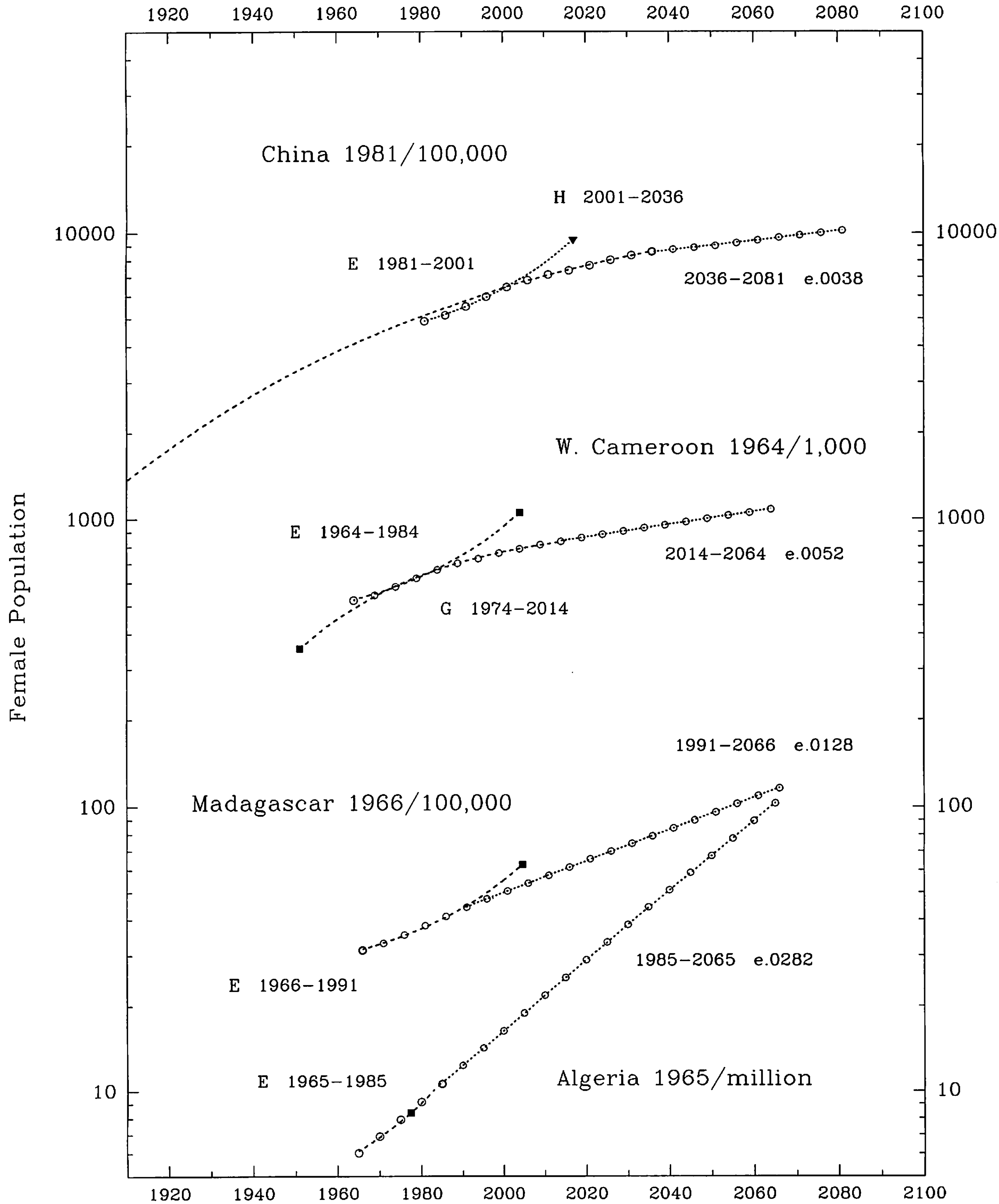
Momentum in the Growth of Some Modern Populations: Slow Growth and Transition into Decline



Sources: Keyfitz and Flieger 1971, 436, 456, 398; 1990, 348; Harris 2001, 27.

Figure 9.1b

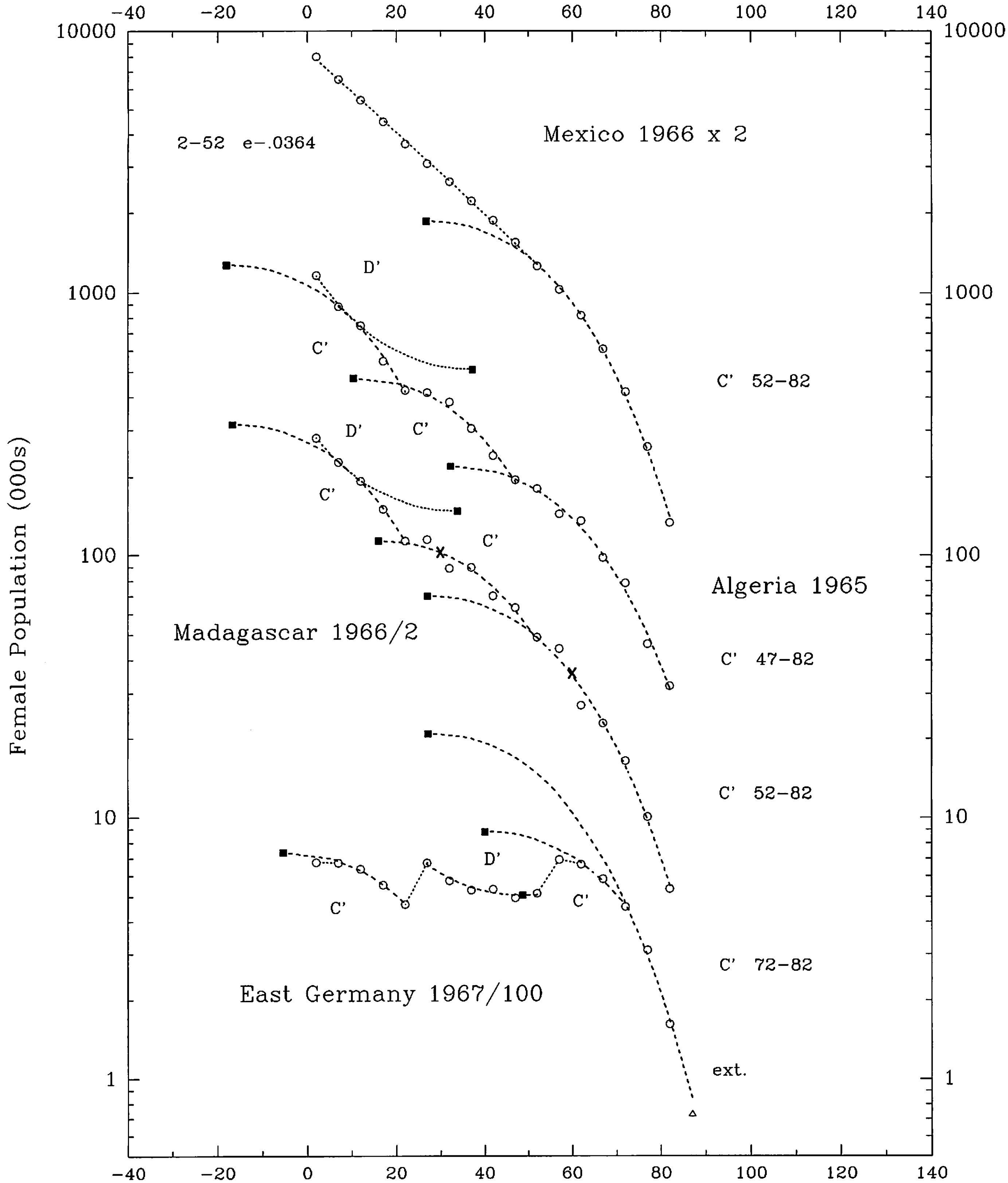
Momentum in the Growth of Some Modern Populations: Trends of Continuing Expansion



Sources: Keyfitz and Flieger 1990, 350; 1971, 310, 312, 308.

Figure 9.2a

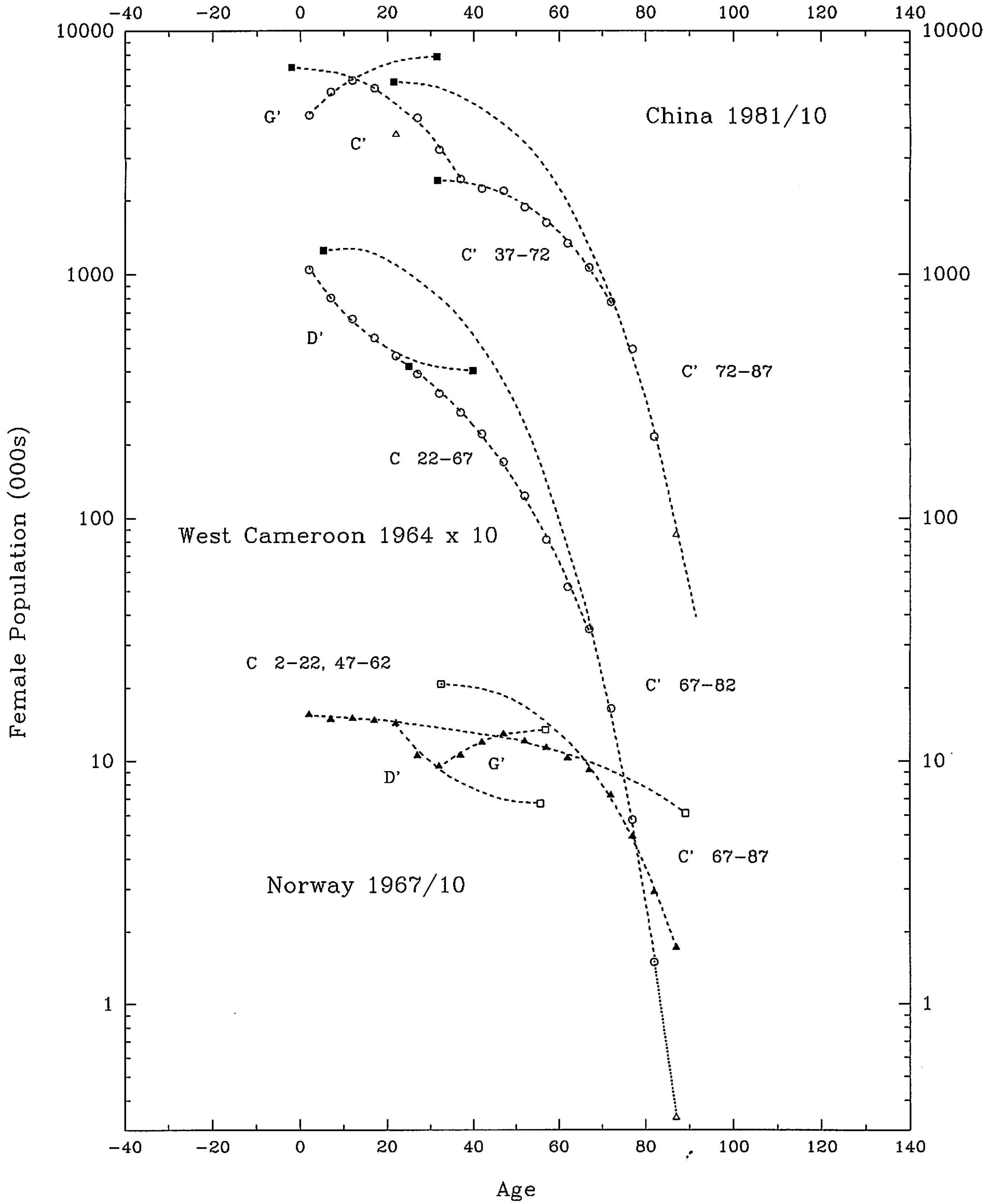
Initial Age Structures of Populations Projecting Various Patterns of Growth: Accelerating E Followed by Log-Linear



X = average of two successive cohorts; details of shorter curves in Tab. 9.1

Figure 9.2b

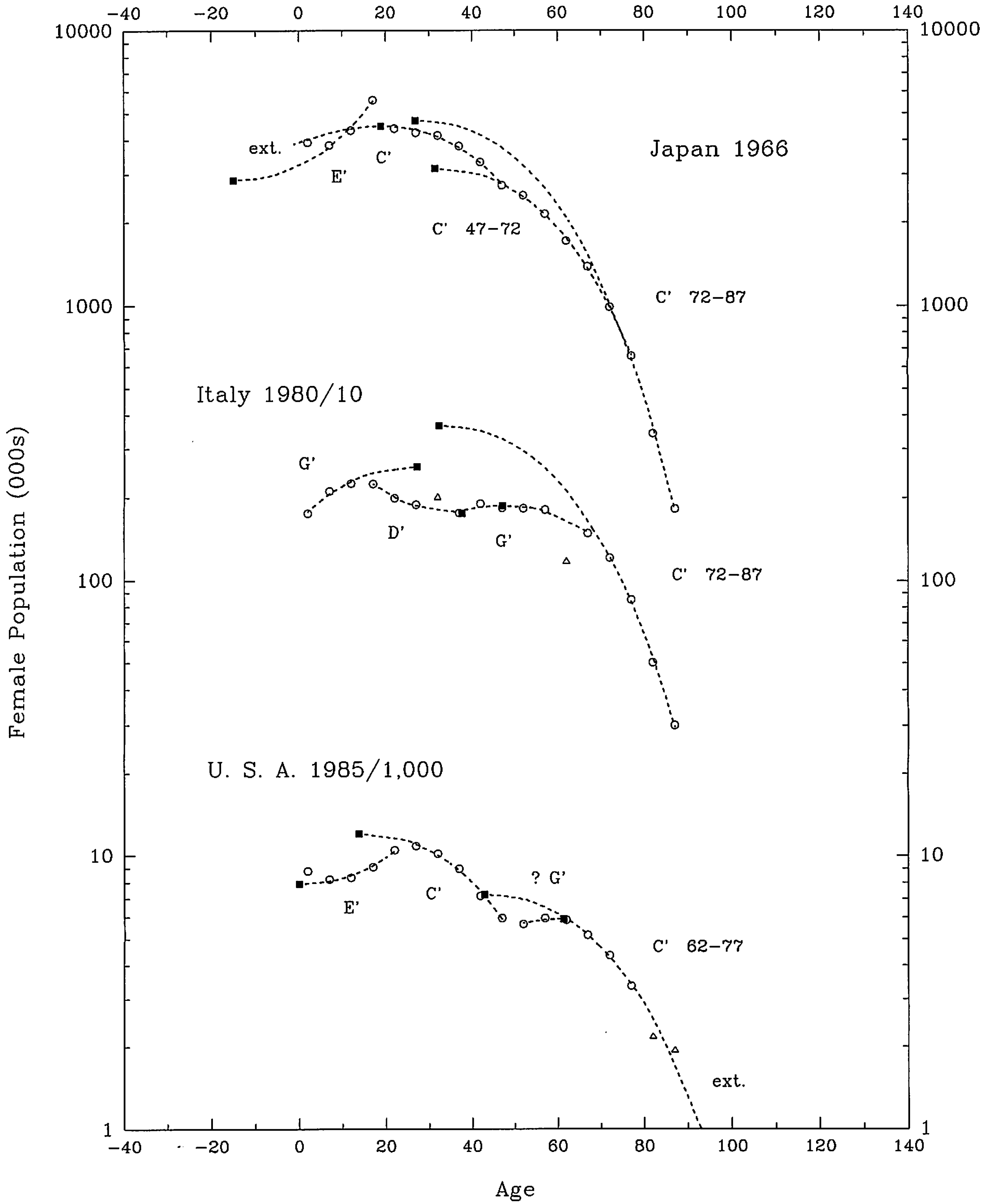
Initial Age Structures of Populations Projecting Various Patterns of Growth: H or G after E; G Followed by E



Details of shorter curves in Tab. 9.1.

Figure 9.2c

Initial Age Structures of Populations Projecting Various Patterns of Growth: G Increase Yielding to C–Shape Decline

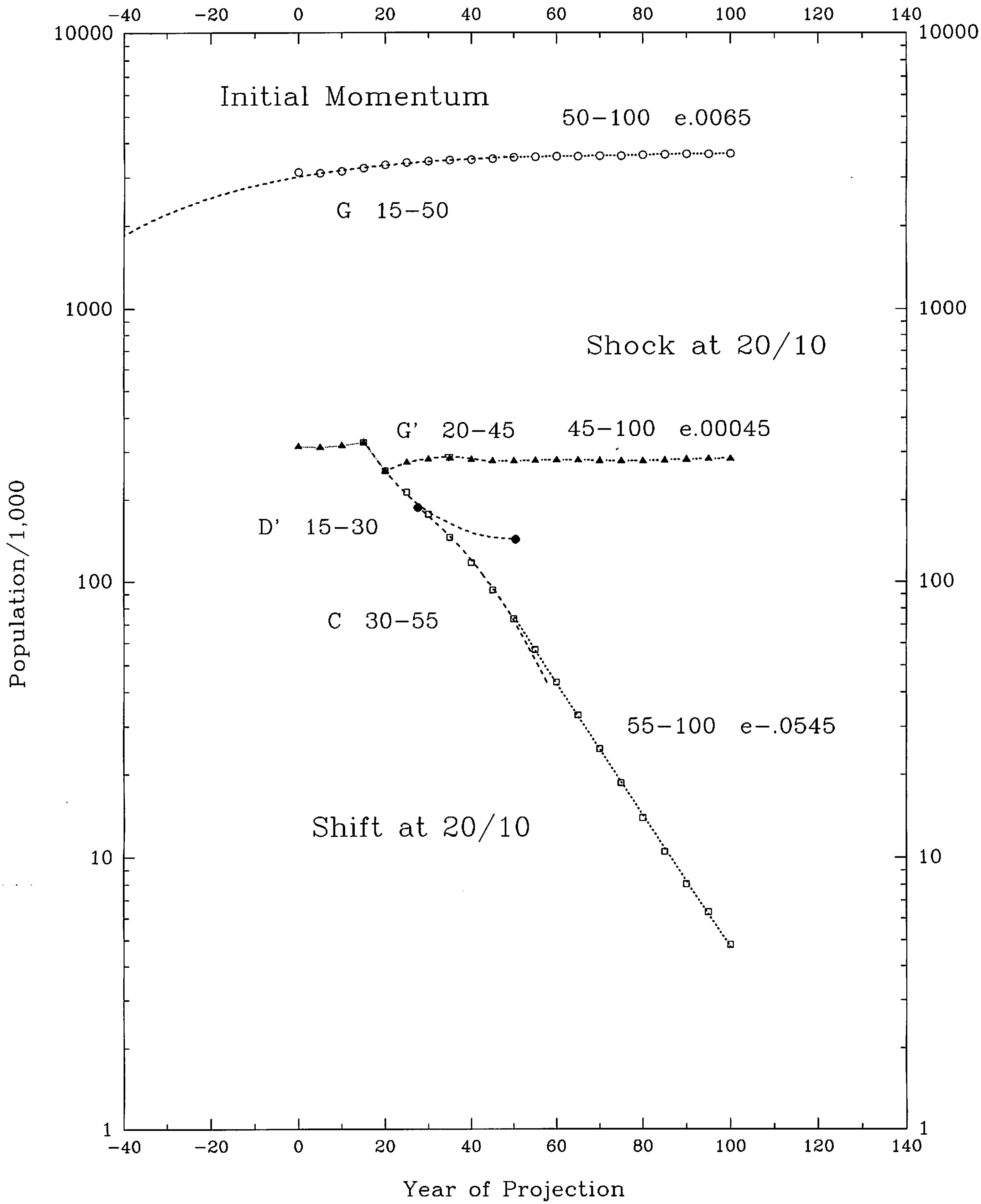


Details of shorter curves in Tab. 9.1.

{Please note that Figure 9.2 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.2a

Population Projections When Mortality Is Doubled: Pre-Transition Results of Two Simple Modifications

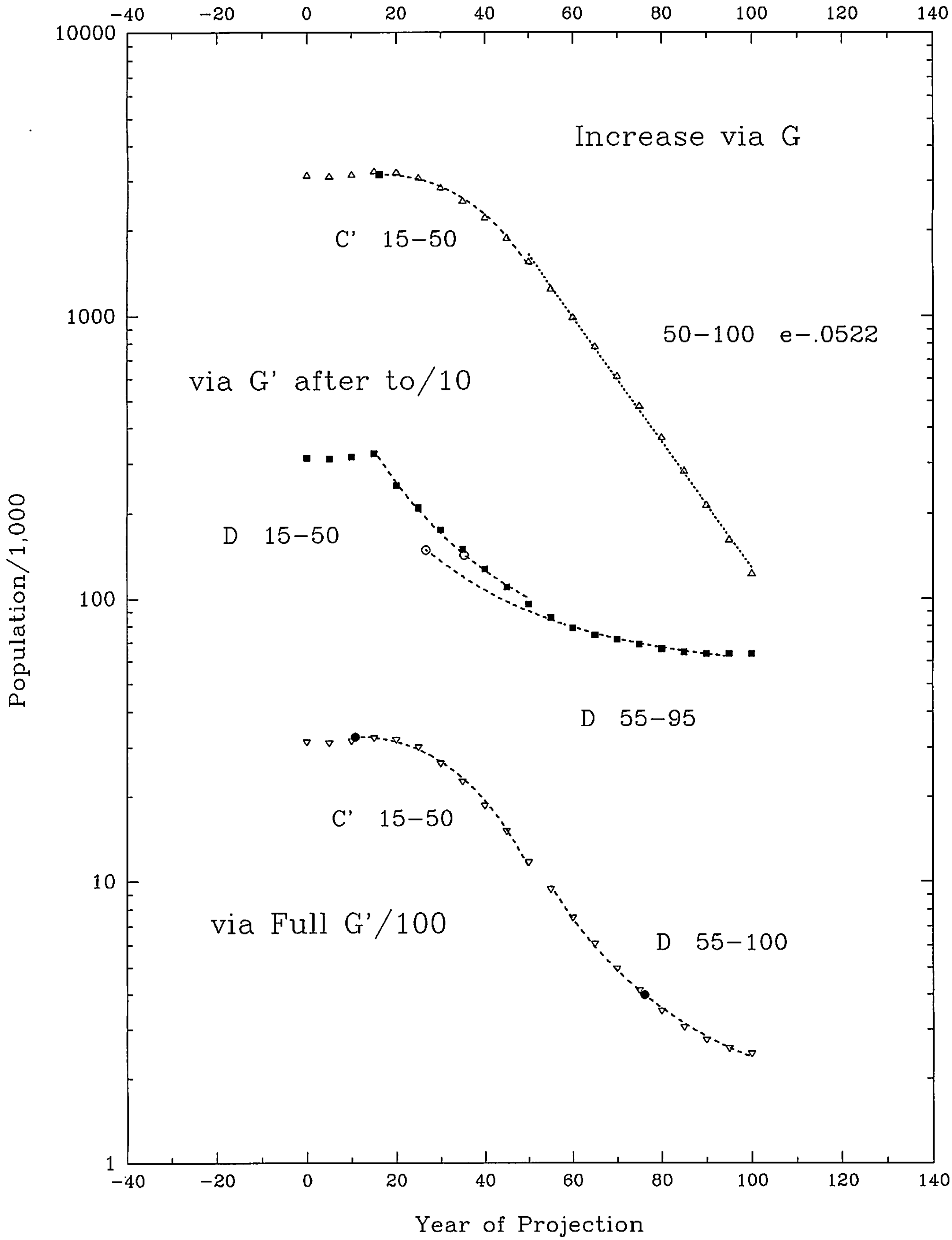


Sources: Tab. 9.3 and text.

{Please note that Figure 9.2 has two iterations. This is the second one. The text of Chapter 9 and chapter M provides some guidance. MSW 31 July 2015}

Figure 9.2b

Population Projections When Mortality Is Doubled: Pre-Transition Results of Other Modifications

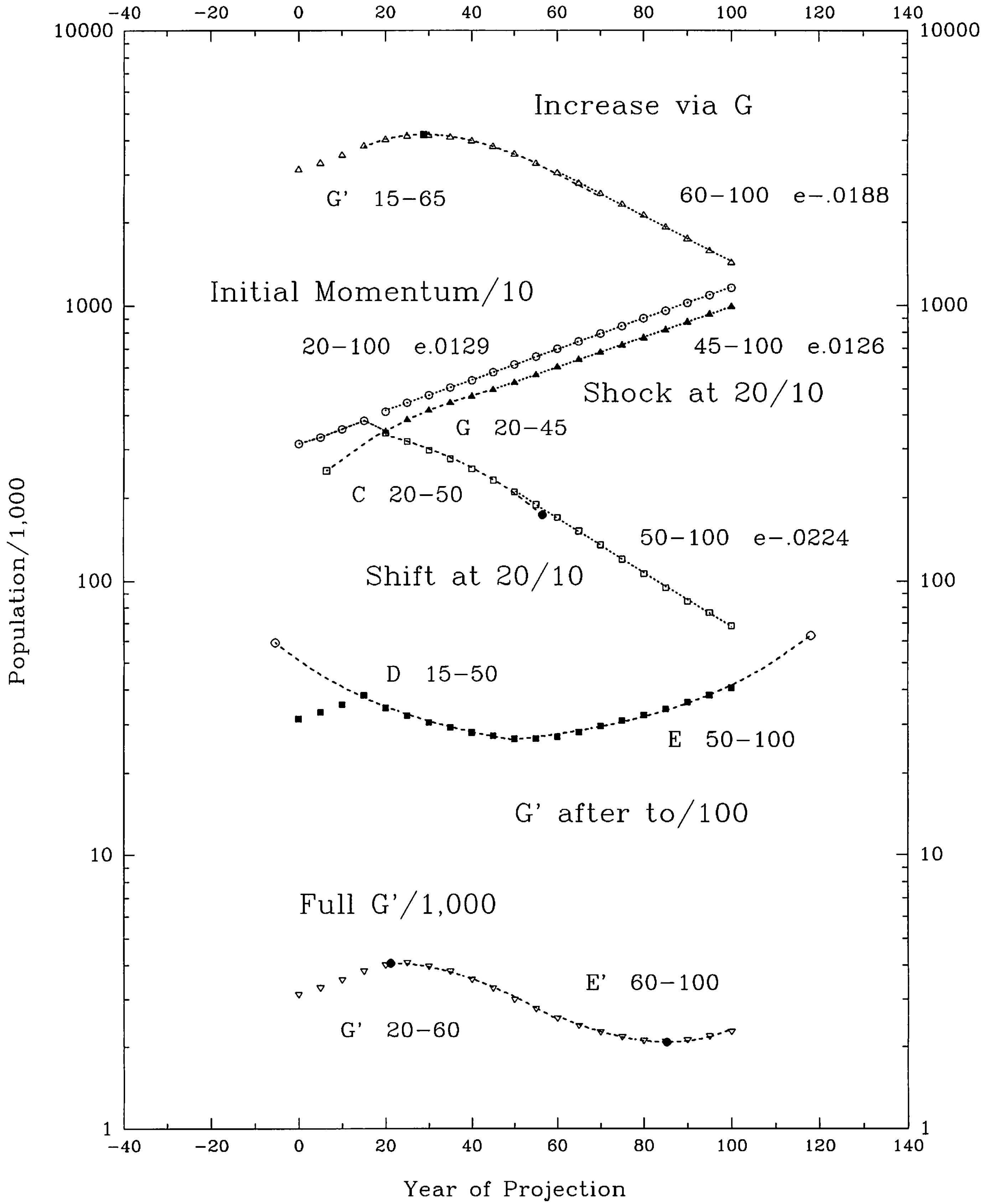


Sources: Tab. 9.3 and text.

{Please note that Figure 9.2 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.2c

Population Projections When Mortality Is Doubled:
Results for a Population Early in Transition

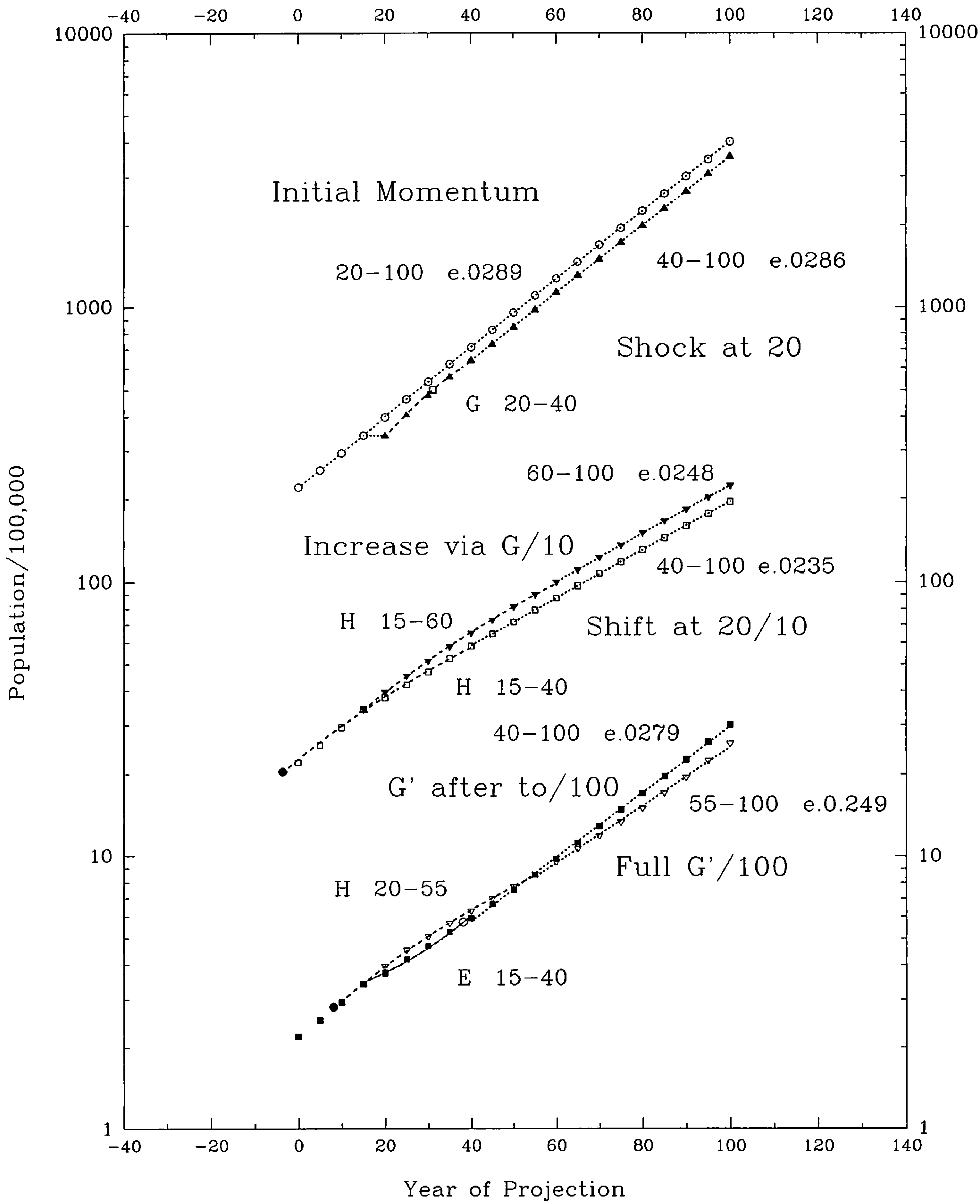


Source: Keyfitz and Flieger 1971, 312 (Madagascar females 1966).

{Please note that Figure 9.2 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.2d

Population Projections When Mortality Is Doubled: Trends for a Population at the Peak of Transition

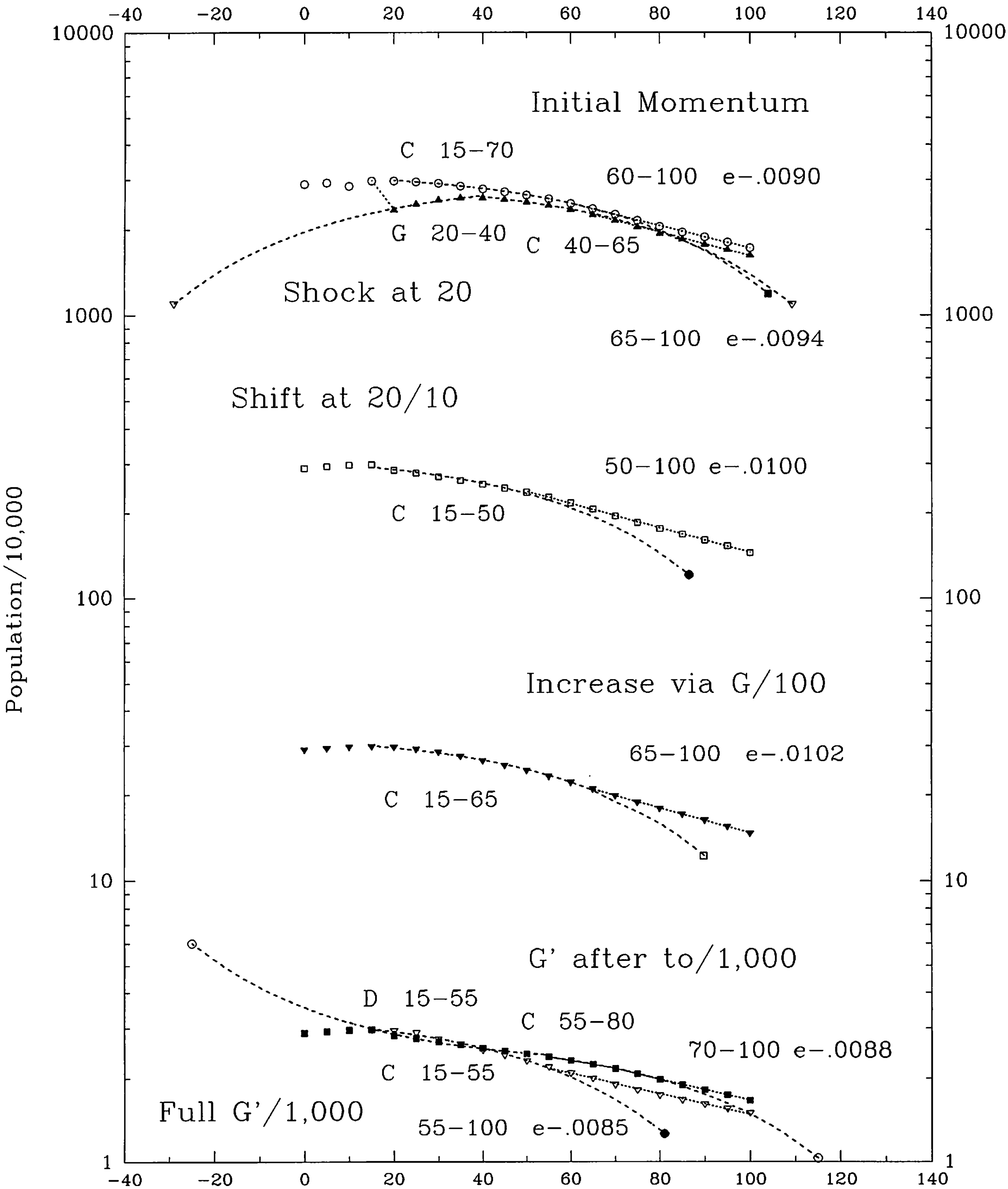


Source: Keyfitz and Flieger 1971, 344 (Mexico females 1966).

{Please note that Figure 9.2 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.2e

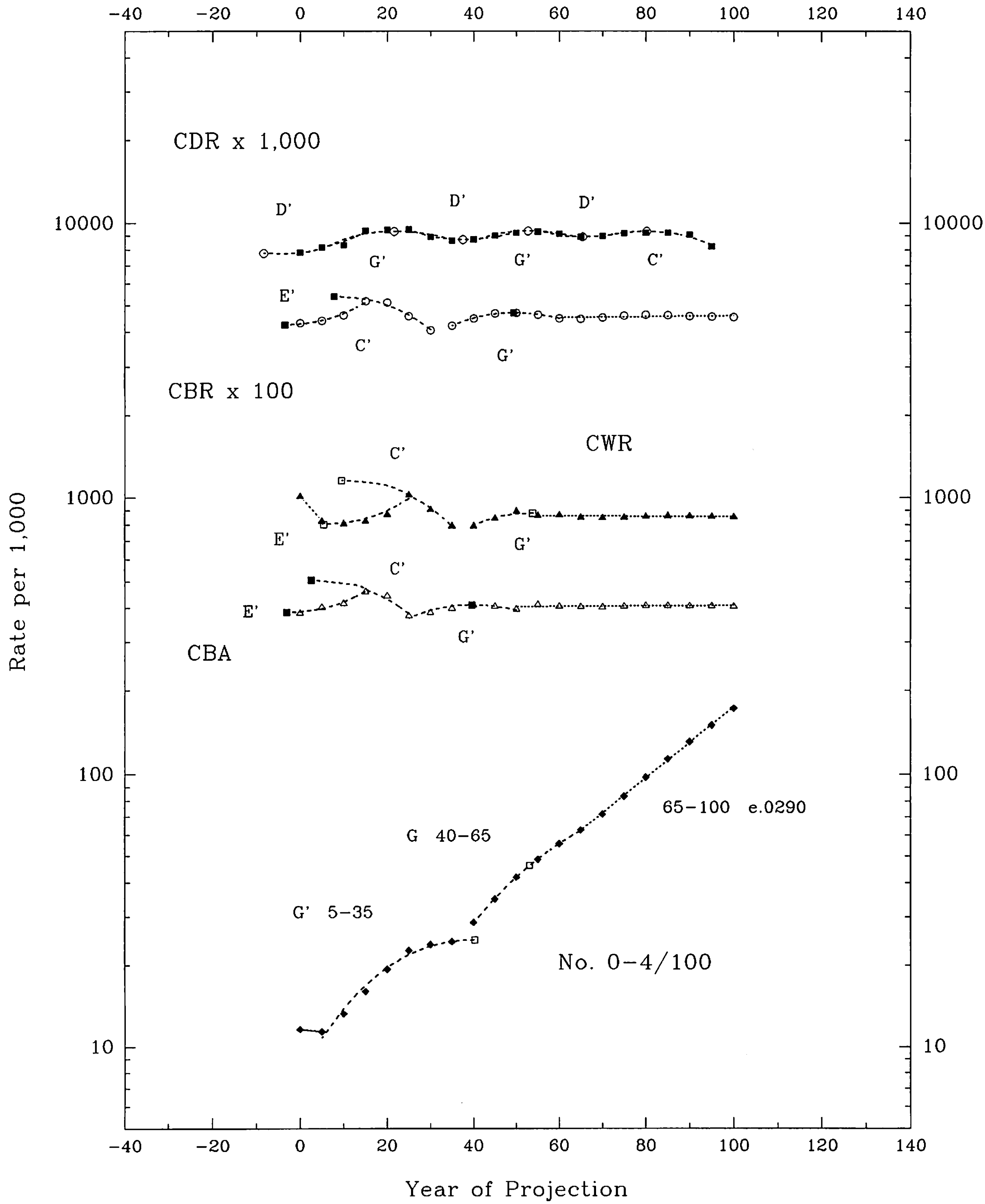
Population Projections When Mortality Is Doubled: A Post–Transition Example



Source: Keyfitz and Flieger 1990, 479 (Italy 1980).

Figure 9.3a

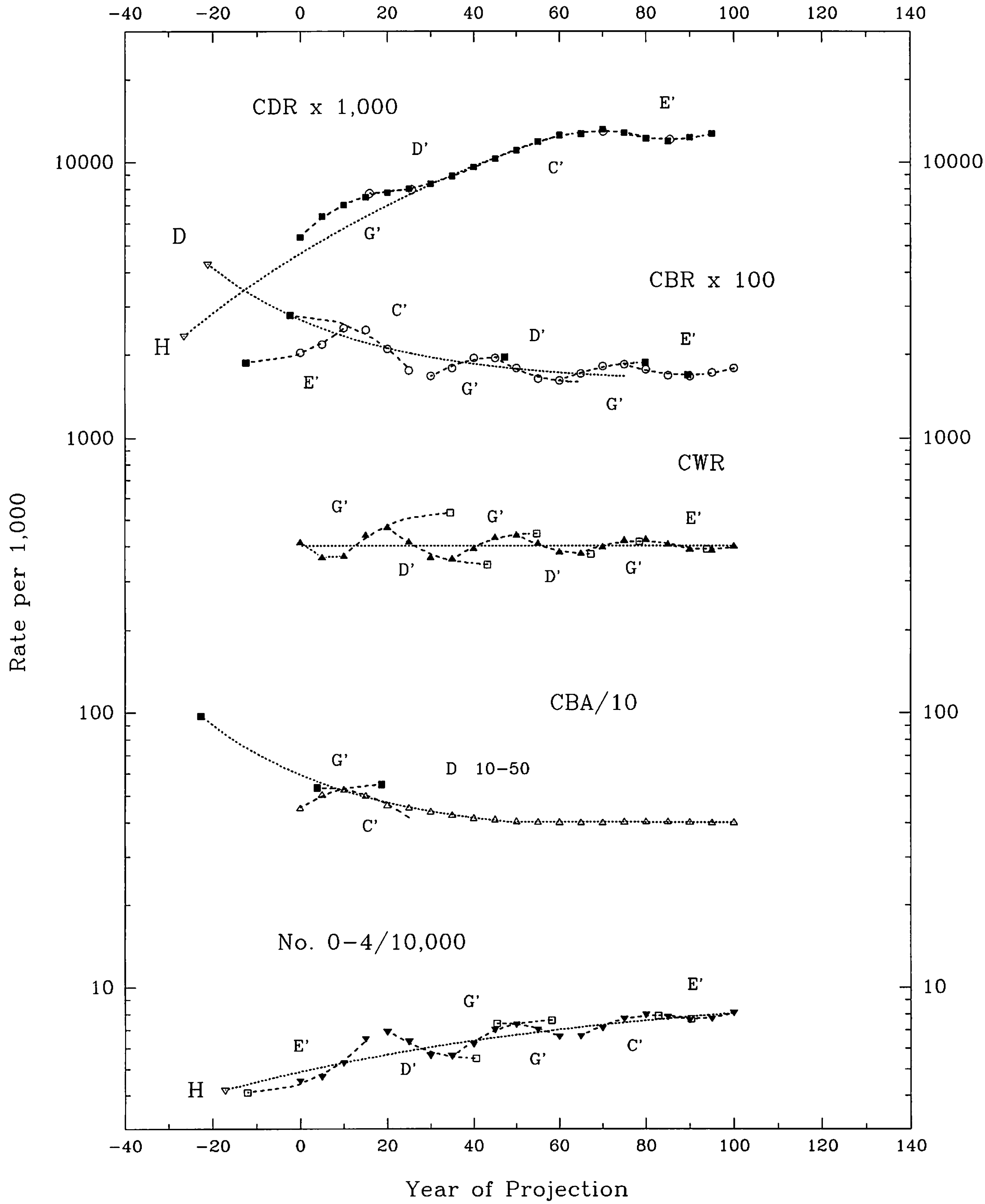
Demographic Trends Accompanying Patterns of Growth: E Followed by near F (Algeria 1965)



Tab. 9.2 has duration of movements.

Figure 9.3b

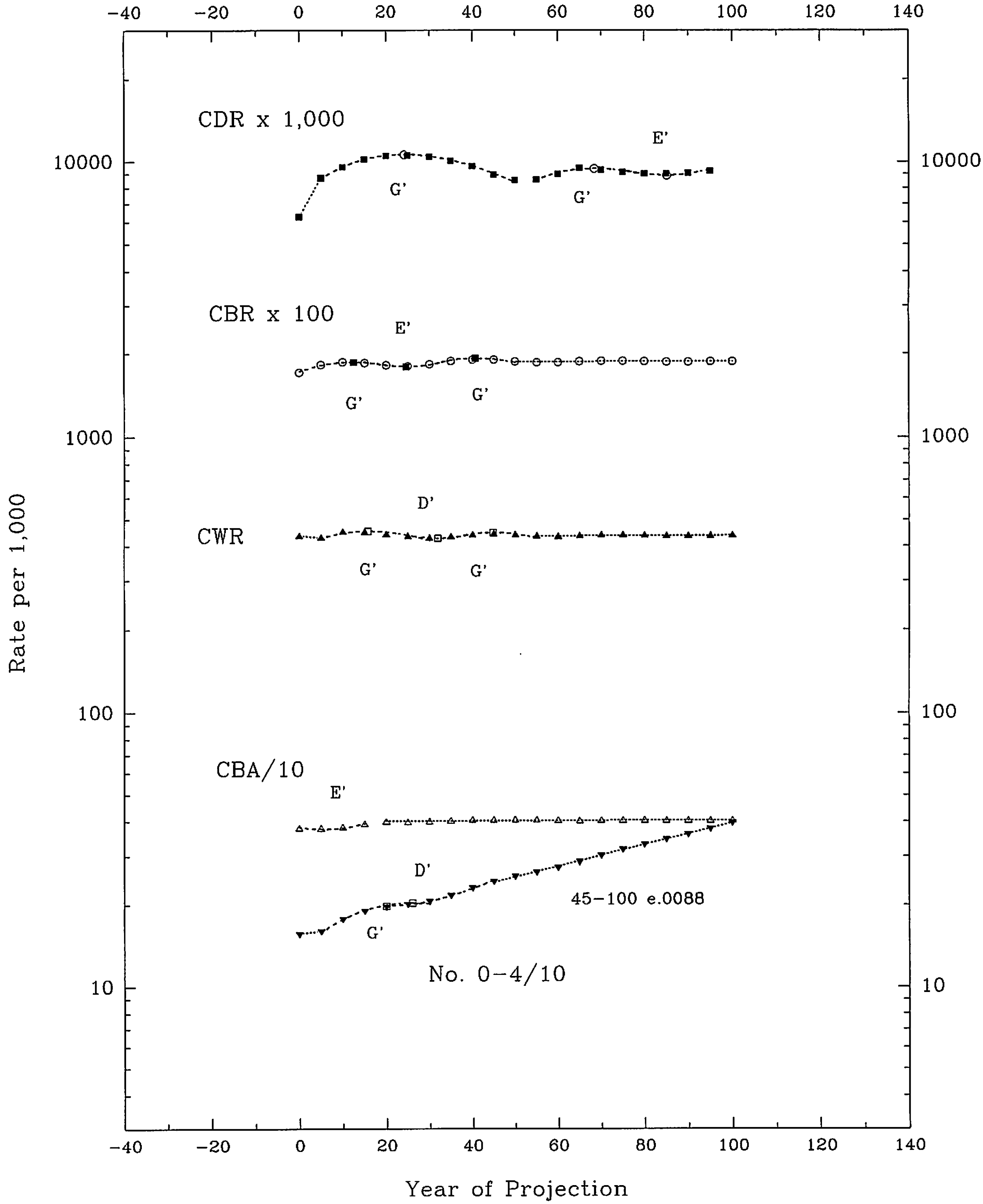
Demographic Trends Accompanying Patterns of Growth: E Followed by H (China 1981)



Tab. 9.2 has duration of derivative movements.

Figure 9.3c

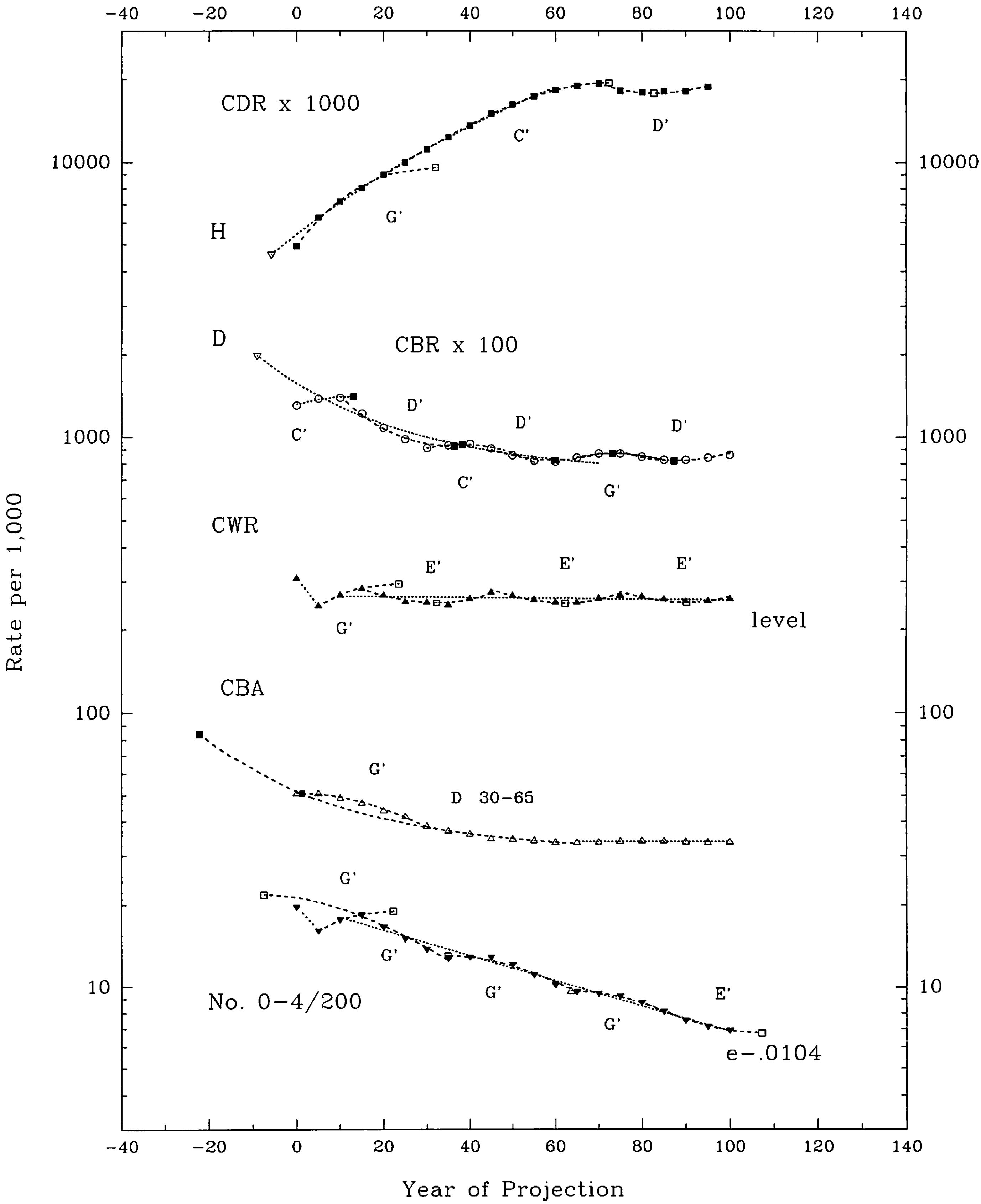
Demographic Trends Accompanying Patterns of Growth: G before E (Norway 1967)



Tab. 9.2 has duration of movements.

Figure 9.3d

Demographic Trends Accompanying Patterns of Growth: G Increase Yielding to C Decline (Japan 1966)

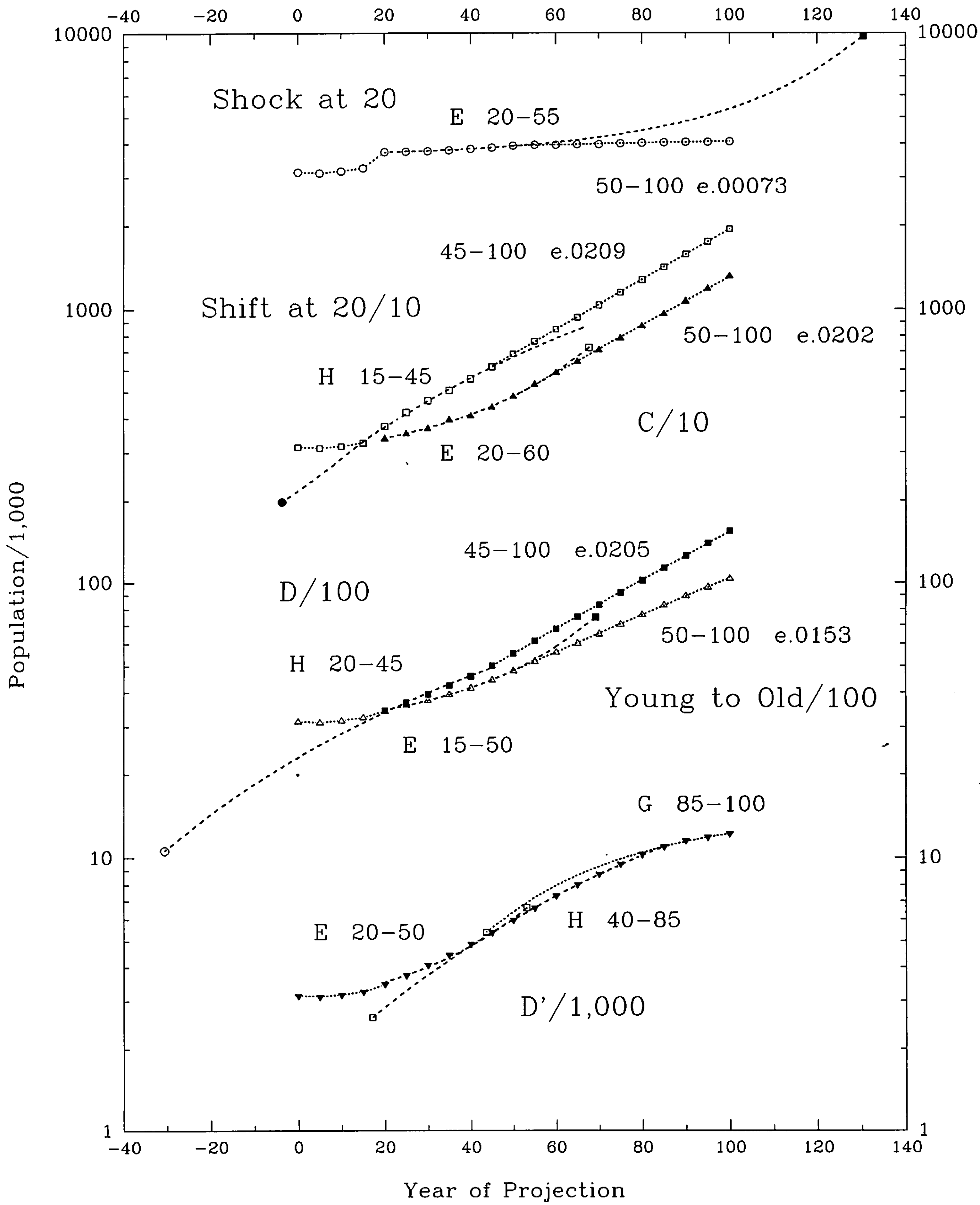


Tab. 9.2 has duration of movements.

{Please note that Figure 9.3 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.3a

Population Projections When Mortality Is Halved: Trends for a Pre-Transition Model

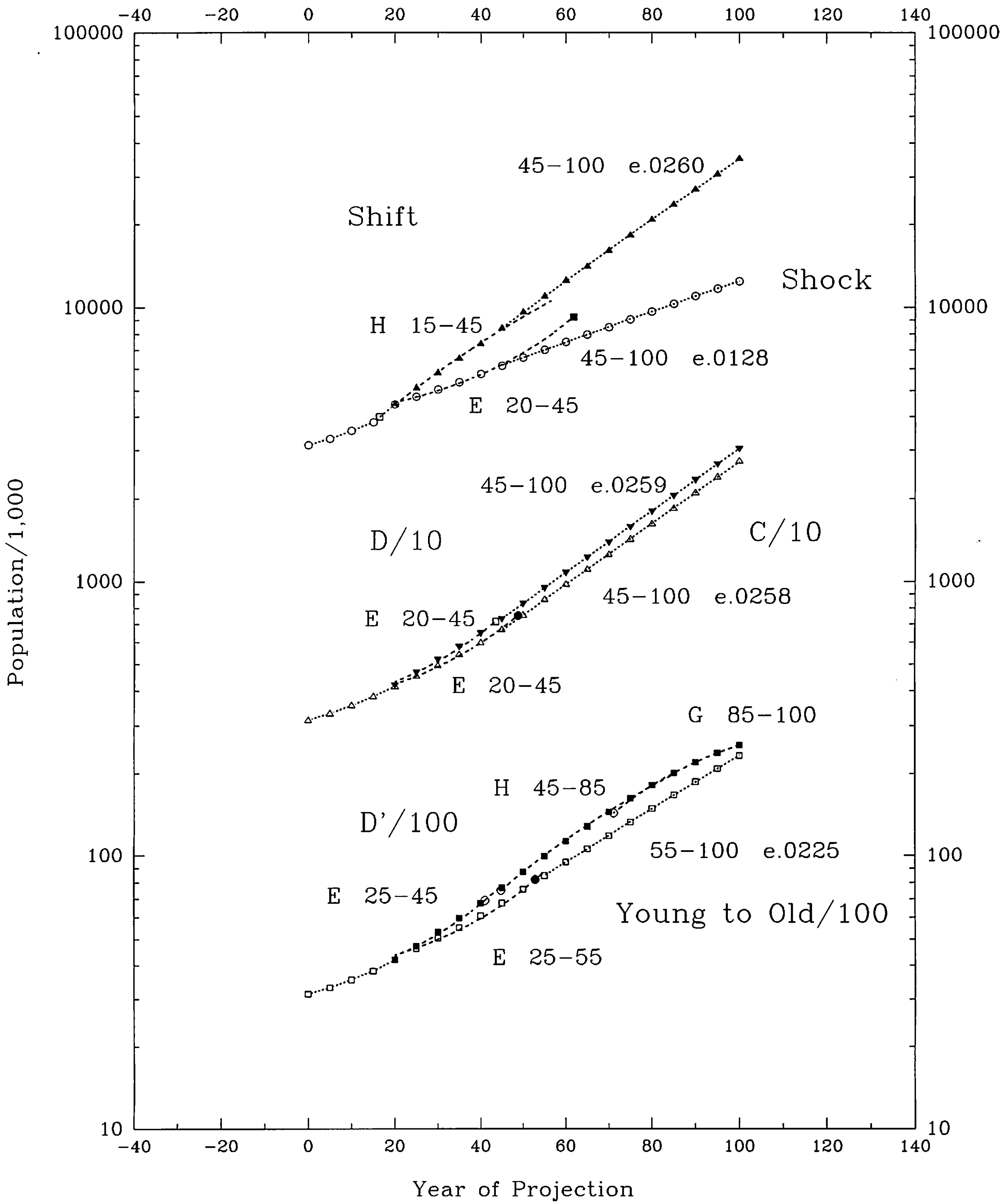


Sources: Tab. 9.3 and text.

{Please note that Figure 9.3 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.3b

Population Projections When Mortality Is Halved: Trends for a Population That Has Begun Transition

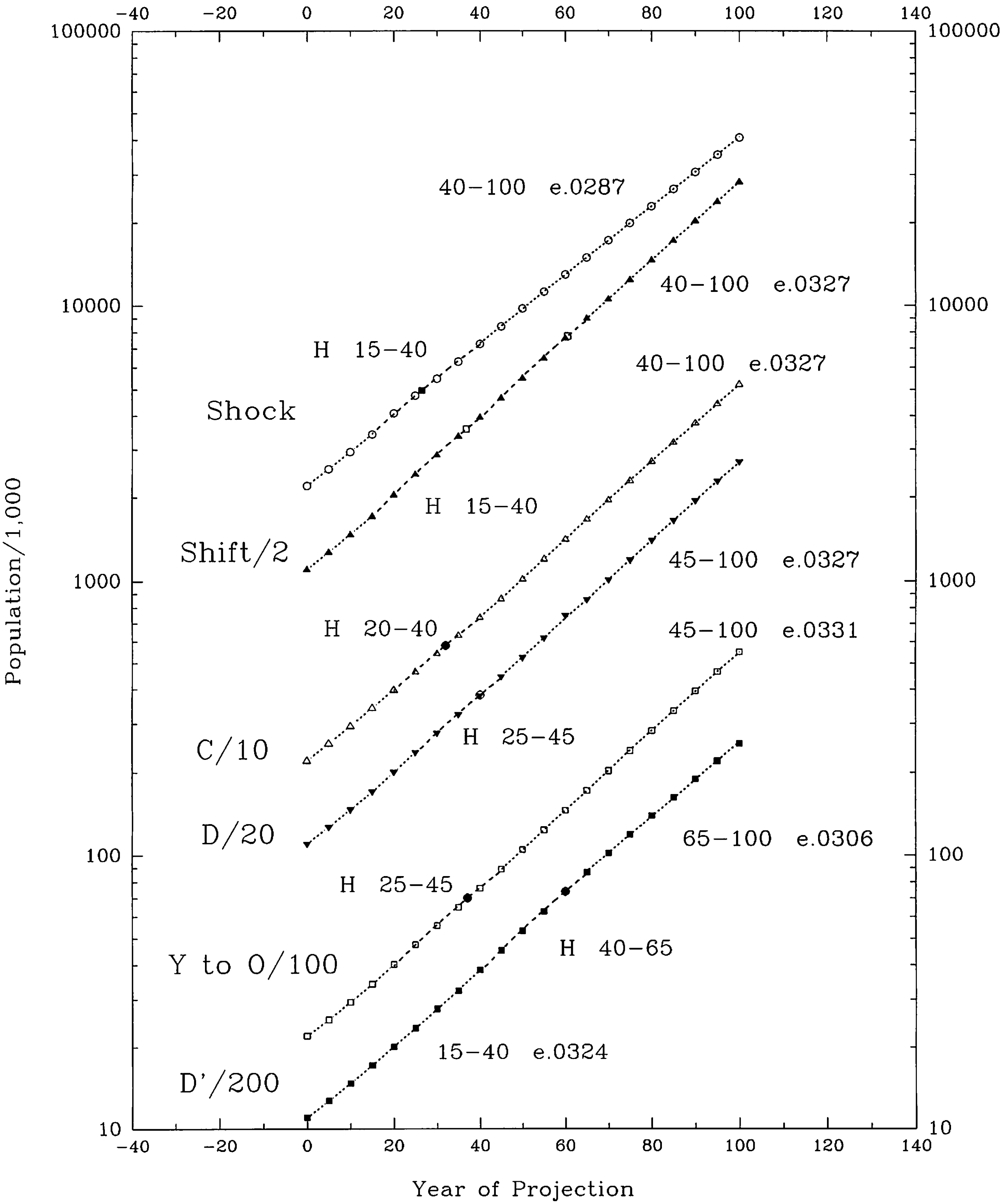


Source: Keyfitz and Flieger 1971, 312 (Madagascar females 1966).

{Please note that Figure 9.3 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.3c

Population Projections When Mortality Is Halved: In a Population at the Peak of Transition

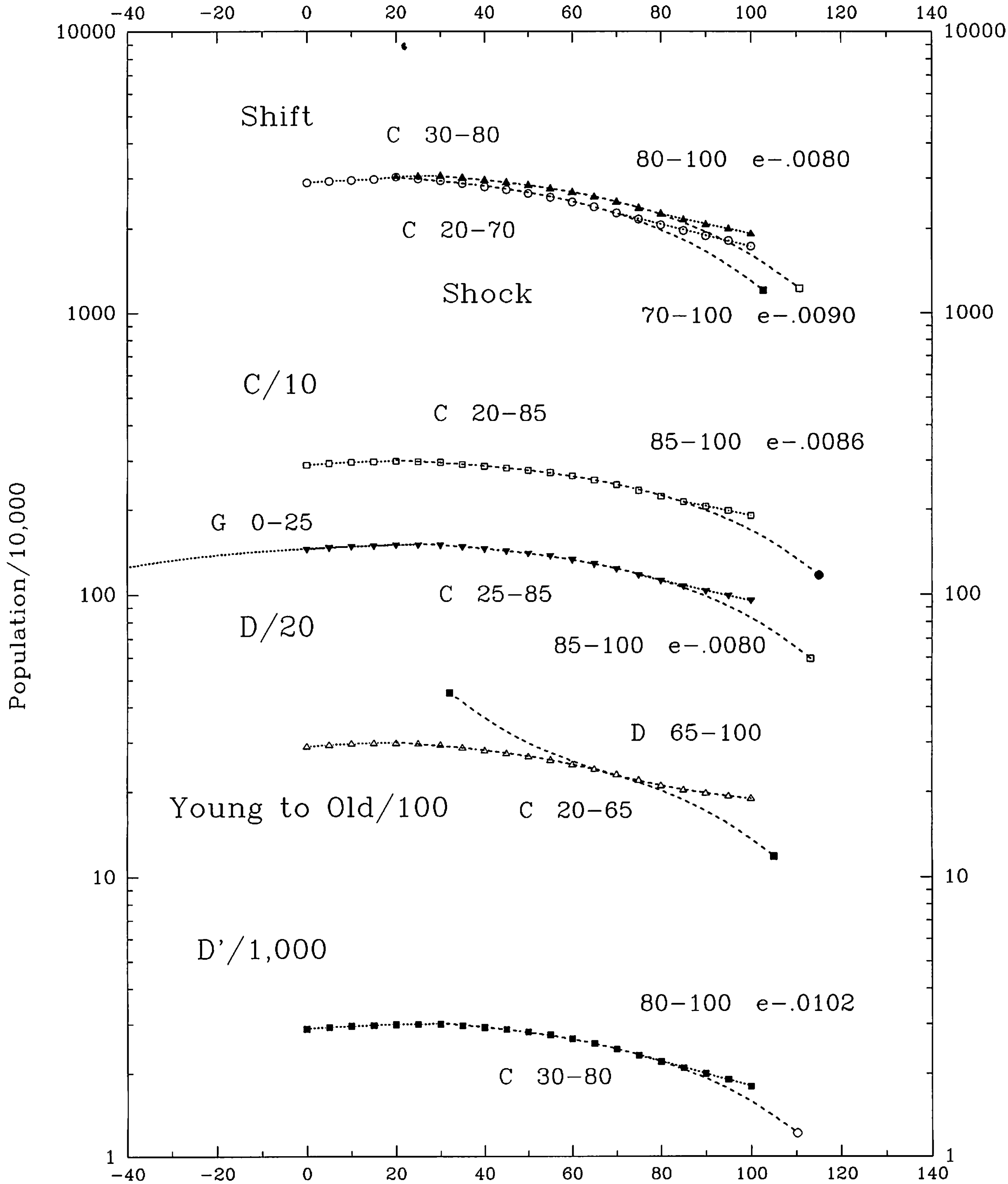


Source: Keyfitz and Flieger 1971, 344 (Mexico females 1966).

{Please note that Figure 9.3 has two iterations. This is the second one. The text of Chapter 9 and Chapter M provides some guidance. MSW 31 July 2015}

Figure 9.3d

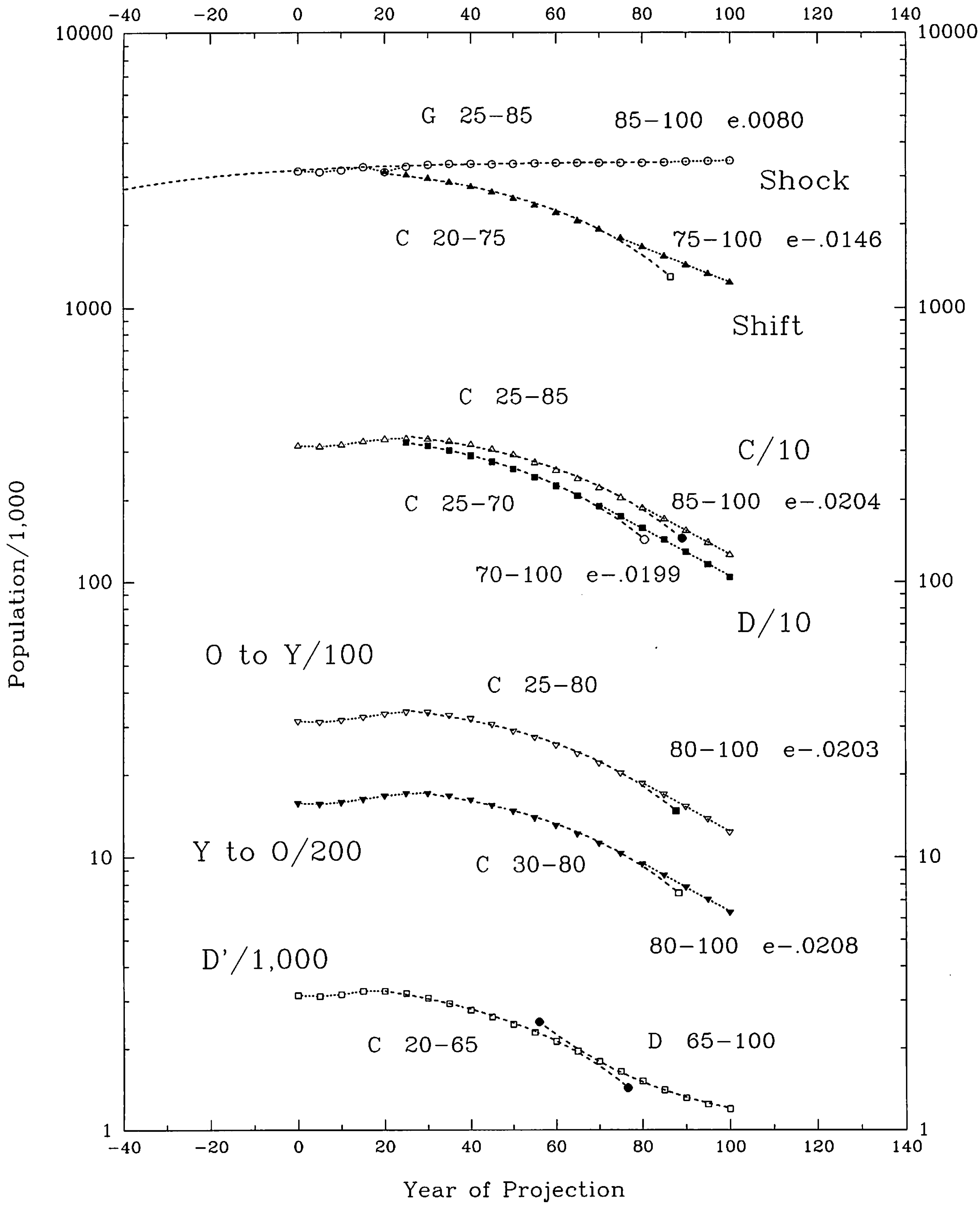
Population Projections When Mortality Is Halved:
A Population that Has Gone Through Transition



Source: Keyfitz and Flieger 1990, 479 (Italy females) 1980).

Figure 9.4a

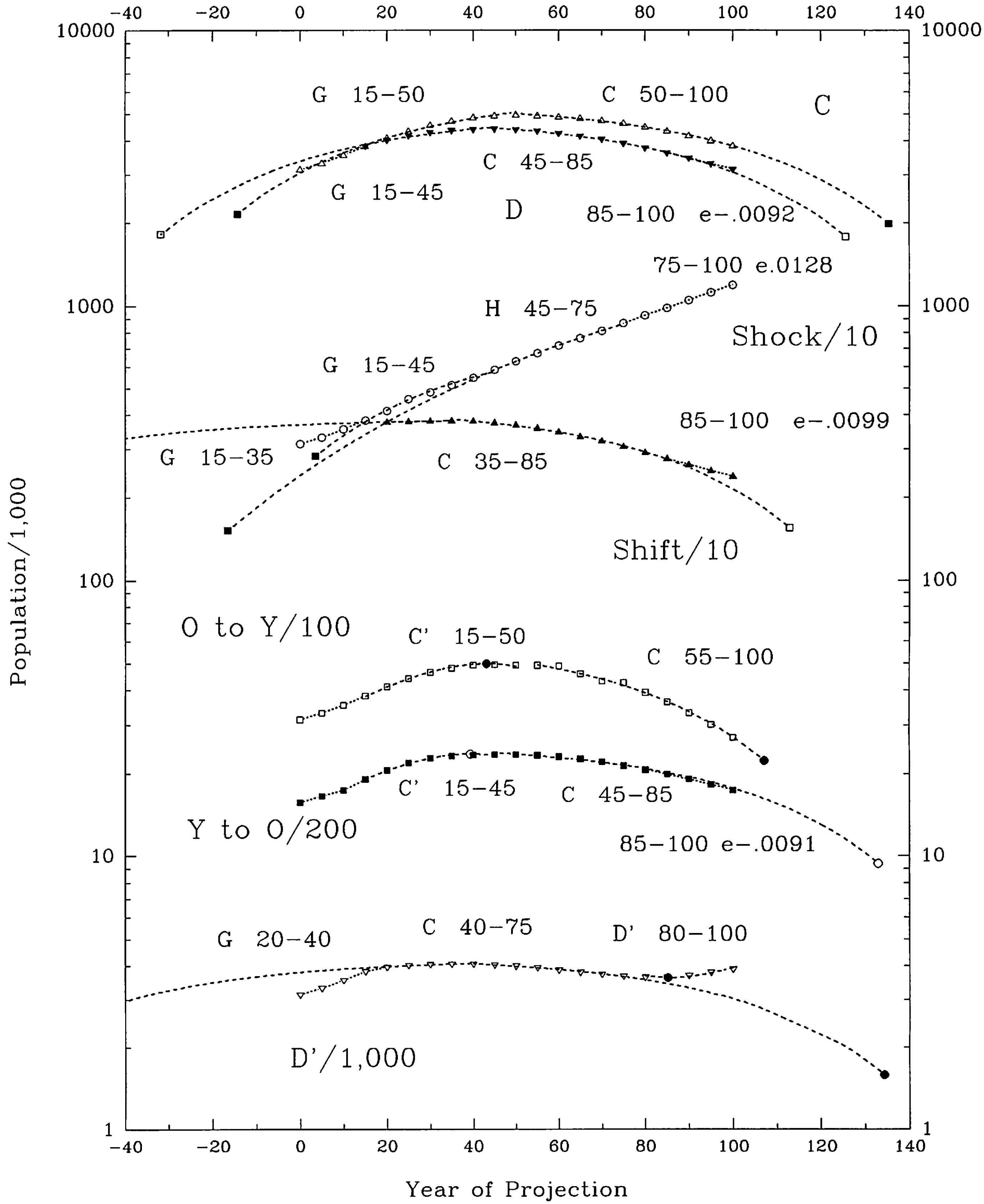
Population Projections When Fertility Is Halved: Trends for a Pre-Transition Model



Sources: Tab. 9.3 and text.

Figure 9.4b

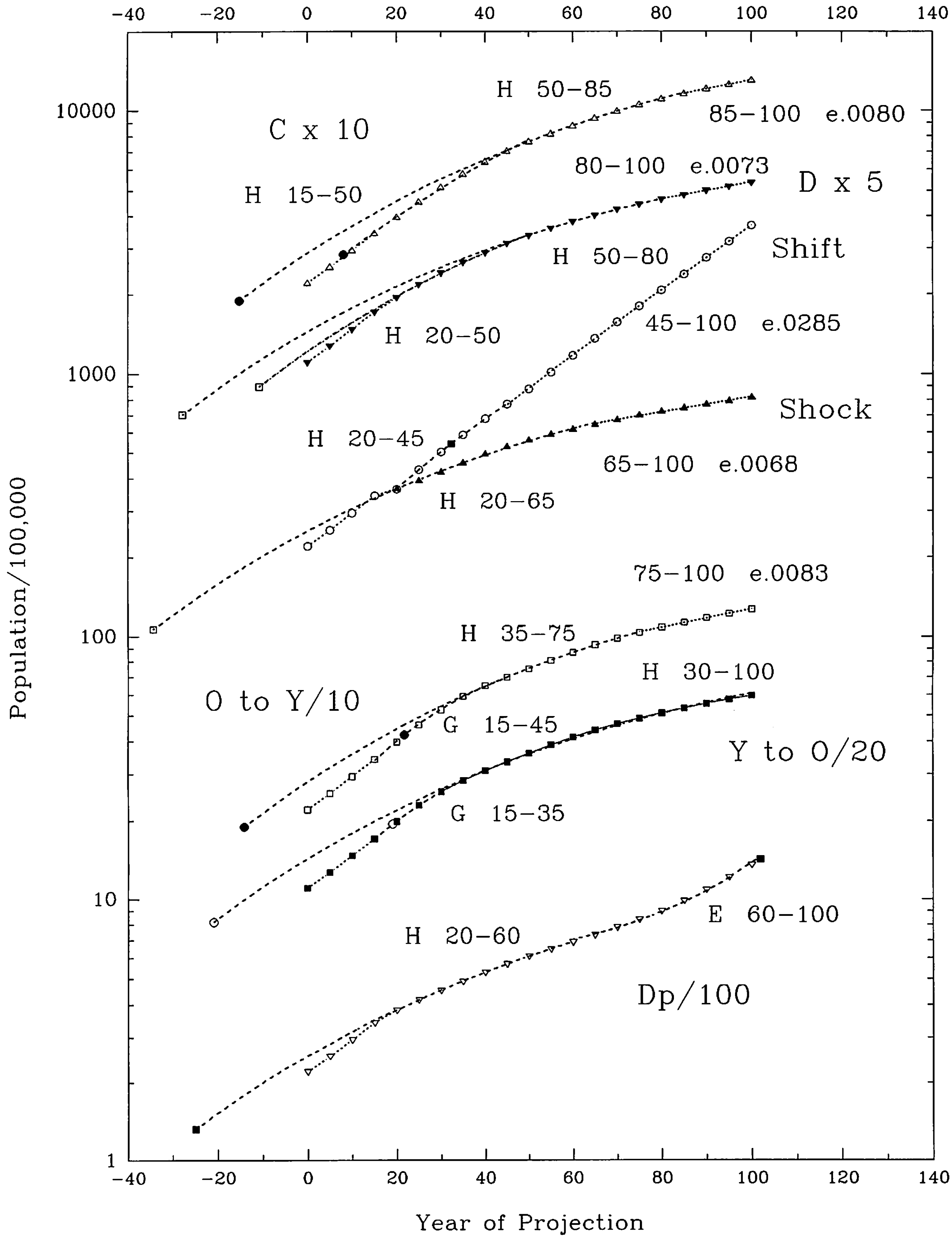
Population Projections When Fertility Is Halved: Patterns for a Population Early in Transition



Source: Keyfitz and Flieger 1971, 312 (Madagascar females 1966)

Figure 9.4c

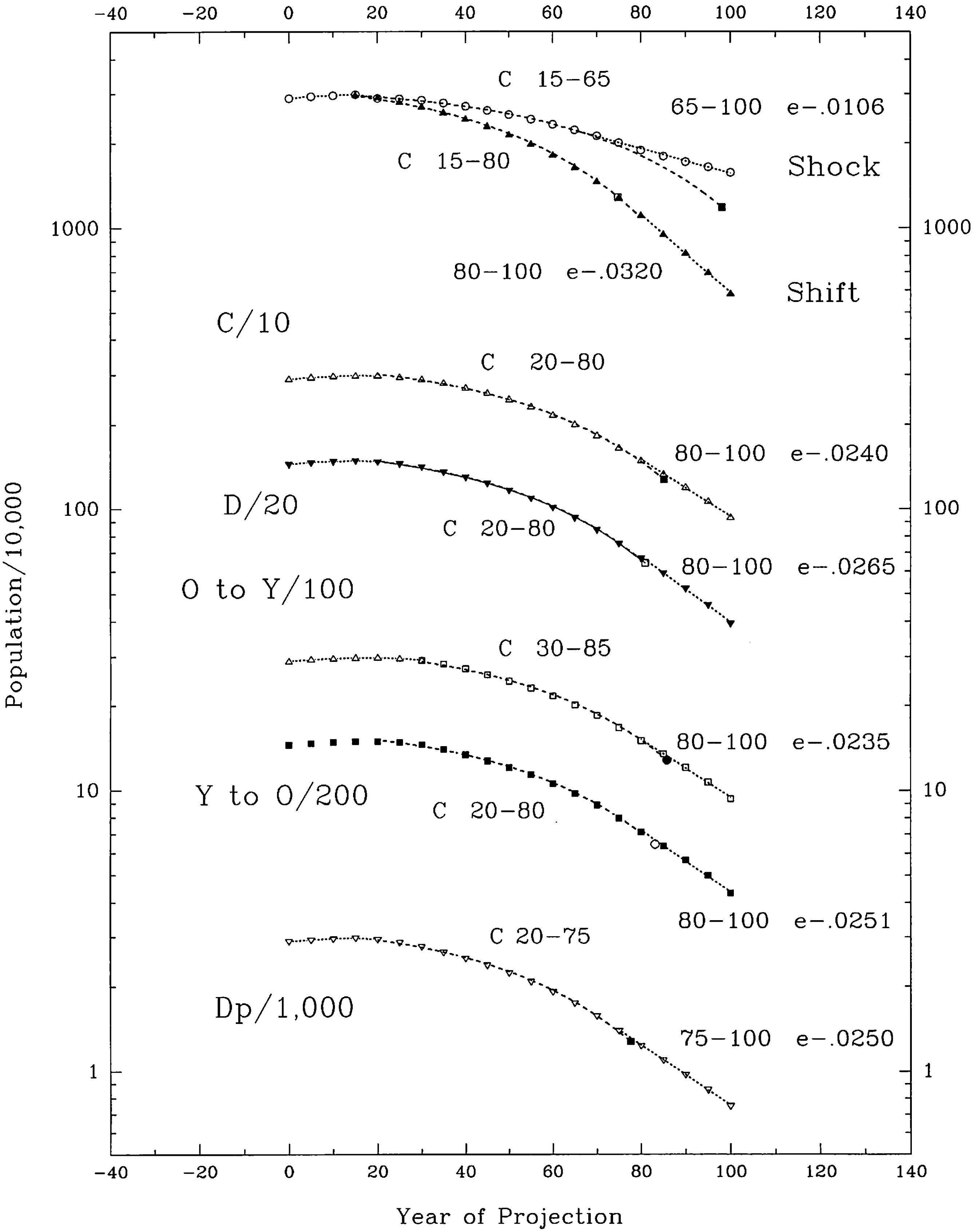
Population Projections When Fertility Is Halved:
Trends at the Peak of Transition



Source: Keyfitz and Flieger 1971, 344 (Mexico females 1966)

Figure 9.4d

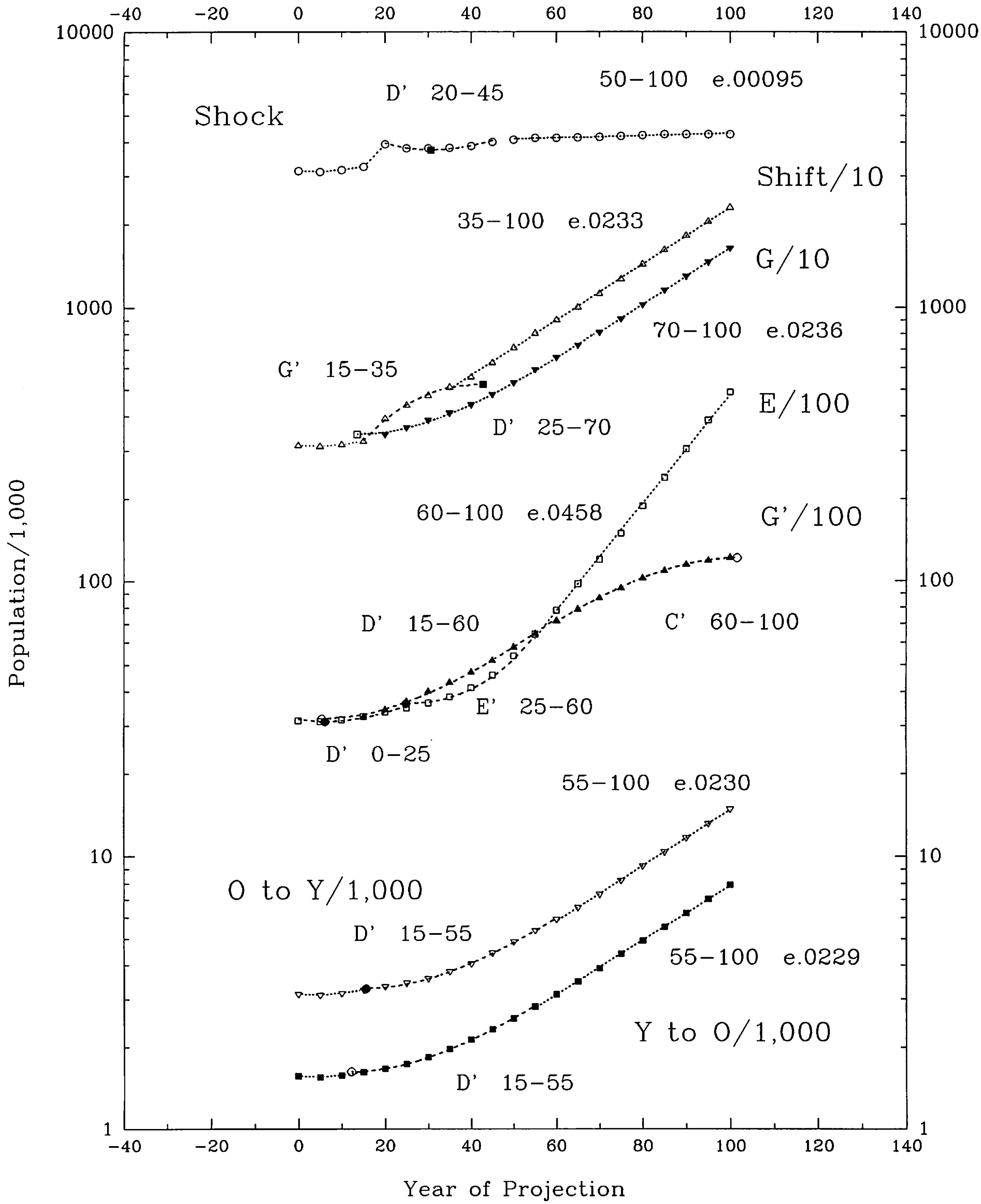
Population Projections When Fertility Is Halved: Results for a Population Past Transition



Source: Keyfitz and Flieger 1990, 479 (Italy females 1980).

Figure 9.5a

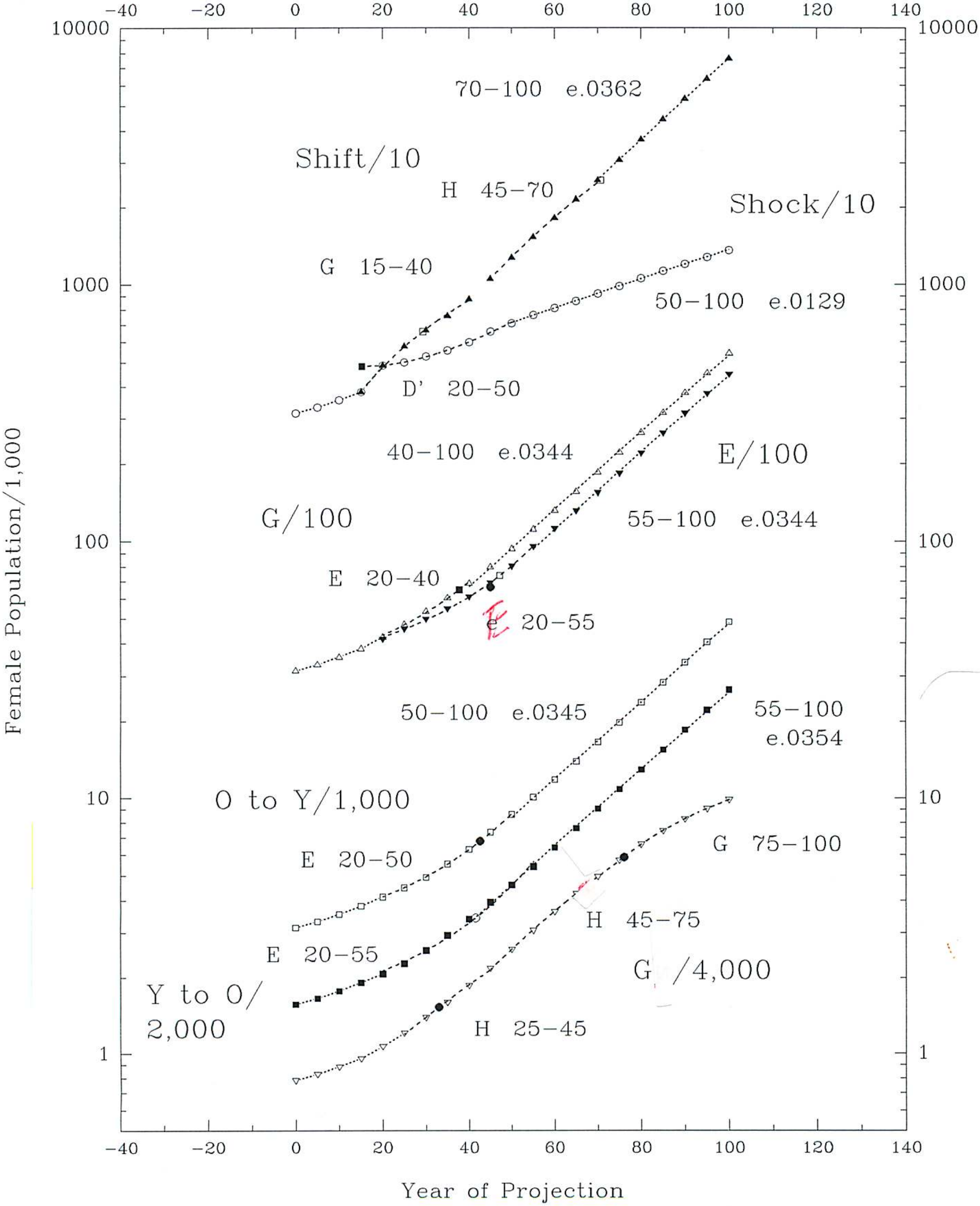
Population Projections When Fertility Is Doubled: In a Pre-Transition Model



Source: Tab. 9.3 and text.

Figure 9.5b

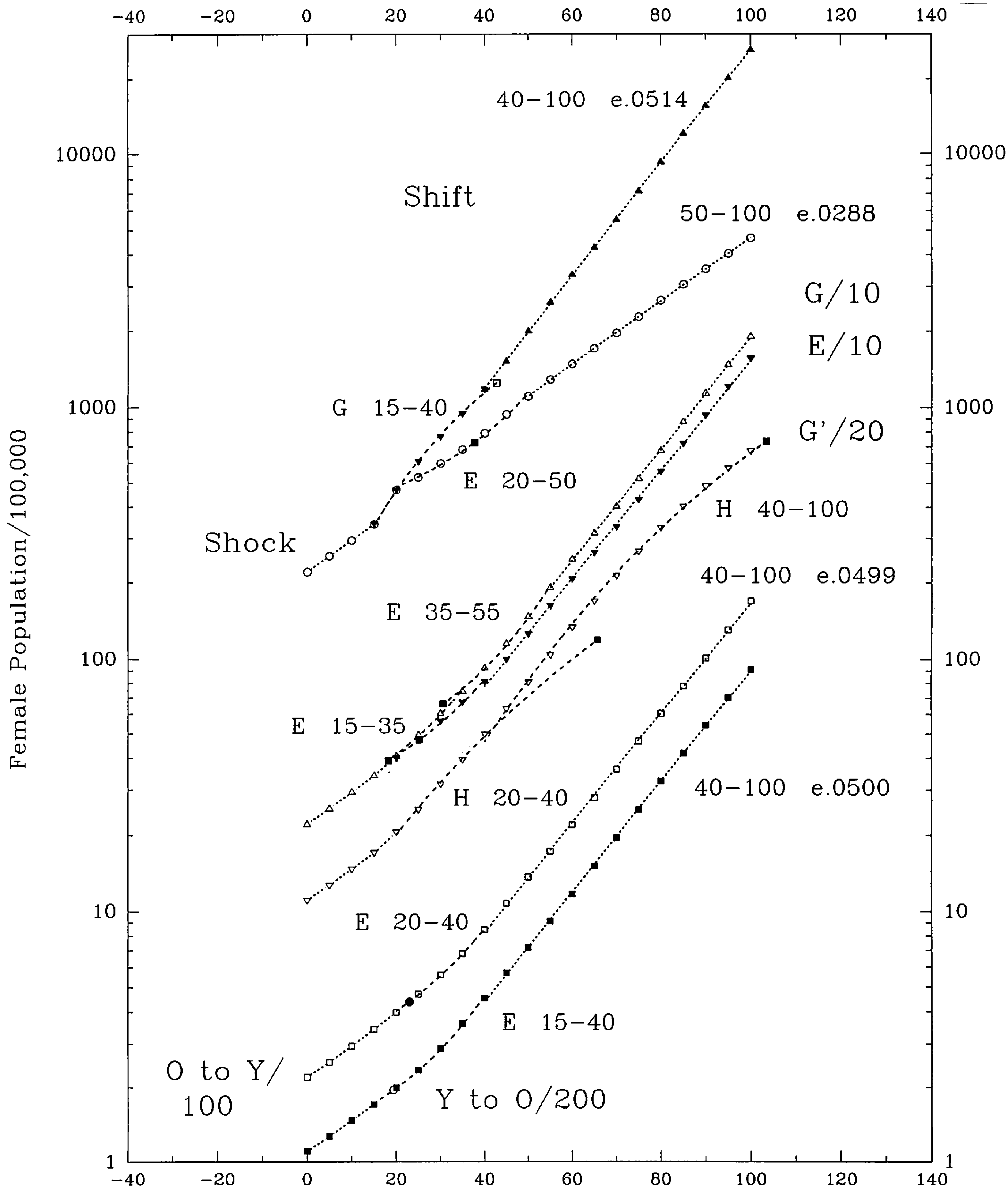
Population Projections When Fertility Is Doubled: Early in Transition



Source: Keyfitz and Flieger 1971, 312 (Madagascar females 1966)

Figure 9.5c

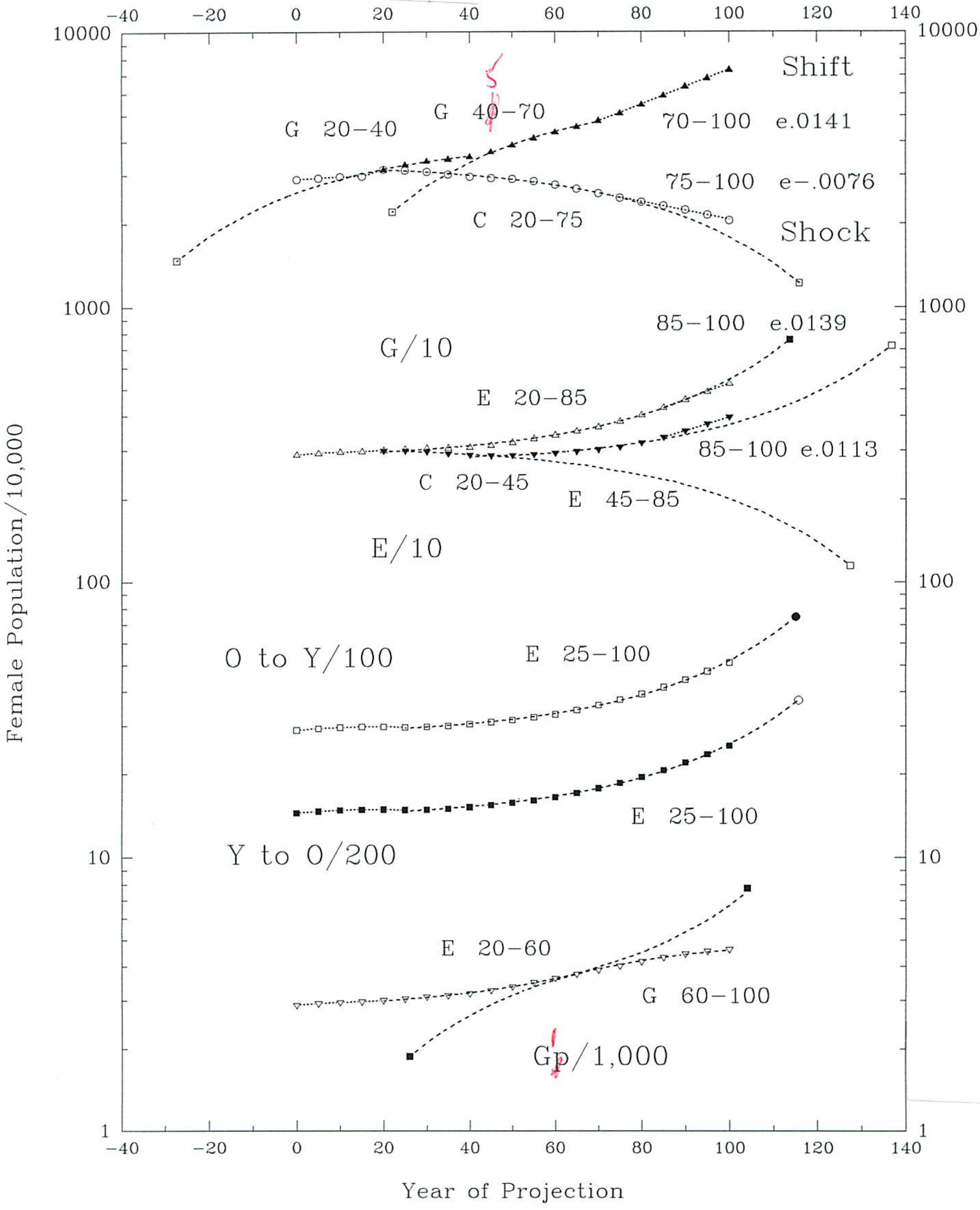
Population Projections When Fertility Is Doubled: At the Peak of Transition



See Tab.9.7 for omitted labels of G and E types of increase.
Source: Keyfiitz and Flieger 1971, 344 (Mexico females 1966)

Figure 9.5d

Population Projections When Fertility Is Doubled: Post-Transition



Source: Keyfitz and Flieger 1990, 479 (Italy females 1980)

Figure 9.6z
Changing Vital Rates and Age Structure: D' Population Dip in Pre–Transition Model

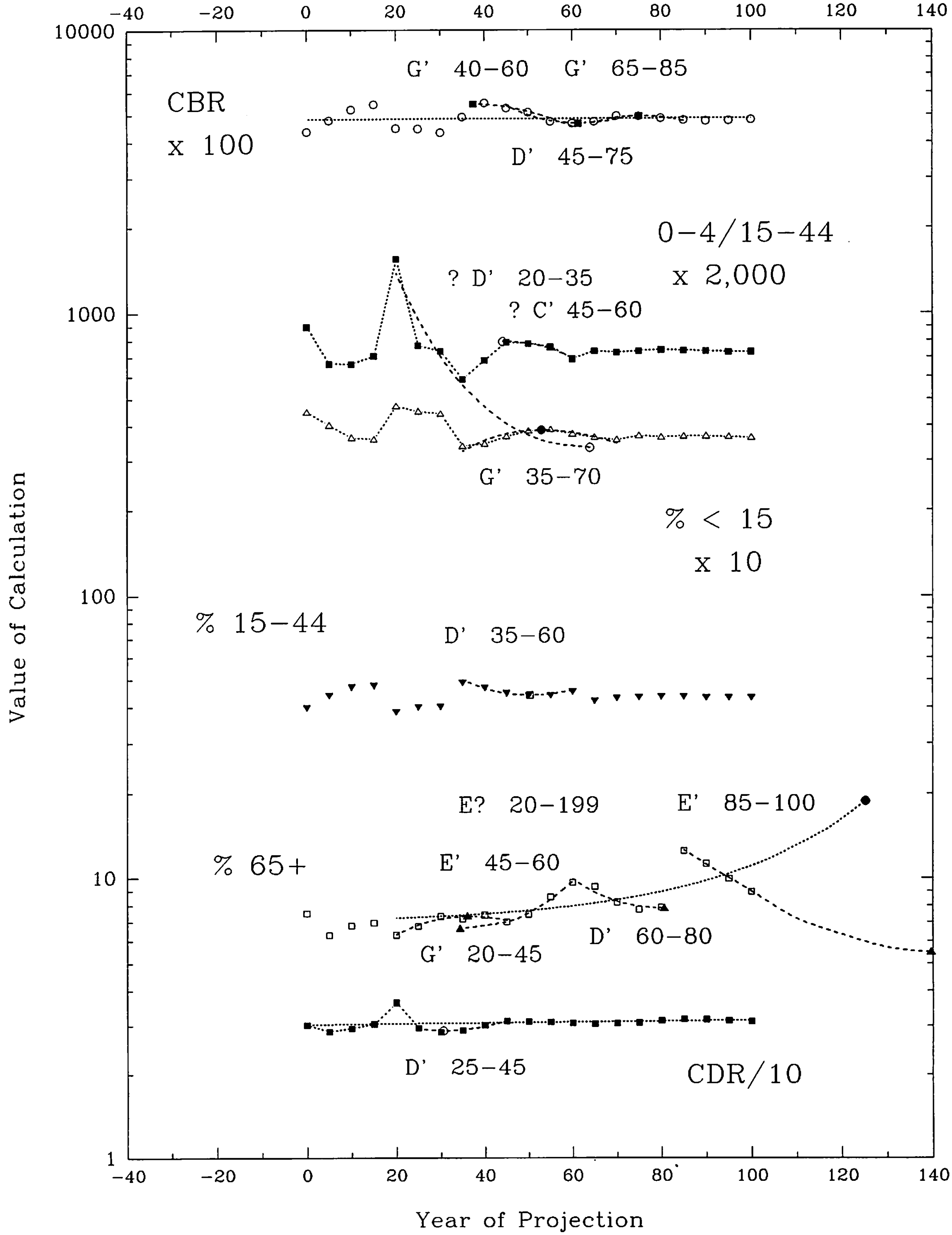


Table 9.1

Age Structures of Female Populations with Diverse Patterns of Growth

A. E-Shape Acceleration Followed Only by Log-Linear Increase

Mexico 1966	2-52	$e^{-.0364}$								52-82	C'	27
Algeria 1965	2-12	D'	38	7-22	C'	-18	22-47	C'	10	47-82	C'	32
Madagascar 1966	2-12	D'	34	7-22	C'	-17	22-52	C'	16	52-82	C'	27
East Germany 1967				7-22	C'	-5	27-52	D'	49	72-82	C'	27
							57-72	C'	43			

B. E Beginning Followed by H or G before Going Log-Linear

China 1981 (H)	2-12	G'	32	12-37	C'	-2	37-72	C'	32	72-87	C'	22
W. Cam. 1964 (G)	2-22	D'	40				22-67	C	25	67-82	C'	5

C. E Only after G during Early Years of Projection

Norway 1967	2-22	C	89	22-32	D'	56	32-47	G'	57	67-87	C'	33
	47-62											

D. G-Form Expansion Yielding to C-Shape Contraction

Japan 1966	7-17	E'	-15	22-47	C'	19	47-72	C'	32	72-87	C'	27
Italy 1980	2-12	G'	27	17-37	D'	38[a]	37-67	G'	46[b]	72-87	C'	32
U.S.A. 1985	7-22	E'	0	27-47	C'	14	52-62	?G'	61	62-77	C'	40

[a] = w/o 32; [b] = w/o 62.

Table 9.3

Approximating Pre-Modern Populations

A. Moderate Growth

	Madagascar 1966 F		England 1816	England 1821
CBR	43.5	:	41.9	40.8
CDR	24.6	:	25.5	24.1
CRNI	18.9	:	16.4	16.6
Age Structure:				
	2-22 C -1	:	2-20 $e^{.0296}$	5-45 $e^{.0274}$
	22-57 C 42	:	20-55 C 42	-
	52-82 C' 26	:	42-75 C' 28	45-75 C' 28
l_x:		:	Breslau 1693	
	10-45 C 54	:	10-55 C 52	
	50-70 C' 35	:	45-75 C' 29	

	England 1861	Sweden 1750	Sweden 1820
CBR	36.2	37.1	35.8
CDR	21.9	26.3	22.1
CRNI	14.3	10.8	13.7
Age Structure:			
	10-42 C 40	12-45 C 45	17-62 C 54
	42-75 C' 27	45-77 C' 31	45-77 C' 29
l_x:			
	10-60 C 71	10-55 C 64	?
	65-80 C' 31	40-80 C' 30	?

Table 9.3 (cont.)

Approximating Pre-Modern Populations

B. Slow Growth

	Modified Mad.*	:	France 1750	France 1800
CBR	43.5	:	39.8	32.9
CDR	43.4*	:	35.8	30.6
CRNI	0.1	:	4.0	2.3
Age Structure:				
	17-37 C 42**	:	7-47 C 48	12-47 C 58
	42-67 C' 27**	:	32-82 C' 25	37-77 C' 28
l_x:		:	Breslau 1693	
	10-45 C 54	:	10-55 C 52	
	50-70 C' 35	:	45-75 C' 29	

	England 1561	England 1656	England 1686	England 1726
CBR	34.7	28.9	32.9	32.9
CDR	32.9	28.7	31.4	31.6
CRNI	1.8	0.2	1.5	1.3
Age Structure:				
	10-42 C 39	10-55 C 52	10-55 C 61	10-55 C 54
	42-75 C' 29	42-75 C' 30	42-75 C' 30	42-75 C' 30
l_x:			Breslau 1693	
			10-55 C 52	
			45-75 C' 29	

* Age-specific mortality of 1966 x 1.4; age-specific fertility and initial age structure retained.
** Approximate eventual age structure after several decades.

Sources: Tabs. 8.5, 8.6, 9.1; Keyfitz and Flieger 1971, 312; Wrigley and Schofield 1980, 528-29; France?; Sweden?.

Table 9.4

Female Population Projections When Mortality Is Increased*

A. Pre-Transition (Madagascar 1966 with ASDR x 1.4)

Momentum	15-50	G	-52				50-100	$e^{.0007}$
Shock	20-45	G'	29				45-100	$e^{.0005}$
Shift	15-30	D'	50	30-55	C	28	55-100	$e^{-.0545}$
G	20-50	C'	17				50-100	$e^{-.0522}$
G' t_0+	15-50	D	37				55-95	D 27
Full G'	15-50	C'	11				55-100	D 76

B. Early Transition (Madagascar 1966)

Momentum				20-100	$e^{.0129}$
Shock	20-45	G	6	45-100	$e^{.0126}$
Shift	20-50	C	57	50-100	$e^{.0224}$
G	15-65	G'	29	60-100	$e^{.0188}$
G' t_0+	15-55	D	-5	50-100	E 119
Full G'	20-60	G'	21	60-100	E' 85

C. Peak Transition (Mexico 1966)

Momentum				20-100	$e^{.0289}$
Shock	20-40	G	31	40-100	$e^{.0286}$
Shift	15-40	H	0	40-100	$e^{.0235}$
G	15-60	H	15	60-100	$e^{.0248}$
G' t_0+	15-40	E	38	40-100	$e^{.0279}$
Full G'	20-55	H	8	55-100	$e^{.0249}$

D. Post-Transition (Italy 1980)

Momentum	15-70	C	104				60-100	$e^{-.0090}$
Shock	20-45	G	-29	45-65	C	109	65-100	$e^{-.0094}$
Shift	15-50	C	87				50-100	$e^{-.0100}$
G	15-65	C	90				65-100	$e^{-.0102}$
G' t_0+	15-55	D	-25	55-80	C	115	55-100	$e^{-.0088}$
Full G'	14-55	C	81				55-100	$e^{-.0085}$

* All changes begin with 20th year. Age-specific mortality doubled except for 10 times shock at year 20 for Italy.

Sources: Figs. 9.2a through 9.2e; Tab. 9.3; Keyfitz and Flieger 1971, 312, 344; 1990, 479.

Table 9.5

Trends in Female Population Size from Some Different Ways of Halving Mortality

A. Pre-Transition									
Shock	20-55	E	131				50-100	$e^{.0007}$	
Shift	15-45	H	-4				45-100	$e^{.0209}$	
C	20-60	E	68				50-100	$e^{.0202}$	
D	20-45	H	-31				45-100	$e^{.0205}$	
Y to 0	15-50	E	69				50-100	$e^{.0153}$	
D'	20-50	E	53	40-85	H	18	85-100	G	44
B. Early Transition									
Shock	20-45	E	62				45-100	$e^{.0128}$	
Shift	15-45	H	16				45-100	$e^{.0260}$	
C	20-45	E	49				45-100	$e^{.0258}$	
D	20-45	E	44				45-100	$e^{.0259}$	
Y to 0	25-55	E	53				55-100	$e^{.0225}$	
D'	25-45	E	40	45-85	H	45	85-100	G	71
C. Peak Transition									
Shock	15-40	H	37				40-100	$e^{.0287}$	
Shift	15-40	H	37	40-65	H	61	65-100	$e^{.0327}$	
C	20-40	H	32				40-100	$e^{.0327}$	
D	25-45	E	41				45-100	$e^{.0327}$	
Y to 0	20-45	H	37				45-100	$e^{.0331}$	
D'	15-40	$e^{.0324}$		40-65	H	62	65-100	$e^{.0306}$	

D. Post-Transition

Shock	20-70	C	103				70-100	$e^{-.0090}$	
Shift	0-30	G	-52*	30-80	C	111	80-100	$e^{-.0080}$	
C	20-85	C	115				85-100	$e^{-.0076}$	
D	25-85	C	113				85-100	$e^{-.0080}$	
Y to O	20-65	C	105				65-100	D	22
D'	30-80	C	110				75-100	$e^{-.0102}$	

* Illustration. Other types of change may produce temporary continuation of the 0 through 15 trend, not necessarily in G form.

Sources: Figs. 9.3a through 9.3d.

Table 9.6

Trends in Population Size from Certain Methods of Halving Fertility

A. Pre-Transition

Shock	25-85	G	-89				85-100	$e^{.0080}$	
Shift	20-75	C	87				75-100	$e^{-.0146}$	
C	25-85	C	90				85-100	$e^{-.0204}$	
D	25-70	C	81				70-100	$e^{-.0149}$	
O to Y	25-80	C	88				80-100	$e^{-.0203}$	
Y to O	30-80	C	88				80-100	$e^{-.0208}$	
D'	20-65	C	77				65-100	D	56

B. Early Transition

Shock	15-45	G	4	45-75	H	-17	75-100	$e^{.0128}$	
Shift	15-35	G	-101	35-85	C	112	85-100	$e^{-.0099}$	
C	15-50	G	-14	50-100	C	135		-	
D	15-45	G	-32	45-85	C	128	85-100	$e^{-.0092}$	
O to Y	15-50	C'	43	55-100	C	107		-	
Y to O	15-45	C'	39	45-85	C	133	85-100	$e^{-.0091}$	
D'	20-40	G	-75	40-75	C	134	80-100	D'	84

C. Peak Transition

Shock	20-45	H	32				45-100	$e^{.0285}$
Shift	20-65	H	-34				65-100	$e^{.0068}$
C	15-50	H	8	50-85	H	-15	85-100	$e^{.0080}$
D	20-50	H	-11	50-80	H	-28	80-100	$e^{.0073}$
O to Y	15-45	G	22	35-75	H	-14	70-100	$e^{.0083}$
Y to O	15-35	G	19	30-100	H	-21		-
D'	20-60	H	-25	60-100	E	101		

D. Post-Transition

Shock	15-65	C	96				65-100	$e^{-.0106}$
Shift	15-80	C	75				80-100	$e^{-.0320}$
C	20-80	C	85				80-100	$e^{-.0240}$
D	20-80	C	81				80-100	$e^{-.0265}$
O to Y	30-85	C	86				85-100	$e^{-.0235}$
Y to O	20-80	C	83				80-100	$e^{-.0251}$
D'	20-75	C	78				75-100	$e^{-.0250}$

Sources: Figs. 9.4a, 9.4b, 9.4c, 9.4d.

Table 9.7

Female Population Projections When Fertility Is Doubled

A. Pre-Transition

Shock	20-45	D'	31				50-100	$e^{.0010}$
Shift	15-35	G'	43				35-100	$e^{.0233}$
G	25-70	D'	14				70-100	$e^{.0236}$
E	0-25	D'	6	25-60	E'	25	60-100	$e^{.0458}$
O to Y	15-55	D'	18				55-100	$e^{.0230}$
Y to O	15-55	D'	12				55-100	$e^{.0229}$
G'	15-60	D'	5				60-100	C' 102

B. Early Transition

Shock	20-50	D'	15				50-100	$e^{.0129}$
Shift	15-40	G	29	45-70	H	71	70-100	$e^{.0362}$
G	20-40	E	38				40-100	$e^{.0344}$
E	20-55	E	47				55-100	$e^{.0344}$
O to Y	20-50	E	43				50-100	$e^{.0345}$
Y to O	20-55	E	42				55-100	$e^{.0354}$
G'	20-45	H	33	45-75	H	66	75-100	G 76

C. Peak Transition

Shock	20-50	E	38				50-100	$e^{.0288}$	
Shift	15-40	G	43				40-100	$e^{.0517}$	
G	15-35	E	??	35-55	E	31	55-100	$e^{.0509}$	
E	20-40	E	25				40-100	$e^{.0492}$	
O to Y	20-40	E	23				40-100	$e^{.0499}$	
Y to O	15-40	E	16				40-100	$e^{.0500}$	
G'	20-40	H	66				40-100	H	104

D. Post-Transition

Shock	20-75	C	116				75-100	$e^{-.0076}$	
Shift	20-40	G	-27	45-70	G	22	70-100	$e^{.0141}$	
G	20-85	E	114				85-100	$e^{.0134}$	
E	20-45	C	127	45-85	E	137	85-100	$e^{.0113}$	
O to Y	25-100	E	115						
Y to O	25-100	E	116						
G'	20-60	E	104				60-100	G	26

Sources: Figs. 9.5a, 9.5b, 9.5c, 9.5d.

Chapter 10

The Interplay of Demographic and Economic Change: More Insights through the History of England from Early Modern Times to World War I

For many years and in many ways, historians, economists, and demographers have connected population trends to economic conditions and developments. The relationships--which shaped which under what conditions?--have been debated vigorously at least since the later-18th-century era of Adam Smith, Thomas Robert Malthus, and others.

If demographic patterns have *of their own making* repeatedly followed G-based forms, as previous chapters have demonstrated, certain consequences are implied for demonomic interaction. On the one hand, economic shifts, shocks, or stimuli--whether sudden or gradual--will be digested in G-related paths as the experience diffuses through the age structure and the replacement process of populations. As with other alterations of exogenous origin--for example biological attacks or famines--that is just how populations digest change. On the other hand, developments within populations, whatever their origins, will alter the number and type of producers and consumers in ways expected by economic thinking to shape prices, wages, investments, profits, trade, and the adoption of technological change. The demographic change in one of the recurrent G-based patterns will imprint itself upon economic results. From both perspectives economic trends can be expected to parallel demographic ones, which constantly take G-related shapes.

Volume II has already shown how the flows of people in migration take G-based shapes, whether from continent to continent, nation to nation, region to region, or country to town. The marginal G' path has repeatedly been the form of particular movements. These have aggregated into G, H, and E patterns for cumulative relocations of multiple origin and/or destination. The specific and combined flows have taken the same G-based shapes for free persons, contracted workers of one sort or another, and totally unfree slaves. Migrants are workers, investors, consumers, spouses, and parents who both fulfill a need in the current economy and bear consequences for its future. Some examples from western Europe and North America illustrated how broad paths for urbanization, occupational change and shifts among economic sectors, economic growth, and productivity--fundamentals of the rise of modern life--paralled historical demographic increase and the movement of peoples that it involved. Analysis of the international slave trade demonstrated how details of the supply and demand for labor and the business of securing, transporting, and selling Africans evolved along G-related paths over time--including slave prices, international competition, composition of the labor force by sex and age, and the nature of shipping and the trans-Atlantic voyage.

The purpose now is, again employing the seminal and much-studied English case, to illustrate how recognition of the G-type foundation of demographic trends involved can help in depicting and in explaining how demographic and economic changes have interacted in the past, and can be expected to do so in the future. For example, the much-debated fate of workers and their role in the Industrial Revolution (by implication, contemporary cases of economic development) can be better understood. Or, the nature of development during the particular phase from the middle 1700s into the early 1800s can be more profitably compared with real, but different, advances that occurred before (as early as the 1500s) and afterward. The reinterpretation can only be suggestive. But there seem to be some insights with relevance for economic analysis in general.

IMPLICATIONS FOR UNDERSTANDING ECONOMIC AND SOCIAL CHANGE:
THE DEMONOMIC EXAMPLE OF ENGLAND

The G family of trends in demographic change are, as generations of Malthusian and competing analysis would expect, not unrelated in demonomic systems to the paths taken by economic change. Think, simply, of the consequences if the number of consumers or producers independently alters in some G-related form. In fact, patterns of such shape appear in many economic variables. Perceiving the G-based nature of economic as well as demographic movements makes possible a better understanding of how the two types of change are related to each other in a variety of historical circumstances or eras. Again, the English example between about 1550 and 1850 illustrates this point, in four successive and distinct phases, and indicates how such analysis might profitably be applied to other demonomic systems in diverse historical settings. The evidence can be improved and extended--as is being done for more complete and accurate presentation elsewhere. This introductory treatment, nonetheless, should serve to demonstrate the value of examining the G-based characteristics of social and economic developments as well as population change.

Phase I: Gains from Agricultural Improvement ca. 1550-1650

A drop of the crude death rate into the 1570s, which after 1500 exceeded more modest decline in the birth rate, opened up a margin for natural increase in the years to come. As Table P.1 summarizes, the short record of contraction in mortality from the *Population History* that

{Please note that the Figures and Tables referenced in Chapter 10 are not interleafed in the text but appear at the end of the chapter (notes). MSW 31 July 2015}

appears after 1541 in Figure 1.1 seems to have been the culmination of long-term C-shape improvement in the CDR during the 1400s and the first half of the 1500s (R. D. Lee 1973[, 581-607]; fitted in Harris 1997, Fig. 12.2). This was the era that saw the turbulence of the Wars of the Roses give way to the national consolidation of Henry VII and the arrival of the Renaissance in England, followed by a significant transfer of church lands into private hands under Henry VIII. It also witnessed an interest by owners and tenants of land in new and better ways of farming, as evidenced by a G-shape increase in the publication of books on agriculture from the 1520s into the 1560s (Fig. D.4).

The C-shape declines in reproduction and life expectancy and E-type increase in the death rate that followed until the middle of the 1600s then whittled away at the rate of growth that would have been anticipated from the amount of initial excess in births over deaths to give the population a slowly decelerating, not log-linear, trajectory of growth from the 1560s into the 1650s: via H with t_0 at 1461 (Fig. 1.1, Tab. 1.1; Harris 2001, 148, 150-51). The advances in farming that helped improve mortality so as to open up a substantial margin of natural increase for population growth as of the accession of Elizabeth I (Fig. 1.3) continued from the first half of the 16th century forward into the 17th century. Data at 1600 and 1700 for output per acre and output per worker, for example, would in both cases fit H-type change--with zero years at 1438 and 1455 respectively, compared with 1461 for the population growth of England between 1561 and 1656 (Fig. D.6, from Allen 1991, 487). According to Gregory Clark (1991, 447), total grain yields and yields per acre at 1590 and 1700 would both suit H trending only slightly flatter, with zero year in the 1420s.[1]

As the population grew, more of it shifted to towns and cities (Harris 2003, 225); and a rising proportion participated in the emigration that would make England the dominant colonizing and trading power of Europe (Fig. 1.3). Prices, meanwhile, were pushed up by increased demand relative to supply and by the added costs of transporting food and other rural products to urban centers. After rising through the second half of the 1500s via E, from 1599 through 1660 prices advanced in G fashion with zero year at 1571 (Harris 1997, Tab. 12.1, from Phelps Brown and Hopkins), while increasing urbanization in England between 1600 or earlier and 1670 would fit a G curve based about 1582 (Harris 2003, 225, though fitted there in H form based at 1497).[2] This movement to towns and cities, resembles the rise in rate of enclosure for previously unenclosed land, whose pace probably increased from 1550 to 1750 in G fashion with t_0 in the vicinity of 1580 (Harris 1997, Fig. 12.9; based upon Jones 1990, 352).

As an illustration of the regional and local migrations that composed the overall shift from country to town during this era, a G' surge of new, non-native apprentices into Norwich between the 1530s and the first years of the 1700s peaked at 1587 (Harris 2003, 185). The population of London, meanwhile, expanded along a fresh G path between 1580 and 1620 with base year at 1586 as London's interurban reach as a central place ("potential") rose during the second half of the 16th century to rival the leading metropolises of Italy, France, and the Low Countries (Harris 2001, 304-05, 307; 2003, 262, 264). A possible 16th-century G' crest in the deficit of births relative to deaths in the city during the third quarter of the 1500s also reflects a wave of movement into London at this time (Harris 2003, 187). Consequences of the reorganization and relocation taking place in English town and countryside were G' surges in the death rate for all children under 15 and also in extramarital fertility (I_h), the proportion of births that were illegitimate, and the rate of clearly not marginal premarital pregnancy (births within 6 months of marriage), which across the later 1500s and early 1600s all crested near the turn of the century. The prospect of lasting celibacy for young women reaching the age of marriage topped out via G' rather later, about 1610--or 1630 for these women in their early 40s (Figs. 1.4, 1.5).

From 1541 through 1661, meanwhile, the rate of net emigration from England rose slightly more flatly than urbanization in what may be a G path with zero year at 1543 (Fig. 1.3). As noted, H-form alternatives to these two G-shape estimates of trend would have t_0's around 1500 and 1480, respectively. In all, as fewer deaths relative to births made population expand, agricultural development freed up population for other rural occupations, urbanization, and emigration in what was still primarily an agricultural society.

Having largely produced the original margin in vital rates for future demographic growth during the first half of the 1500s, the agricultural sector in turn responded to rising prices from this kind of population pressure in four largely parallel movements: 1) Price increases rewarded more efficient agricultural production, an incentive that made the publication of books on farming expand significantly from the 1560s into the 1650s in G fashion with base year around 1588 along with trends in prices, urbanization, and emigration (Fig. D.4). Production enterprises--many of them small, rural ones--flourished (Thirsk). 2) The scale of farms in terms of labor employed increased in what, while previously graphed via H, could be G fashion between 1599 and about 1700 with zero year around 1587 (Harris 2003, 241). 3) The proportion of the rural population that was not engaged in agriculture could have expanded via G between 1600 or sooner and 1670 with t_0 about 1562--rather than H based in the vicinity of 1444, which would be more like population increase (ibid., 237-38). 4) The number of people supported per person in agriculture may have grown in G form between 1600 or earlier and 1670 with base year in the vicinity of 1540 (ibid., 236, 238).

From 1555 through 1615 real rural wages fell in D fashion with zero year at 1559, or *opposite* to these changes in agriculture. Subsequently, as population growth became flatter, they improved between 1615 and 1725 *along with* them in a G-shape path based at 1550 (Harris 1997, Tab. 12.1, from Tsoulouhas 1992). Real urban wages (for builders), meanwhile, shrank between 1558 and 1616 toward a t_0 at 1624--reflecting, with about a quarter century of lag, the E-shape rise in prices that occurred in England between 1558 and 1599 with zero year at 1598 (ibid., from Phelps Brown and Hopkins). As real urban wages fell, undermined by rising prices, per caput national income for England (Fig. D.3) declined between 1526 and 1600 in parallel C fashion (t_0 around 1628) before improving across the 17th century in E form, again approximately parallel with urban wages (zero year at 1740 compared with 1718). Lagging a few years, the rate of natural increase for the English population from 1556 through 1651 also contracted in C manner with zero year at 1643 before actually turning negative (Fig. 1.3). As far as the early 1600s, real wages and national income per caput deteriorated in the wake of rising prices. Natural increase followed these changes in standard of living downward, but continued such a trend into the third quarter of the 17th century as the death rate kept surging (Figs. 1.3, 1.1)--even as wages and national income per caput improved--eventually producing some depopulation for England.

As real urban and rural wages both declined to lows in the 1610s--the one via C, the other in D manner--the percentage of English women who remained celibate into their 40s surged in G' shape from the late 1500s into the early 1600s toward a crest around 1630 (Fig. 1.5). This meant that for young females in their 'teens, the loss in future prospects for marriage echoed the G' migration to towns and cities observed in Norwich, which peaked about 1587, resembling the first derivatives for the likely or possible G curves of the late 1500s and early 1600s for urbanization, non-agricultural employment in the countryside, emigration, prices, and agricultural wages. The rearrangement of the English economy during this period significantly interfered with marriage.

Thereafter, as Table P.1 recapitulates, female celibacy expanded somewhat further until about 1670 in approximate E form with zero year around 1718 (Fig. 1.5). This accelerating increase did much to make nuptiality for English women fall oppositely, in C fashion, toward t_0 at 1712 (Fig. 1.4). The crude marriage rate (Tab. 5.1) declined from the 1550s into the 1660s along a somewhat steeper C path (zero year about 1684). Simultaneously, the crude death rate--and the rate of loss among young persons 5 through 14--rose in opposing E trajectories that targeted about 1722 and 1716 respectively, while life expectancy at birth decreased in C fashion toward a t_0 at 1729 (Fig. 1.1, Tab. 1.4). Increasing mortality trimmed the opportunity for forming families as the percentage of women who married young declined in C fashion, pulling down the years women were 'at risk' in similar form as the proportion of females wed only after 35 rose via E--like celibacy for females. Life expectancy for young adults stayed relatively stable, though that at birth declined (Figs. 1.5, 1.1, 1.10).

Fertility for married women at ages up to 45 decreased in C shape, bringing total age-specific marital fertility down in that pattern across the first three-quarters of the 17th century toward a zero year about 1730 (Fig. 1.6). This aided shrinking nuptiality in depressing overall fertility for the English population from 1558 through 1663 via C--with t_0 at 1707. A lessening loss of infants from the 1580s or sooner to 1640 and decreased mortality for young children 1 through 4 to 1610--both in C shape targeting the end of the 1600s--apparently encouraged fertility decline of that form for married women at most ages (Fig. 1.8a). In a context of stable, continuing, long-term H-type advances in productivity, supported population, and shifts between economic sectors, fertility falling in C fashion along with mortality after age 5 that rose via E then, after the early 1600s helped lift real urban wages in an E trend that, with zero year around 1718 closely mirrored the decline in reproduction--and perhaps improved rural wages via a much flatter E movement as well.[3] It also helped national income per capita (Fig. D.3) start to advance via E across the 1600s (t_0 about 1740). As a consequence of adverse trends in both fertility and mortality, natural increase from the 1560s through the 1650s was depressed in much steeper C fashion with zero year about 1643, straining the labor market before--even worse--turning negative.

Trends for urbanization in England, and for changes in domestic agriculture that fostered and fed it, continued their early-17th-century advances past 1660. Indeed, urban wages rose relative to rural ones from the 1630s through the 1690s in G form with base year at 1581, parallel with urbanization and basic agricultural changes of the 17th century. The safety-valve of emigration through London, Bristol, and lesser ports, however, which had been following a comparable G path, started to close in D fashion after the 1650s (Fig. 1.3). The zero year for this decline in the rate of net emigration, in the 1680s, follows by about a decade the t_0 for the first several decades of population growth in G shape for British North America (both collectively and in individual early colonies), also the point at which further settlement as a whole slowed into a constant $e^{.03}$ pace (Harris 2001, 17, 42). Older colonies saw increases of proportions in their populations who were white women and children and native-born individuals (Harris 2003, 410-13, 430, 432). These trends repeatedly took G shape with zero years that on average fell in the third quarter of the 1600s, just a little before the opposite D-shape decline in the rate of English emigration (Fig. 1.3). Normalizing colonial populations no longer needed so many new competitors for resources. Some turned to African slaves for their labor needs, making the percentage of their populations of that stock increase in G form--with zero years in the 1660s then the 1690s for Virginia, the 1690s for Maryland and South Carolina, while spread across the 17th century but most in the 1650s and 1660s for English, French, and Dutch colonies of the West Indies (Harris 2003, 314-16, 306-11). Newly arrived English found it more difficult to make their way in older colonies. Immigration became less attractive, and flows from the original English pools contracted. Ireland, the other major outlet for surplus English population, meanwhile turned turbulent in the 1640s.

As searching for employment in a city--then, if not successful there, venturing overseas--continued to be a significant process in English life, but opportunity to be had from the second or colonial step withered, more and more uprooted men and women (mostly young) added to the demographic pressure on a central place and key port like London. The rise of wages relative to rural ones from the 1630s forward, for those who could find work in cities and towns *as a whole*, kept the first or urbanizing stage of the migration flow going, aggravating stress where a bottleneck to further relocation occurred. Between the first quarter of the 1600s and the early 1700s, net losses through burials relative to baptisms in the key port of London surged in G’ shape, cresting about 1660. With zero year rather later, about 1680, the G’ path for the proportion of the demographic surplus generated elsewhere in England that was devoured by the losses of London was synchronous with, but opposite to, the first derivative for the D trend of decline in the English rate of emigration (Harris 2003, 187). The fewer young people moved on to the colonies, the more died in London and other ports as change in farming kept feeding non-agricultural activities with manpower. The evolution of an urban demographic sink-hole in

London and perhaps other key centers helped drive the crude death rate for England to its peak in the early 1680s. This national E trend, however, had been a long-term development since 1560, not just the product of fire and plague in the metropolis during the 1660s. Even London's losses built up over half a century.

Phase II: Rebounding from Demographic Disaster ca. 1650-1725

The next stage of early modern English demonomic history began with this mortality crisis of the third quarter of the 17th century and involved demographic and economic adjustments as population growth returned to approximately the path observed from the 1550s through the 1650s. Because of the crisis, from 1656 through 1686 the number of English actually atrophied, in D form with base year at 1580, before returning to H-type expansion through 1726 or so--a path that resembled the pre-contraction trend of 1556-1661, with zero year at 1492 compared with 1461 (Tab. P.2; Harris 2001, 148, 150-51).

While the trends of agricultural productivity per acre and per worker and total grain production in England appear to have changed little from the second half of the 17th century into the first half of the 18th (Fig. D.6), the proportion of remaining land being enclosed kept rising in G fashion, based around 1580, to about 1750 (Fig. D.8). With first decline, then only gradual growth in national population, however, prices fell via D from 1660 through 1692 and again from there to 1748--from zero years at 1625 then 1642, or rather more steeply than the 1580-based demographic contraction of 1656 to 1686 (ibid., Tab. 12.1, from Phelps Brown and Hopkins). Agricultural innovation atrophied with them in D manner. The publication of books on farming declined from the 1650s into the 1710s as did agricultural patents from the 1620s to the 1750s--from base years at 1650 and 1617 respectively (Fig. D.4). Nominal rural wages kept rising via G parallel with the enclosure rate, from 1615 through 1755 with t_0 at 1578 vs. 1580, which was inverse to the contraction of the national population between 1656 and 1686. Real wages in agriculture, however, increased rather more flatly in G fashion to 1720 or so (zero year at 1550) before jumping upward into the 1730s (Harris 1997, Tab. 12.1, from Tsoulouhas 1992).

Alternatively, the lower lines of the right column in Table P.2 indicate, rural wages could be said to have increased in E manner between 1595 and 1735, targeting 1789. This path emphasizes their inverse relationship to C-shape declines in the rate of return on agricultural capital between 1625 and 1725 and to the ratio of rent to the price of land (with t_0's at 1762 and 1768) but parallel with E-type increase in the cost of agricultural capital from 1625 through 1725 (targeting 1803)--which incorporates the real rural wage as a component (Harris 1997, Fig. 12.9, from G. Clark 1990, 357; 1988, 273).

During the second half of the 17th century, meanwhile, urbanization in England followed a new, stronger trend of growth that exceeded the renewed 1686-to-1726 expansion of the population. This trajectory took H shape into the middle of the 18th century: calculating from places with 5,000 or more inhabitants, from 1670 through 1750 with t_0 at 1554; using a threshold of 10,000, from 1650 through 1750 with base year at 1550, (Harris 2003, 224, from Wrigley 1985a; ibid., 275, from de Vries 1984, 39). The proportion of rural people who were not engaged in agriculture enlarged in parallel H fashion from 1670 through 1800 with zero year in the vicinity of 1540. Increase in the number of workers per farmer in the countryside comparably continued along an H path based about 1554 (or perhaps a G trend anchored around 1587). The amount of population supported per person in agriculture, however, expanded along a flatter H path: with base year about 1515, more like the H anchored at 1492 for demographic growth in England as a whole (Harris 2003, 236-38, 241). Meanwhile the proportion of farmers in parish populations contracted via D from 1688 forward (with t_0 about 1670) despite little change in the weight of farmers and their workers together as the scale of farms increased (ibid., 241). The publication of agricultural books contracted in a somewhat earlier D trend (based at 1650) from the 1650s into the 1710s (Fig. D.4).

All patented processes, an indicator for overall innovation in the English economy, in contrast multiplied from the 1660s into the 1750s via H based about 1563 (Fig. D.4), supporting approximately parallel trends in urbanization, the proportion of rural people not engaged in agriculture, and perhaps increase in the number of workers per farmer. Real urban wages, meanwhile, after accelerating upward in E fashion during the 17th century, rose in G form based at 1676 from 1693 through 1731, making the ratio of urban to rural wages also increase in that shape from 1695 through 1725 with t_0 at 1653, as real rural wages remained relatively flat (Harris 1997, Tab. 12.1, Fig. 12.3). Thus urban wages, both of themselves and relative to rural earnings, gained via G opposite to contemporary D-type declines in prices, rates of net emigration, and the proportion of farmers in rural populations, but perhaps parallel with the proportion of laborers among farm hands during the late 1600s and early 1700s (t_0 in the vicinity of 1675, if estimated via G without 1599 in lieu of the H proposed in Harris 2003, 241).

Demographically, during this period from the middle of the 1600s into the early 1700s reproduction re-expanded in G form. The crude birth rate, the gross rate of reproduction, and overall fertility all increased this way, along curves with base years in the early 1600s, approximately in inverse response to the contraction of the English population. So did nuptiality and the crude marriage rate (Figs. 1.1, 1.2, 1.4, C.2; Tabs. 1.1, 1.2, 5.1). Comparable G-shape gain in total age-specific marital fertility and fertility for all age groups of wives except those 15 to 19 and 25 to 29 (Fig. 1.6, Tab. 1.3), however, suggests that not just more marriage but more births within marriage contributed to the expansion of reproduction, even if marital fertility (I_g) as calculated by Wilson and Woods shows virtually no change (Fig. 1.4). In all, within the economic context that has been described, D-type decline of the English population between 1656 and 1686, caused by the urban-centered mortality crisis of the period, triggered opposite G-shape gains in fertility and nuptiality to get demographic growth back on the kind of H path that it had been following since the 1560s, which paralleled growth in the agricultural economy and the urbanization that it allowed. Exploiting various rural changes cited, the H trend between

1670 and 1750 in the ability of English agriculture to support proportionally more people underwrote the H-type growth of the population between 1681 and 1726 or somewhat later (base years at 1514 and 1492 respectively). This agricultural improvement and expansion supported rather steeper H trends of advance across the era in urbanization and in rural crafts and commerce, which were aided by parallel increase in innovation as illustrated by patents. Much flatter productivity measures for farming (Fig. D.6), meanwhile, are based upon grains, which with time formed less and less of agricultural production as activities such as dairying, animal husbandry, and industrial crops flourished (Thirsk ; R. M. Smith 1999). Technical improvements for agriculture, however, sagged with prices, the proportion of farmers in the rural population, and the proletarianization of the agricultural work force. Economies of scale accompanied by monetarized labor, not increasing innovation, generated the ability of agriculture to feed more people during this period.

Between 1681 and 1731 the crude death rate, and mortality during the first 15 years of life, dipped in D' fashion, bottoming out near the turn of the century. Life expectancy across the life cycle for all but the 20 years following age 25 meanwhile bumped up reciprocally in G' shape (Fig. 1.10). Mortality rates for adults 25 through 39, however, surged via G' to maximize a few years earlier (Tab. 1.5, Fig. 1.9), cutting into the total reproduction of fertile women--and helping push the rate of natural increase for England to a low in the 1720s (Fig. 1.3).

Celibacy for English women into their 40s shrank significantly for those who would have been of average age to marry (about 23) from about 1650 forward. From the third quarter of the 17th century into the second quarter of the 18th, this has been estimated in Figure 1.5 as a G' trend down from a crest about 1655 for women of that age (1675 for those 40-45). Alternatively, quarter-century evidence concerning women at age to marry for just the two periods 1655-1680 and 1680-1705 would fit D-form decline based around 1660, in part lowered by a D-shape contraction during these years in the rate of net emigration (Fig. 1.3). Meanwhile, the demographic deficit imposed by London upon the English population as net emigration began to recede after the 1650s--reflecting overseas flows that began to contract by then thanks to the development of creole families in the New World along with a related shift to Africans for labor, and to turmoil in Ireland (Harris 2003, 187, 57, 70)--had surged to a G' maximum around 1675. In turn, this movement was echoed with a 15-year lag by comparable G' bulges in mortality for all English age groups between 25 and 40.

Infant mortality, in contrast, increased in G manner from 1640 through 1730. Its base year at 1596 (Fig. 1.6, Tab. 1.3) resembles the 1602 of the G path for the crude birth rate between 1656 and 1751 and the 1607 for the G trends of total marital fertility and the crude rate of marriage from about 1660 into the middle of the 18th century. Mortality among children 1 through 4 (ibid.), meanwhile, worsened in G fashion between 1610 and 1690 from a zero year at 1589, making it rise with G or possible G movements in urbanization, expansion of non-agricultural work in the countryside, workers per farmer, the rate of continuing enclosures, and--from 1635 on--the ratio of urban wages to rural ones, as described for the bulk of the 17th century. Then from 1690 though 1750 losses among these young children increased along a new, steeper G path with t_0 at 1663, once again approximately parallel with G-type change in the ratio of urban to rural wages and the rise of real urban earnings, but now inverse to the weight of farmers in the rural population, the publication of agricultural books, prices, and the pace of net emigration from England. These G trends were noticeably steeper than those for basic measures of fertility and nuptiality , which--with zero years in the early 1600s--instead resembled the path of infant mortality. The occupational shifts and migrations of the period seem to have diminished the survival of young children in particular, while increased mortality during the very first year of life tended to reflect instead the rate at which marriage expanded with such economic changes.

Among English females, marrying young--especially under 20 and to some extent under 25--became less common in C paths between 1625 and 1725 while the proportion of women marrying only when 35 or older, though it increased into the last quarter of the 17th century, subsequently also contracted this way. A result was that the number of years during which women bore children (approximated by the average age of last birth minus the average age at marriage) also further contracted gradually in C fashion from the later 1600s into the early 1700s (Fig. 1.5). At the same time, age-specific marital fertility for teenagers declined parallel with the proportion marrying under 20, while this rate for wives 25 through 29 increased via E opposite to C-type trends in women marrying only at age 35 or later and the shortening of the reproductive span (Fig. 1.6, Tab. 1.3). Child-bearing became more focused upon the later 20s as how women and their mates worked and migrated evolved in a changing society, in which per capita income to 1700 or later seems to have been rising in E fashion (targeting about 1740, or inverse to marriage and fertility within marriage under the age of 20). The role of urbanization outside London for English society during this period is underscored by how its increase in E fashion from 1520 through 1700, toward 1720, parallels movement in real urban wages, national income, national income per capita, and the focusing of marriage and fertility more upon the later 20s, while moving roughly opposite to returns from agricultural capital and rents.[cf. Peter Clark]

Phase III: Exploiting Surplus Population ca. 1725-1815

Between about 1725 and 1810 the population of England grew in E form toward a zero year at 1822 chiefly because yields in agriculture (per acre and per hand) improved between 1700 and 1800 in a way that would fit new, E-shape trends with t_0's at 1834 (Fig. D.6). These advances produced increase between 1750 and 1801 in the number of people sustained per person in agriculture that would conform to an E trend also targeting the mid-1830s (Harris 2003, 236, 238).

The gain in population derived, first of all, from a flatter E-shape rise in the crude birth rate from 1726 through 1816 with zero year at 1862. This lift was supplemented by C-type decline in the crude death rate from 1761 through 1831 (t_0 at 1880), following a D' dip in the CDR between 1731 and 1761, which was accompanied by opposite G' and E movements in life expectancy at birth (Figs. 1.1, 1.2; Tabs. 1.1, 1.2). Decreasing mortality rates for the young, even as their proportion in the population expanded (via E with zero year at 1868 between 1726 and 1816), made especially significant contributions toward improving overall death rates. Across much of the 18th century and the early years of the 19th, C-type contractions headed toward zero years around 1856 for infants, 1870 for children 1 through 4, and--most steeply--1816 for those 5 through 14 (Tab. 1.4; Figs. 1.8a, 1.8b). Mortality rates for adults, meanwhile, declined rather less in the long term, and passed through a series of G' and/or D' swings on the way (Fig. 1.9, Tab. 1.5). They also improved, however, notably making the chance at age 25 to reach 45 rise via E (t_0 at 1860) during the later 1700s and early 1800s. This movement expanded overall reproduction since fewer marriages were broken by death during the fertile years for women.

Though the CBR climbed, the crude rate of marriage *fell* somewhat between 1761 and 1841, along a C path targeting 1895, as the share of the population too young to marry increased. Nuptiality (I_m), however, could expand contrarily in E fashion (zero year at 1858) because the percentages of women who married young increased significantly in some form between the first quarter of the 1700s and the first quarter of the 1800s, while reduced mortality among women of fertile age and their partners allowed reproductive unions to last longer (Fig. 1.5). Total age-specific marital fertility, on the other hand, edged up only slightly between the earlier 1700s and the first quarter of the 1800s, along a very late-timed E path (1922), thanks primarily to steeper E-shape trends for married women under 20 and from 25 through 29, as fertility for wives 30 through 39 and 45 through 49 shrank oppositely via C (Fig. 1.6).

Changes in wages, meanwhile, which are so often cited as the source of demographic trends, actually moved *against* higher fertility and lower mortality, unless one wants to rely for explanation upon the ‘money illusion’ of nominal rather than real or inflation-adjusted earnings. E-shape advances in money wages for urban workers from the 1750s into the 1790s turn into C-type declines when the rising cost of living in this era is taken into account, while a G trend for farm workers becomes D instead (Figs. D.1, D.9; Harris 1997, Tab. 12.1). With zero years at 1839 and 1849 the urban C paths (from Phelps Brown and Hopkins and from Crafts and Mills, respectively), instead reflect the shift of surplus population out of agriculture into towns.

The percentage of the national male labor force engaged in agriculture and extraction (1700-1800: 1830), the percentage of farmers among rural parish populations (1777-1831: 1815), the proportion of British GNP coming from agriculture and extraction (1700-1840: 1868), and perhaps gains in agriculture derived from capital accumulation and technical progress (1730,1780: 1819?) all atrophied in C fashion even as the size of farm operations (1765-1831: 1838) and possibly the rate of enclosure for remaining common lands (1750,1850: 1880?) increased via E (Figs. D.5, D.6; Harris 2003, 241; Fig. D.8). Since the proportion of the English people who lived in the countryside but were not engaged in agriculture between 1700 and 1800 increased only along a relatively flat H path based back at 1558, the surplus population from the farming sector went not into rural protoindustrialization but the life of towns and cities, making urbanization increase in E fashion across the second half of the 1800s or somewhat longer--with t_0 about 1836 according to Wrigley and 1854 (for 1750 to 1850) according to Bairoch (Harris 2003, 237-38, 225, 286). Particularly of note was the growing proportion of the English population that lived in towns and cities other than London, which rose between 1750 and 1801 to a degree that would support an E trend targeting 1813, while between 1737 and 1812 the weight of London within the national total shrank via D from a base year at 1701 (ibid., 225, 187).

Though the real urban wage was depressed in C fashion as more and more of the male workforce moved into manufacturing and construction, the temporary decline of earnings in agriculture that took D shape from 1735 through 1785 (around a baseline that seems to have remained relatively stable from 1625 through 1835) made the ratio of urban to farm wages rise in E manner from 1715 through 1795 toward a zero year at 1851, encouraging urbanization. Meanwhile, however, cheaper real wages during the second half of the 1700s--in both town and countryside--allowed the proportion of GNP that was invested to rise via E from 1770 or earlier to 1816, even as GNP expanded (Figs. D.5, D.3). Returns on 3% consols (government bonds) and dividends paid by the Bank of England comparably increased in E shape across the second half of the 18th century as competing gains to be had from other investments improved. Nationally, in other words, capital gained at the expense of labor even while the rate of return on *agricultural* capital and rents relative to the price of land declined in D fashion (Fig. D.8) much like real rural wages between 1735 and 1785 as prices rose in roughly opposite G manner (with zero years about 1662, 1671, 1700, and 1725 respectively). This pushed capital as well as labor into commercial and industrial operations.

Capital flowed especially into industrial production, which surged from 1730 to 1800 in E fashion toward a zero year at 1799, then in the same form from 1810 through 1830 anchored at 1821. This movement took advantage of the cheapening of real industrial wages, which were declining in somewhat flatter C fashion (t_0 between about 1840 and 1850). Between 1760 or sooner and 1800 the proportion of the male work force that was in manufacture and construction expanded comparably. Per caput, the E-type advance in industrial production ran from 1730 through 1810 with t_0 1826, closely parallel with the growth of the English population (from 1726 through 1806 targeting 1822). GNP per caput, however, from 1760 through 1840 increased along a noticeably flatter E path (with zero year only about 1870), though between 1700 and 1760 it grew rather more steeply than industrial production--suggesting more investment in trade, which burgeoned in the 18th century.[4] The E trend for private consumption per caput in England rose slightly later--from 1760 through 1831 with t_0 around 1878 (Figs. D.3, D.5).

More GNP and personal consumption were not fruits that urban workers shared directly, since their wages fell oppositely via C. Where they did gain, however, was through C-shape decline in mortality and E-form increases in nuptiality and fertility. These, however, further expanded the population and added to surpluses of labor, making wages less valuable. The demonomic imprints of innovation, meanwhile, took a rather different shape: G rather than the E and C trends that were most common in the demographic and economic changes of this era. Beginning in the 1710s, the publication of books on agriculture--which had contracted since the era of the Commonwealth--expanded in a new G path, anchored at 1742--that lasted through the end of the 1800s. This pattern resembles the rise in the cost of living, or prices, during the second half of the 18th century (t_0 at 1725 via Phelps Brown and Hopkins, at 1728 according to Crafts and Mills). Up to about 1790, farmers were getting more for their products even as wages that they paid deteriorated, helped by a long-term D-shape decline in emigration--which could be said to have continued across most of the 18th century in spite of sharp swings (Fig. 1.3)--that stabilized the national labor force. D-type contraction in the proportion of rural parish populations that was composed of farmers and their workers (from 1752 through 1831 with zero year about 1733) would seem to reflect the pattern of agricultural books and the decrease in real wages in agriculture (Figs. D.4, D.1, D.8; Harris 1997, Tab. 12.1; 2003, 241). Innovation became popular again in farming as, while prices rose, the rate of return on capital and rents relative to the price of land decreased from about 1725 through 1825 in D fashion from zero years in the 1660s, perhaps accompanied by the cost of agricultural capital during the first half of this period based about 1690 (Fig. D.9--from G. Clark 1988, 273; 1990, 357). This stage of innovation in agriculture, as evidenced by books, in turn helped depress farm wages between 1735 and 1785 along a D path based at 1700 .

Patents for agriculture, on the other hand, became more numerous from the 1750s into the 1830s parallel with new patent-based processes in England as a whole and patents for five key industries central to the Industrial Revolution--all three along G paths with zero years in the vicinity of 1790 (Fig. D. 4). One trending for the rate of emigration from England has G form from 1766 into the 1900s with base year about 1806 (Fig. 1.3). This suggests that innovation helped generate surplus labor nationally. The alternative H-type path, for emigration rates between 1726 and 1926 with base year around 1692 is, on the other hand, approximately parallel with the 1710-based trend of that shape from 1752 through 1831 for the proportion of laborers among all agricultural workers (Harris 2003, 241). Monetarization of the relationship between farm hands and their employers in English agriculture, in other words, seems also to have fostered emigration as population surplus shaped the English economy in several significant ways.

Phase IV: Fruits of Industrialization ca. 1815-1865

The G-shape gains in innovation indicated by patenting for agriculture and industry from the middle of the 1700s into the early 1800s, with base years on average in the later 1780s, laid the foundation for economic change during the first half or so of the 19th century (Fig. D.4). They stimulated closely parallel G trends in industrial output, industrial output per caput, percentage of GNP invested, percentage of GNP invested in equipment, real GDP growth, and perhaps gains in agriculture from investment and technology, the movement of male labor out of agriculture and extraction and into manufacturing and construction, the proportion of GNP coming from manufacture and construction, and the advance of urban wages relative to agricultural ones (Figs. D.4, D.5, D.6; Harris 1997, Tab. 12.1)

These G-shape economic changes raised the crude rate of marriage in parallel G fashion from 1831 through 1871, and perhaps nuptiality (I_m) from 1851 through 1871. Before increasing this way, however, the CMR continued its later 18th-century C-type decline to about 1840, while--beginning in the 1820s-- nuptiality fell in D’ form to about 1845 before following that trend upward into the 1860s. This contraction in nuptiality depressed overall fertility in England in similar D’ manner (Figs. C.1, 1.4). Meanwhile the total fertility rate, the crude birth rate, and (a little less steeply) the proportion of the population under 15 declined in D form opposite to the

CMR (Fig. 1.1, Tab. 5.1). The rate of infant mortality, in contrast, from 1815 through 1848 increased along a G path based at 1768 (Fig. 4.3b). More frequent and younger (Fig. 1.5), but temporarily less reproductive, marriage was accompanied by a drop in extramarital fertility but rising loss of infants, as the C-shape contraction of the crude death rate since the 1760s came to a halt. While finer details on the English population can be extracted from the censuses, beginning in 1801, these broad changes in marriage, fertility, and mortality would seem to reflect relocation of the workforce, particularly young adults, to industrial conditions.

In the early 1800s, however, in spite of some demographic setbacks, real wages for urban workers began to rise in G fashion after falling through most of the 18th century. Builders' wages, cost of living wages for industry, and (most flatly or latest-based) wages relative to workers' own products rose in G fashion into the 1860s as prices fell oppositely via D into the 1840s before turning upward approximately parallel with real earnings (Fig. D.1; Harris 1997, Tab. 12.1). This strengthened urban wages relative to rural ones, which remained relatively flat, and allowed innovation in production--which advanced in similar G manner--to draw in labor from the countryside. The rate of emigration, however, also rose along with the same domestic occupational and other economic changes since not all people uprooted from agriculture and protoindustrial occupations could find in England suitable work or wages that were acceptable relative to perceived opportunities of the New World, while both industry and agriculture extensively exploited Irish labor as well as home-country workers.

Contrary to the setbacks observed in marriage (except for marrying young), fertility, and mortality among the living conditions that prevailed during the first half of the 19th century, some aspects of the consumption of English workers improved. Thanks in large part to the expanding role of imports, the inflation-adjusted annual value of food and beverages consumed per person rose between 1792 and 1863 in G shape from a zero year about 1774, much like real wages. So, roughly, did the proportion of this consumption, in value, that was not composed just of grain and dairy products. Grams of protein and calories per caput for textile workers, meanwhile, from 1839 (perhaps as early as 1815) through 1890 increased along G paths based in the 1780s and 1790s (Fig. D.7, from Clark, Huberman, and Lindert 1995, 220). The proportion of food and beverages that was imported between 1800 and 1850 increased in a way that would fit a G trend based around 1790, or opposite to the decline in prices between about 1810 and 1850--the movement that made real urban wages more valuable. Imports weakened the constraints of limited English agriculture upon economic and demographic growth. Expanding imports sufficed to make the share of food and beverages either imported or produced in England that was consumed increase little during the first two-thirds of the 19th century (via a G path that was based well back at 1727).

In another improvement, furthermore, from 1816 through 1906 the percentage of the English people who had attended formal primary schools advanced, somewhat more tardily, in G manner (t_0 about 1818). This trend parallels gains in total factor productivity between 1790 and 1852 (G with base year around 1820) as human capital improved in the economy of England. The return on the safe investment in government consols, to the contrary, decreased from the 1790s into the 1880s along a D path anchored about 1780, as the passion for investment began to flag in the third quarter of the 19th century, taking industrial output--and, soon, real GDP growth--down with it (Fig. D.5).

Only indirectly related to these G and D movements, population increase and urbanization in England increased along H paths through the first half of the 19th century, trajectories largely followed into the 1900s. Gain in the gross national product between 1800 and 1850 was comparable (perhaps via an H pattern based somewhat later, in the 1780s, rather than the E then G patterns graphed). Per caput it continued to advance in E fashion through the first half of the 19th century (Fig. D.3).

SPACE

In sum, between about 1550 and 1650, the dissemination of agricultural improvements across England--a manifestation of widespread economic growth in northern Europe over the period, to which England was becoming less peripheral[5]--permitted the margin for population growth that was generated by declining mortality during the Tudor consolidation of the country during the later 15th and early 16th centuries to persist at an only slowly decelerating rate (via H) for a century. More labor- and land-efficient farming produced people for other activities in town and countryside, and supplied the settlers that would gobble up Ireland and make the overseas colonies of England flourish demographically and some ways economically relative to those of European competitors. The demographic inputs to this sustained population growth, however--in nuptiality , fertility, and mortality--while weakening only slowly at first, deteriorated in an accelerating C form that by the middle of the 1600s produced crisis for the population.

As deaths came to exceed births, from the 1650s through the 1680s the population of England contracted. This crisis was the culmination of long-term change, not just a result of the Civil War, the Interregnum, and the plague of the 1660s. And it occurred in spite of significant decline in the rate of emigration, which occurred as colonial families supplied more of their own manpower, turned in plantation regions to African slaves as a more reliable source of labor than Europeans, and became more unequal competitors for new settlers.

From about 1650 through 1725, however, available data (albeit fragmentary) suggest that agriculture in England continued, much as during the preceding 100 years, to expand its ability to support more population: most clearly in an H trend for the number of people sustained per person in agriculture, as the average farm workforce enlarged comparably, less certainly (and more flatly) in what may have been continuing improvements of that shape in grain production and output per worker and per acre. As a consequence, with previously parallel emigration exogenously curbed, shares of the population living in towns and cities or engaging in rural activities other than farming increased in H fashion even more strongly--along with innovative procedures to utilize the extra workers productively, as indicated by patenting.

Within this framework of continuing long-term economic growth, the demographic contraction of the third quarter of the 17th century, caused mostly by the upward acceleration of the national death rate from the 1550s into the 1680s, generated a shortage of labor and of demand. The decline of consumers from the 1650s into the 1680s pulled down prices, which discouraged agricultural innovation even as the shortfall in producers (and lower prices) pushed up real wages. Better wages in turn made it easier to marry and stay married, which produced more children. Greater fertility, though, brought higher rates of loss among infants and young children. Nonetheless, declines in mortality for other ages from G’ highs in the third quarter of the 17th century (most notably a reduction in the demographic devastation caused by London) allowed the crude death rate for England on the whole not to rise but to dip at least temporarily between about 1681 and 1731. In all, the population of England after about 1680 returned to the H-type path of growth that had been followed from the accession of Elizabeth I to the Restoration.

From the early 1700s to the end of the Napoleonic wars, in contrast, *surplus* population was central to demonomic development in England, much in the manner proposed decades ago by Ester Boserup (1965, 1981). Cheapening labor, thanks to mounting demographic pressure, was exploited for gain in farming through increases in the scale of operations (and some fresh technological innovation) even as agriculture came to constitute a smaller portion of labor and of GNP. Industrial production, which meanwhile took on a greater role for the economy, expanded in E form parallel with population increase--aided by vigorous G-shape advances in technological innovation, which took advantage of the increasing labor supply and weaker real wages. Urbanization (specially outside London), GNP, investment, returns on government investments (though not those in agriculture), and--more weakly--private consumption gained in E fashion accompanying population growth.

Rising consumption and greater national wealth, however, hardly encouraged the determinative population growth that was taking place because real wages fell both in town and countryside. It was the wealthy who reaped the financial harvest. For the bulk of the population, nonetheless, life expectancy rose and death rates declined. Nuptiality, furthermore, also increased via E even while the crude marriage rate declined somewhat oppositely in C fashion as reduced mortality helped unions last longer and more of the population was still too young to marry. This advance in nuptiality elevated overall fertility even while reproductive rates within marriage experienced less change. One source of these demographic improvements contributing the population growth the drove English development in this era seems to have been the geographical distribution of people. Instead of disappearing down the sink-hole of London, the demographic surplus generated by more productive agriculture shifted to lesser provincial centers, in particular to those where protoindustrialization thrived in the 18th century. Other contributing factors may be changes in diet as products of farming evolved and disseminated, and in the labor of women, which affected the survival of infants and children (R. M. Smith 1999).

From the 1810s to the 1860s, finally, population increase in England returned to the kind of H path that had been followed for most of the time between the 1560s and the 1720s. Now, however, urbanization and gross national product that was based increasingly upon manufacture set the course for demographic expansion, no longer primarily agricultural change. Real wages rose, assisted by falling prices; and some aspects of workers' diets began improve, bolstered by imports. Expanding formal primary education not only helped raise total factor productivity for the economy; it joined rising wages in cutting back fertility and in making nuptiality dip during much of the period, as women's work shifted from farm to factory. Long-term C-type decline in the crude death rate came to a temporary halt about 1830 (as a new flatter C trend began) and infant mortality rose, thanks to the risks of more and larger urbanization and the conditions in which families lived. Though as the value of foodstuffs typically consumed by workers increased, additions included not just meats but sweets and spirits.

Some of these established or hypothesized demographic and economic trends across the successive periods between about 1550 and 1850 are supported by little or only widely spaced evidence, and based upon calculations or estimates that might well be improved. Collectively, however, they do seem to offer a narrative for three centuries of demonomic development in England that is at once more richly textured and inclusive, yet better integrated and weighted, than previous interpretations. Recognizing the G-related trends of the data brings more elements together and better clarifies the relationship of various movements in them to each other. This one-country, English, case of demonomic analysis in a G-based framework, furthermore, should be fruitfully applicable to other societies in other times.[6]

Several possible applications of what is be learned from the demonomic history of England come to mind. Every elements will, of course, not be the same from one case to another. Still, to examine both fundamental similarities and aspects that differ should be illuminating.

For example, in spite of increased immigration many ‘developed’ countries in Europe and elsewhere are currently on the verge of, or in the midst of, experiencing population decline. What do these societies, though they are industrial and post-industrial rather than primarily agricultural, have in common with England during the second half of the 1600s that might elucidate what will happen to them in the future? Did, on the other hand, historically recurring demographic disasters in China or Egypt (Harris 2001, 242-43, 285) comparably raise incomes, improve demographic conditions for survivors, and shape urbanization in new ways? There are signs that this did happen in England after the plague struck in the 1340s as wages and the birth rate rose (R. D. Lee 1973), consequences likely to pertain across much of the rest of Europe at the time. The history of migrations suggests much the same for the aftermath of the Thirty Years War in the Rhineland and other depopulated parts of central Europe.

‘Globalization,’ as it has been occurring in the later 20th and early 21st centuries has in large part involved the exploitation with capital and technology of cheap labor in world populations that have been rapidly expanding. How do the dynamics of this process, both nationally and across a framework of intercontinental competition, compare with the way that the Industrial Revolution in England ‘took off’ during the later 18th century, melding global trade with innovation and investment to take advantage of population pressure and resulting low wages? The kind of E-shape accelerating population increase that characterized England has appeared subsequently in several European countries and, more recently, in Latin America, Asia, and some parts of Africa (Harris 2001). How does the modern internationalization of this kind of demonomic process alter it? What remains comparable? Did the ‘development’ of ancient societies--through irrigation projects, city-building, commerce, political and military expansion--evolve much the same way, capitalizing upon population pressure to extract labor, discipline, and sacrifice from the majority while not sharing the fruits of growth with them? Under what circumstances might demographic and economic interactions of this type appear even in a future of globally restricted resources?

The decreasing mortality of the later 1400s and early 1500s in England set the stage for a long, upward-drifting equilibrium between agricultural improvement and population growth from the 1560s through the 1650s--a path generally reacquired, though with several different trends in contributing demographic and economic elements, from the 1680s into the 1700s. H-type population increases have also been observed elsewhere (Harris 2001)--in the eastern provinces of the Low Countries (Antwerp, Flanders, and Brabant up to the Dutch Revolt; Holland into the 17th century), in Germany to 1618, in Sweden to 1720, or for that matter in sugar-rich Jamaica, St. Domingue, and Cuba during the 18th century and in Russia and China repeatedly after the middle 1700s. To what extent were these patterns of population growth part of comparable systems of interacting economic and demographic development? Were they also made possible by an expanded excess of births over deaths at a time when innovation was available to put the extra people to good use? And were they likewise ended by accumulating increases in mortality that ultimately included war and political turmoil but had been building faster and faster over the long term, while fertility declined? Did prices, wages, and structural change in capital and control, on the one hand, and demographic changes, on the other, evolve in similar ways in these at least somewhat similar historical processes? What difference did certain variations that appeared within the shared broader outlines of development make?

Renewed H-type elevation in the demonomic equilibrium for England after 1815, in contrast, was based primarily upon accumulative industrial rather than agricultural innovation and efficiency. In this more modern context, death rates now fell rather than rising--in the start of 'demographic transition.' While fertility again declined, it did so along paths of different shape--and no longer mimicked the trend of nuptiality so closely. Wages and living conditions consistently improved rather than worsening at first. Patterns of population increase suggest that, subsequently, several countries of Europe, certain regions of others, parts of North and South America, and recently--since the middle of the 20th century--India, Pakistan, Indonesia, China, Thailand, and some other societies of Asia and even Africa shared something like this trajectory of development (ibid.). How comparable have movements in various components of these demonomic systems been? Viewing the changes in English experience around 1815, under what circumstances and with what effects might less economically advanced countries whose populations are now expanding in accelerating E fashion in turn shift in the future to H-type demonomic development?

For populations presently evolving in H form, how might this phase of development end? On the one hand, growth along the H path in England from 1816 to 1861 was followed by new and somewhat steeper increase of that sort to World War II. Knowing what changed in the vicinity of the 1860s, what largely remained the same, may help in understanding similar successions of H-type demonomic regimes that took place in the United States of America and China around 1950, in China, Mexico, Brazil, Argentina, and several countries of Europe during the 19th century or slightly earlier--and might lie ahead for more recently developing countries with current H trends such as India, Pakistan, Indonesia, or Egypt (ibid., 17, 243-44, 114, 280, 148-49). On the other, following World War II aging populations with higher death rates and lower birth rates guided all European societies, including England, into more rapidly decelerating, more quickly exhausted G-shape demographic (and economic?) growth. How do the trends shaping these common G movements contrast with those of the preceding H-type experience (a succession to more swiftly decelerating growth that appears also to have occurred around 1720 in Sweden and about 1770 in Portugal and perhaps Spain)--and help explain how, since records begin, countries like France, Finland, and Japan, China down to the 1740s, and Egypt prior to modern times have grown repeatedly over centuries, but via G and never H (ibid., 148, 251, 242-44, 285; though with an E trend here and there).

Given final global resources for human life, meanwhile, it is unlikely that the constant .03 exponential or F growth pattern observed in certain frontier or comparably open-ended will play much of a role in the future. Even as worldwide population accelerated in E fashion up to such a .03 rate between about 1955 and 1970, setting off ‘population explosion’ alarms among demographic observers, it began to taper over into slowing H form (which may still be too challenging), even in Africa by the 1990s (ibid., 385). The chances for accelerating growth, meanwhile, seem to be very limited in a world in which public health and medicine display limits and more and more people, from rich to poor, trade children for lifestyle.

Lurking in the future, of course, are real possibilities of demographic decline. The progressive exhaustion of English development in H shape from 1561 to 1656 gradually raised mortality and lowered fertility to a point of crisis. Modern H growths, including that in England from the middle of the 19th century to World War II, has been based upon a lag in fertility reduction following decrease in mortality, again over long periods of time, but in the end projecting demographic contraction in the same kind of D shape that England experienced during the third quarter of the 17th century (already seen in East Germany during the second half of the 1900s). Historical crises of various other kinds in the past have produced D-type demographic contractions, as in the plague of the 14th century, the European invasion of the Americas, the Thirty Years War, the comparable exposure of isolated Pacific populations to the diseases of the developed world, or the natural and military disasters on record over centuries in China. Some of these contractions were overwhelming. Others cut less deeply before growth renewed. What demonomic features might mark such contractions in the future, and determine whether moderate or extreme decline occurred?

Occasionally in human history regional or local demographic decay has begun slowly but accelerated downward. Such accumulative decline heads toward extinction. Its rare recorded occurrences have appeared in societies or communities apparently clinging to no longer viable ways of life, as in certain islands of the West Indies as the sugar industry consolidated (Harris 2001, 391). Generally the trend has broken and there has been recovery in some form. Extinct populations, however, are unlikely to leave records. The experimentation of Chapter ‘M’, meanwhile, identifies demographic changes that might lead to decline in this form. How might they appear in conjunction with possible economic developments of the future?

Summary of 3 types of conclusions. In all, if devastating mistakes have not been made, three kinds of useful findings emerge from it.

{Please note that Harris drafted this chapter but did not finalize it fully like the preceding chapters. This is evident from the lack of a concluding section that was intended to lead to subsequent chapters; and also note the somewhat incomplete character of the notes. MSW 31 July 2015}

Notes

1. Agricultural development and other elements of early modern demonomic change in England are being analyzed in greater detail elsewhere, especially utilizing recent work by Clark.

2. That H-type trajectory resembles expansion for the number of people living in the biggest cities--with 100,000 or more inhabitants--for all of Europe from 1550 through 1750, with northern Europe having a zero year about 1560, instead of 1520, and such growth for Mediterranean Europe flattening out faster via a G path with t_0 at 1550 (Harris 2003, 252), and the *percentage* residing in towns of 10,000 or more in the Netherlands and France between 1550 and 1650 (ibid., 275).

3. Alternative to the G trend proposed in Tab. P.1 (Harris 1997, Fig. 12.3, graphs both possibilities).

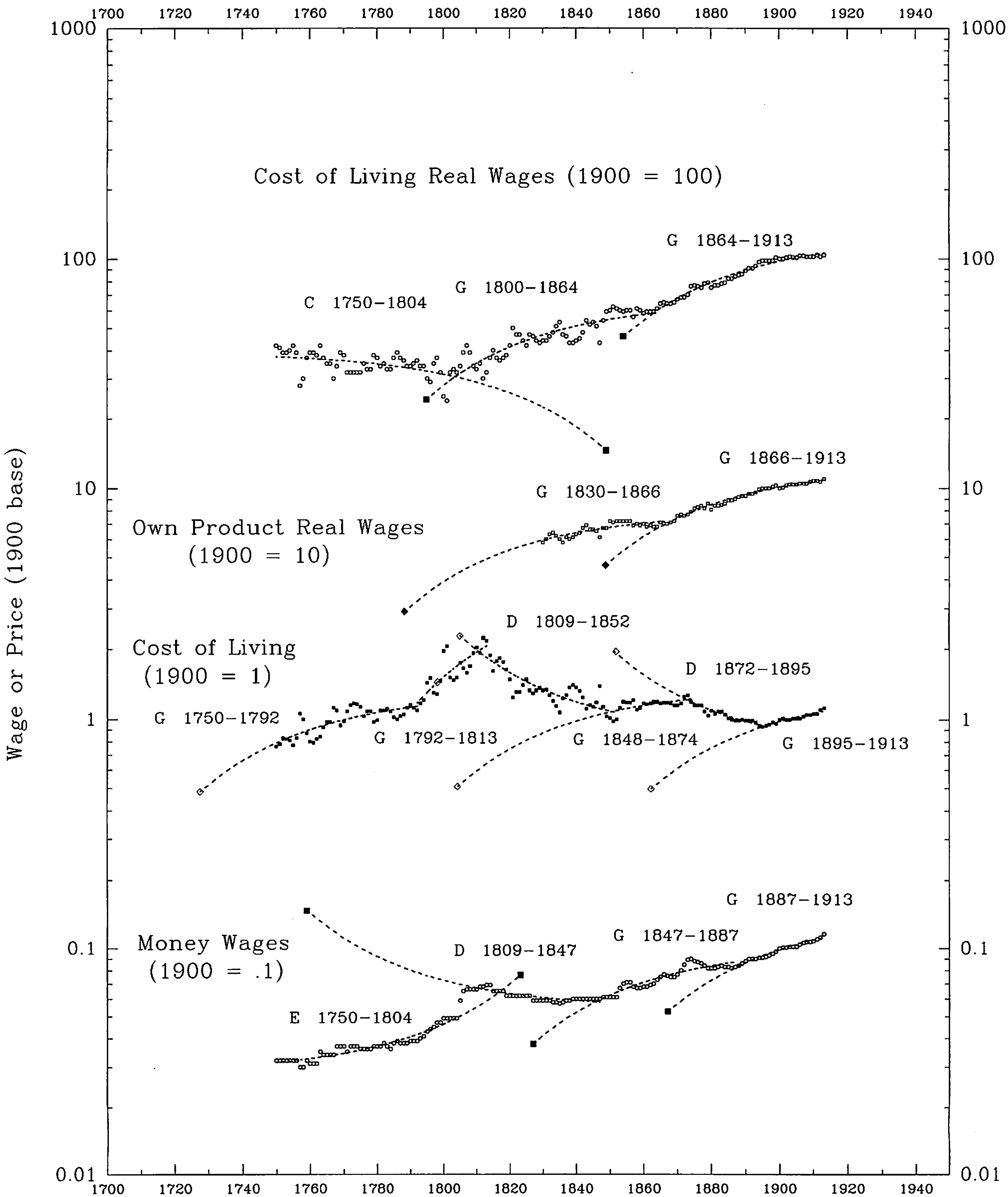
4. Harris 1992 Figs. 5.a, 16.b, 18.b, and 18.c, plots the G trends of tobacco and sugar imports and reexports. Harris 2003, 117 and 102, graphs comparable trends for the British slave trade, which blended business in Africa with commerce in the New World. Harris 1996, 473-75, shows how--after D-shape decline, as in England--regional prices in America all rose in G form as more and more demand appeared for colonial products after about 1730 and English manufacturers expanded their markets overseas to take advantage of increasing colonial demand as these populations grew and consumed more.

5. (Stone ; Wallerstein ; de Vries 1984)

6. More detailed examinations of the English experience from the later middle ages to World War II (including the role of the colonies and further particulars on developments in agriculture and certain industries) and a few other national systems are in preparation.

Figure D.1

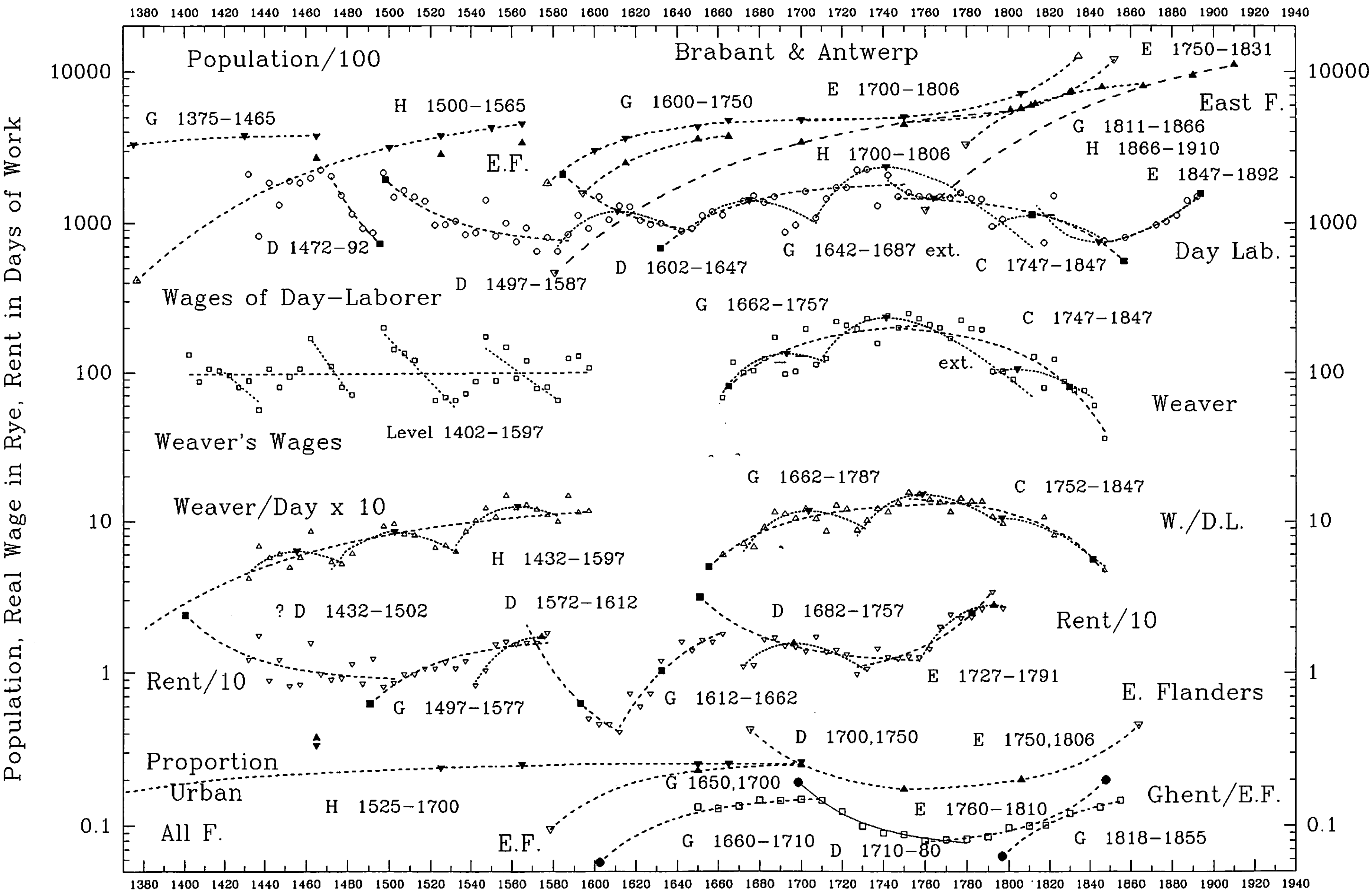
Wages and Cost of Living 1750–1913, Crafts and Mills



Source: Crafts and Mills 1994, 179–82.

Figure D.2

Long- and Short-Term Trends of Population, Real Wages, and Land Rent in East Flanders and Adjoining Regions from the 1400s to the 1900s



Sources: Klep 1991, 505, 498; Vandenbroeke 1984, 922, 924, 916.

Figure D.3

National and Per Caput Income, Production, and Consumption in England 1470–1910

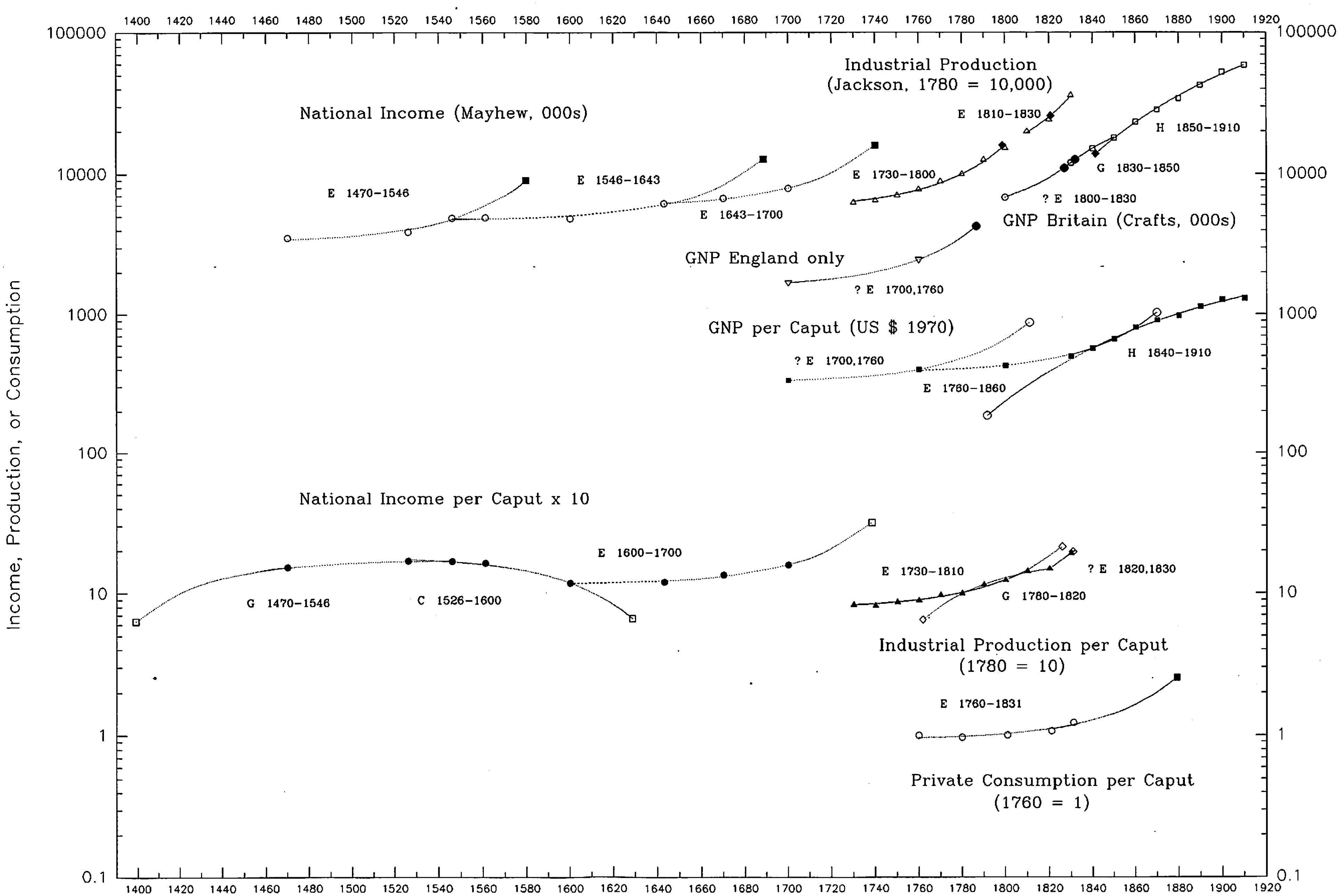


Figure D.4

Innovations in English Agriculture and Industry 1525–1895

a. Patents and Their Applications for Industry and Agriculture, and Agricultural Books

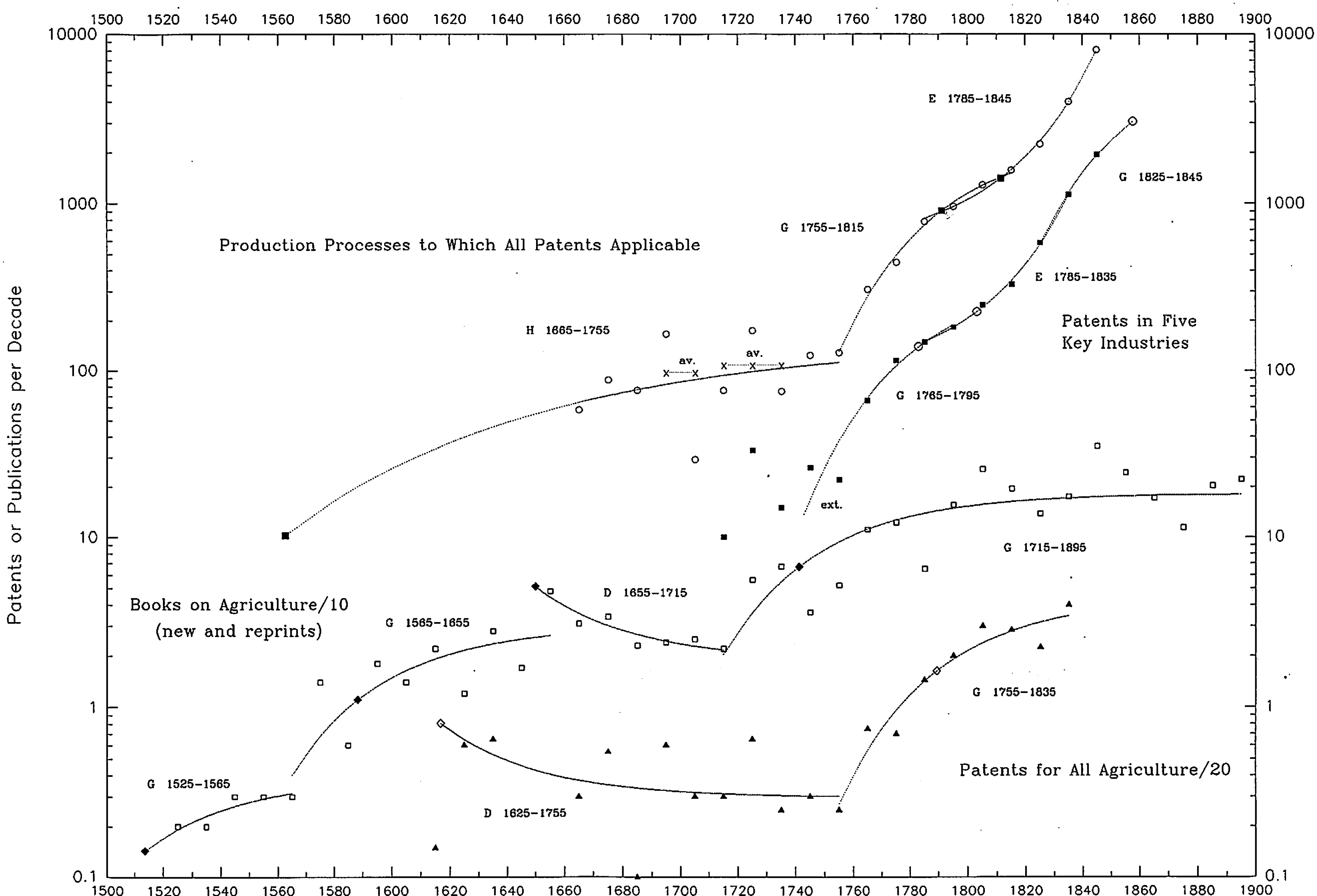


Figure D.5

Trends of Structural Change, Rates of Growth, and Investment in the Economy of Britain 1700–1913

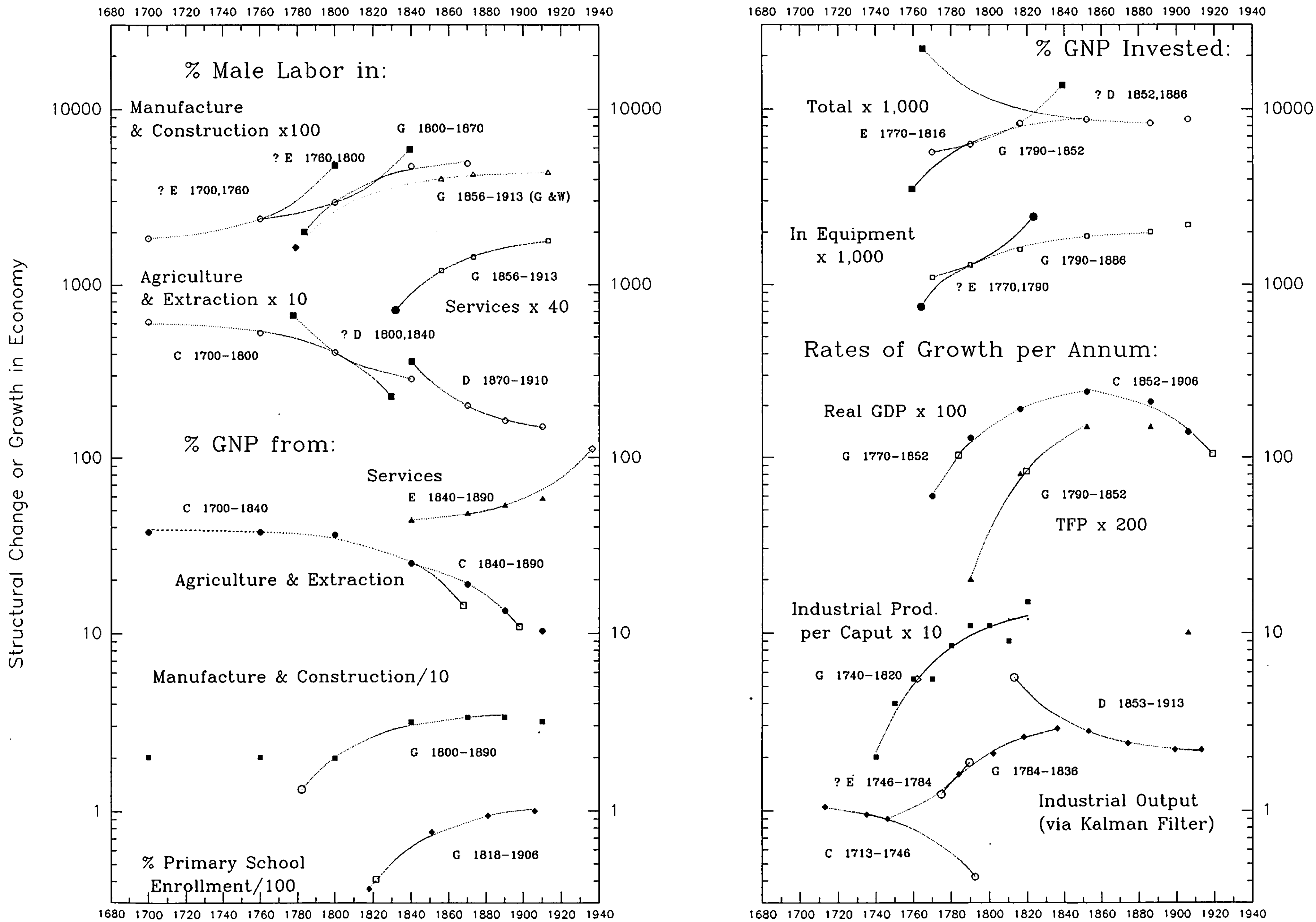


Figure D.6

Population Growth, Urbanization, and Agricultural Productivity in England from 1550

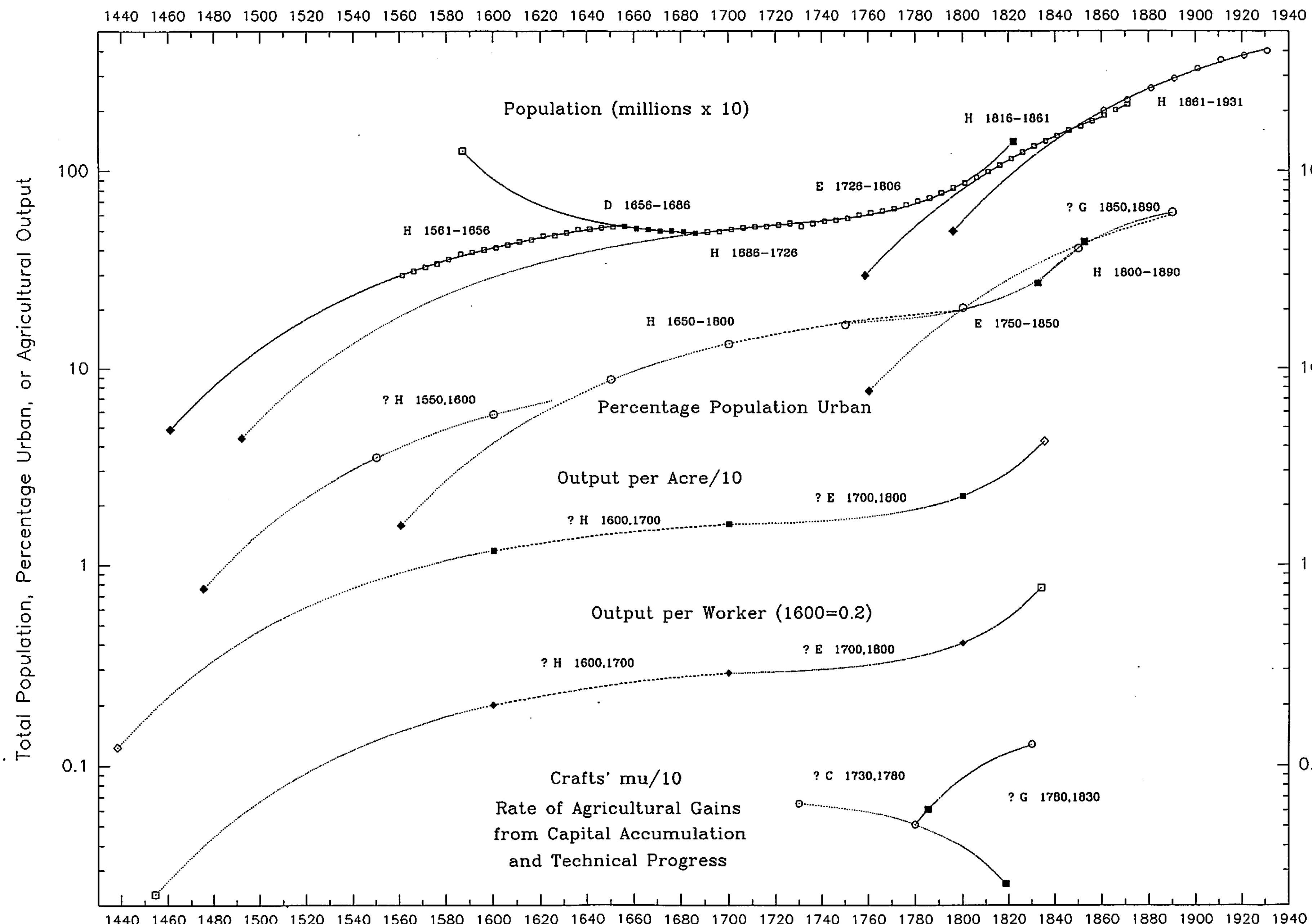


Figure D.7

Some Health and Food Conditions for English Workers during Industrialization

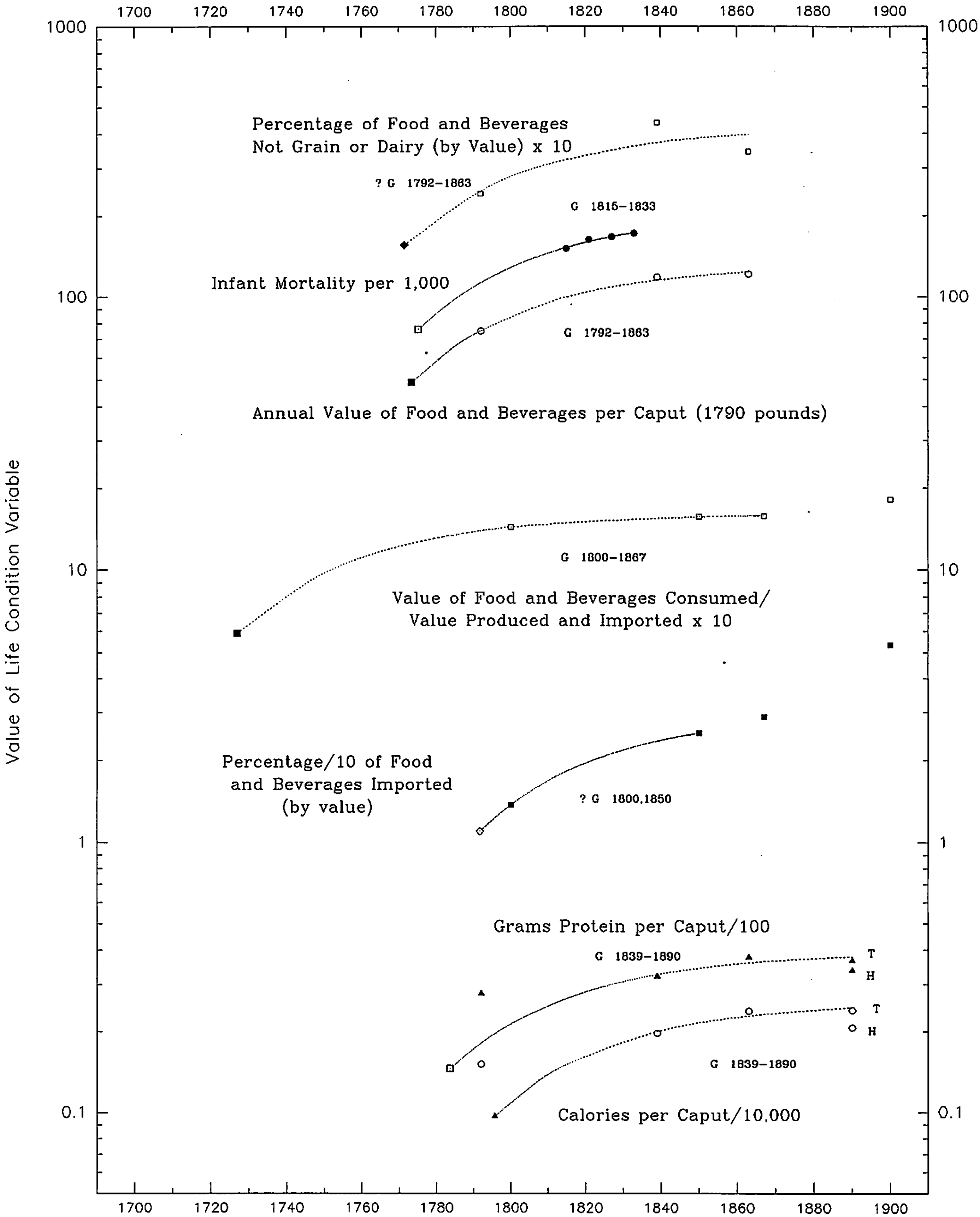


Table P.1

Demographic and Economic Trends in England ca. 1550-1650

Crude Death Rate	1475-1525	?C	1575?
Crude Birth Rate	1425-1525	D	1390
Population	1561-1656	H	1461
Still Birth	1590 - 1661	E	1708
Crude Death Rate	1556-1681	E	1722
% 5-14 Die	1585-1685	E	1716
% 1-4 Die	1585-1610	C	1673
" " "	1610-1680	G	1589
Life Expectancy (e_0)	1556-1681	C	1729
Crude Marriage Rate	1556-1661	C	1684
Nuptuality (I_m)	1558-1663	C	1712
Crude Birth Rate	1556-1661	C	1710
Fertility (I_f)	1558-1663	C	1707
Gross Reproduction Rate	1556-1661	C	1701
Total Fertility Rate	1556-1661	C	1701
Total Marital Fert.	1612-1662	C	1730
Age-Specific M. F.	1612-1662	C	1728±
Infant Mortality	1580-1640	C	1700
Mortality 1-4	1580-1610	C	1673
Crude Natural Increase	1566-1661	C	1643
Premarital Pregnancy	1569-1637	C	1673
Female Celibacy in 40s	1587-1637	G'	1630
" " " "	1612-1662	E	1718
Mortality 0-14	1585-1615	G'	1587
" "	1615-1675	G	1568
% Births Illegitimate	1585-1645	G'	1600
Extramarital Fert. (I_f)	1568-1648	G'	1600
6 Mo.'s Premarital Preg.	1569-1637	?G'	1587

Books on Agriculture	1524-1565	G	1513
" " "	1565-1655	G	1588
Total Grain Production	1590,1700	?H	1420
Agr. Output per Acre	1590,1700	?H	1438
" " " Worker	1600,1700	?H	1455
% Rural Pop. not in Agr.	1600,1670	?H	1444
" " " " " "	1600,1670	?G	1562
Pop. per Person in Agr.	1600,1670	?G	1540
Enclosure Rate	1550-1750	G	1580
Workers per Farmer	1599-1700	G	1587
% Population Urban	1600,1670	?H	1500
" " "	1600,1670	?G	1582
Emigration Rate	1541-1661	H	1480
" "	1541-1661	G	1543
Prices	1558-1599	E	1598
"	1599-1660	G	1571
Real Rural Wages	1575-1615	D	1559
" " "	1615-1725	G	1550
Urban/Rural Wages	1555-1585	G	1522
" " "	1585-1635	D	1530
" " "	1635-1695	G	1581
Real Urban Wages	1558-1616	C	1624
" " "	1616-1692	E	1718
% Farmers in Rural Pop.	1599-1705	C	1705
National Income	1548-1643	E	1690
" " per cap.	1526-1600	C	1628
" " " "	1600-1700	E	1740
Immigration to Norwich	1535-1705	G'	1587
London Urban 'Potential'	1550-1650	G	1525
Natural Increase	1666-1681	deficit	
Emigration Collapses	1656-1736	D	1687
London Demogr. Deficit	1612-1765	G'	1675

Sources: See text.

Table P.2

Demographic and Economic Trends in England ca. 1650-1725

Population	1656-1681	D	1587
"	1686-1726	H	1492
Crude Birth Rate	1656-1751	G	1602
Gross Reproduction Rate	1661-1726	G	1615
Fertility (I_f)	1663-1723	G	1624
Total Marital Fertility	1687-1737	G	1607
Crude Marriage Rate	1661-1756	G	1607
Nuptuality (I_m)	1663-1763	G	1619
Celibacy	1662-1737	G'	1675
"	1687,1712	?D	1680
Infant Mortality	1640-1730	G	1596
% 1-4 Die	1610-1680	G	1589
" " "	1690-1750	G	1663
% 0-14 Die	1675-1715	D'	1692
Crude Death Rate	1681-1831	D'	1704
% 25-29 Die	1655-1735	G'	1682
% 30-34 Die	1655-1755	G'	1690
% 35-39 Die	1675-1735	G'	1694
Life Expectancy (e_0)	1681-1731	G'	1704
" " (e_{25})	1685-1725	G'	1706
" " ($_{20}e_{25}$)	1685-1755	G	1608
" " ($_{20}e_{45}$)	1685-1715	G'	1698
" " ($_{20}e_{65}$)	1685-1715	G'	1703
Still Single	1662-1712	C	1762
% Females Marry by 20	1612-1712	C	1742
" " " " 25	1637-1712	C	1798
" " " 35+	1687-1787	?C	1799
ASM Fert. Rate 15-19	1637-1712	C	1746
" " " 25-29	1662-1712	E	1770

Total Grain Production	1590,1700	?H	1420
Agr. Output per Acre	1590,1700	?H	1426
" " " Worker	1600,1700	?H	1455
Pop. per Person in Agr.	1670-1750	H	1514
Nominal Rural Wages	1615-1755	G	1578
Real " "	1615-1725	G	1550
Enclosure Rate	1550-1750	G	1580
Prices	1660-1692	D	1625
"	1693-1748	D	1642
Agricultural Patents	1625-1755	D	1617
Books on Agriculture	1655-1715	D	1650
Emigration Rate	1656-1736	D	1689
% Farmers in Rural pop.	1688-1793	?D	1670
Laborers % Farm Workers	1687-1795	?G	1675
Real Urban Wages	1616-1692	E	1718
" " "	1693-1731	G	1676
Urban/Rural Wages	1635-1695	G	1581
" " "	1695-1725	G	1653
London Demogr. Deficit	1612-1765	G'	1675
% Population Urban	1670-1750	H	1554[W]
" " "	1650-1800	H	1560[V]
" " London	1612-1712	H	1540?
All Patent Processes	1665-1755	H	1563
% Rural Pop. not in Agr.	1670-1800	H	1540
Workers per Farmer	1680-1793	H	1554
National Income	1643-1700	E	1740
" " per cap.	1600-1700	E	1739
Real Rural Wage (alt.)	1595-1735	E	1789
% Pop. Non-London Urban	1520-1700	E	1720
Cost of Agric. Capital	1625-1725	E	1803
Return on " "	1625-1725	C	1762
Rent/Price of Land	1575-1725	C	1768

[W] = Wrigley 1985a; [V] = de Vries 1984.

Sources: See text.

Table P.3

Demographic and Economic Trends in England ca. 1725-1815

Population	1726-1806	E	1822	
Crude Birth Rate	1726-1816	E	1862	
Gross Reproduction Rate	1726-1816	E	1861	
% Population under 15	1726-1816	E	1868	
Fertility (I_f)	1718-1808	E	1855	
Total Marital Fertility	1712-1812	E	1922	
Age Spec. M. F. 15-19	1762-1812	E	1875	
" " " " 20-24	1762-1812	G	1644	
" " " " 25-29	1737-1812	E	1908	
" " " " 30-34	1737-1787	C	1871	
" " " " 35-39	1737-1787	C	1859	
" " " " 40-44	1687-1812?	G	1654	
" " " " 45-49	1762-1812	C	1898	
Nuptuality (I_m)	1758-1818	E	1861	
Crude Marriage Rate	1761-1841	C	1895	
% Females Marry 35+	1687-1787	?C	1798	
" " " by 20	1712-1812	?G	1705	
" " " by 25	1712-1812	?G	1676	
Crude Death Rate	1731-1761	D'	1752	
" " "	1761-1831	C	1880	
Life Expectancy (e_0)	1731-1761	G'	1751	(PH)
" " "	1761-1831	E	1892	"
" " "	1765-1805	E	1858	(GIP)
" " (e_{25})	1785-1805	E	1860	
" " ($_{20}e_{25}$)	1765-1805	?E	?	
" " ($_{20}e_{45}$)	1725-1805	G	1640	
" " ($_{20}e_{65}$)	1765-1795	C	1848	
Still Births	1712-1762	C	1808	
Infant Mortality	1750-1810	C	1856	
% 1-4 Die	1720-1830	?C	1870	
" " "	1750-1790	G'	1768	
% 5-14 Die	1715-1805	C	1816	
% 0-14 Die	1755-1795	G'	1771	

Total Grain Production	1700,1800	?E	1824	
Agr. Output per Acre	1700,1800	?E	1834	
" " " Worker	1700,1800	?E	1834	
Pop. per Person in Agr.	1750,1801	?E	1836	
Workers per Farmer	1765,1831	E	1838	
Enclosure Rate	1750,1850	?E	1880	
Nominal Rural Wage	1755,1815	E	1811	
Agr. Gain/Capital & Tech.	1730,1780	?C	1819	
% M. Labor in Agr.-Extr.	1700-1800	C	1830	
% GNP from Agr.-Extr.	1700-1840	C	1868	
Industrial Production	1730-1800	E	1799	
" "	1820-1830	E	1821	
Industrial Prod. per cap.	1730-1810	E	1826	
" " " "	1820,1830	?E	1830	
% M. Labor in Mfr.-Const.	1760,1800	?E	1840	
% Return on 3% Consols	1751-1796	E	1816	
Gross Nat. Prod. (Engl.)	1700-1760	?E	1788	
GNP (Britain)	1800-1830	?E	1832	
GNP per Capita	1760-1860	E	1870	
Bank of England Dividend	1732-1797	E	1848	
% GNP Invested	1770-1816	E	1840	
Private Consumption p.c.	1760-1831	E	1878	
Nominal Urban Wages (PBH)	1736-1810	E	1819	
" " " (CM)	1750-1809	E	1824	
Real " " (PBH)	1731-1813	C	1839	constant weights
" " " (CM)	1750-1804	C	1849	
Urban/Rural Wages	1715-1795	E	1851	
% Population Urban	1750,1801	?E	1835[W]	
" " "	1750-1850	E	1854[b]	
% Pop. Non-London Urban	1750,1801	?E	1814	
Emigration Rate	1656-1786	D	1688	
% Population in London	1737-1812	D	1691	
Real Rural Wages	1735-1785	D	1700	
" " "	1785-1835	G	1698	
Return on Agric. Capital	1725-1825	D	1662	
Rent/Price of Land	1725-1825	D	1671	
Cost of Agric. Capital	1725,1775	?D	1692	
" " " "	1775,1826	?G	1725	
% Rural Farmers & Workers	1752-1831	D	1731	
Prices (PBH)	1750-1792	G	1725	
" (CM)	1750-1792	G	1728	
" (PBH)	1792-1809	G	1803	
" (CM)	1792-1813	G	1798	
Books on Agriculture	1715-1895	G	1742	
Agricultural Patents	1755-1835	G	1789	
Patents in 5 Industries	1740-1795	G	1783	
All Patent Processes	1755-1815	G	1792	

PH = Population History; GIP = Wrigley et al. 1997; PBH = Phelps Brown and Hopkins; CM = Crafts and Mills; w Wrigley; b Bairoch

Sources: See text.

Table P.4

Demographic and Economic Trends in England ca. 1815-1865

Population	1816-1861	H	1758
Crude Death Rate	1761-1831	C	1880
Stillbirths	1762-1831	C	1872
% Population under 15	1821-1861	D	1759
Crude Birth Rate	1816-1846	D	1779
Gross Reproduction Rate	1816-1851	D	1787
Total Fertility Rate	1816-1851	D	1787
Fertility (I_f)	1823-1858	D'	1845
Nuptuality (I_m)	1828-1868	D'	1845
" "	1851-1871	G	1780
Crude Marriage Rate	1831-1871	G	1788
Infant Mortality	1815-1848	G	1768
Food & Bev. Value p.c.	1792-1863	G	1774
% F&B not Grain-Dairy	1792-1863	?G	1772?
Protein p.c.	1839-1890	G	1783
Calories p.c.	1839-1880	G	1796
% F&B Imported	1800,1850	?G	1790
F&B Consumed/Prod.-Imp.	1800-1867	G	1727

Labor Prod. in Agric.	1800-1880	H	1650
Urbanization	1800-1950	H	1750
Gross National Product	1800,1850	?H	1783
GNP per cap.	1760-1860	E	1870
" " "	1840-1913	H	1792
Private Consumption p.c.	1760-1831	E	1878
Enclosure Rate	1750,1850	?E	1880
Yield per Hectare	1800,1880	?G	1762
% M. Labor in Agr.-Extr.	1800,1840	?D	1778
Agricultural Patents	1755-1835	G	1789
Agr. Gain/Capital & Tech.	1780,1830	?G	1784
% M. Labor in Mfr.-Const.	1800-1913	G	1780
% GNP from Mfr. & Const.	1800-1890	G	1780
% GNP Invested	1790-1852	G	1760
" " " in Equip.	1790-1886	G	1763
Industrial Output	1784-1836	G	1775
" " p.c.	1740-1820	G	1762
Real GDP Growth	1770-1852	G	1783
Return on 3% Consols	1797-1880	D	1783
All Patent Processes	1785-1845	E	1812
Patents in 5 Industries	1785-1835	E	1803
Prices (PBH)	1809-1843	D	1798
" (CM)	1809-1852	D	1805
" (PBH)	1843-1876	G	1817
" (CM)	1848-1874	G	1804
Real Urban Wages (PBH)	1809-1867	G	1805
" " " (CM)	1800-1864	G	1795
" " " (OP)	1830-1866	G	1788
Urban/Rural Wages	1805-1835	G	1789
Real Rural Wages	1785-1835	G	1698
Emigration Rate	1766-1926	G	1806
% Primary School	1816-1906	G	1818
Total Factor Productivity	1790-1852	G	1820

PBH = Phelps Brown and Hopkins; CM = Crafts and Mills; OP = in own product.

Sources: See text.

CHAPTER 11

Socioeconomic Connections of Fertility and Fertility-Related Trends: Some Insights from Belgium between 1400 and 1900

The rich historical literature on the southern portion of the Low Countries that became Belgium, especially on the region of Flanders, affords a ready opportunity to compare and to connect trends in fertility and related demographic behavior that preceding chapters have discovered and developed with social and economic changes that have been central in the provocative broader discussion of how early modern Europe evolved, and also the debate over how and why historical demographic movements occurred. These Belgian insights illustrate further the way that the new conceptualization of change through time that is put forward by this study is helpful in advancing more familiar forms of social and economic inquiry as well as a better understanding of populations.[1]

In order not to carry the present volume too far afield from its primary mission, only a sample of findings is offered. These, furthermore, are derived here primarily from just a few discussions in what have been complex and long-developing national and regional bodies of study. A more detailed use of the many invaluable materials available in the literature will, *deo volente*, appear in subsequent publication. While the present exploration must be preliminary because of the voluminous detail that exists and the appearance of most of the basic Belgian research in the national languages of Flemish and French, some illustrations of what the trends appear to be and how they seem to relate to each other simultaneously supports the claim that the observed G-related demographic patterns are real and illuminates how these movements interacted with social and economic developments unfolding around them.

Two topics are addressed. On the one hand, evidence from Flanders--the most western and also the most studied of the several Belgian regions--demonstrates how the kind of G' pulses in fertility addressed in the latter pages of Chapter 5 can be related not only to comparable movements in secularization but to G' surges (or 1/G' depressions) in chances to marry, to raise children, and to earn a living. Some of these connections can be followed historically in other parts of Belgium as well. On the other hand, invaluable detail on the development of the province of East Flanders in particular, the area around Ghent, provides a unique opportunity for analyzing at least preliminarily the interplay of longer-term economic and demographic change in a historically significant and revealing context.

FURTHER EVIDENCE CONCERNING SHORT-TERM DEMOGRAPHIC AND ECONOMIC RELATIONSHIPS OF G' SHAPE

Whereas it is tempting to attribute the almost uniform regional Belgian G' movements of secularization that crested in the 1820s to the diffusing effect of the French Revolution upon European values that is first observed in France herself (as in Figure 5.17), the later surges of the middle 1800s in this shape that are evident in Belgium, and also new increases perhaps beginning around 1880 there, do not lend themselves to such an interpretation. Explanation, besides, is complicated by the presence of G' humps in the index for secularity already across the century and a half from the 1630s into the 1780s. These begin in Flanders with t_0's around 1672 for the period from 1637 through 1687 in the area of sandy soils and East Flanders, 1682 for 1662-1737 in the Antwerp campine, and 1686 for 1662-1712 in the region of coast and polders. The average crest for the years from 1662 through 1712 thus comes at 1680 for Flanders as a whole (Lesthaeghe 1992, 9; Figure 5.17 in Chapter 5 graphs some of these local trends). The highest *level* for the index was reached in the countryside around Antwerp. Later G’ surges appear in Brabant (half Flemish, half Walloon), where the cap between 1662 and 1737 came at 1698 and then in a second G’ pattern for East Flanders and the sandy soils of West Flanders (with crest around 1727 for the period from 1712 through 1762). Finally, in other rural Wallonia what is probably a G’ trend appears from 1712 through 1795, though the 1782 level falls below what immediately follows. This movement peaked somewhere in the early 1740s. What might have generated not one but *several* G’ waves of secularization across Belgium this way between the 1630s and the 1880s?

The Low Countries had been riven by religious, political, and economic tensions from the 1570s through the 1640s. In the Spanish (later Austrian) half that the Hapsburgs retained until the French revolution, Antwerp was especially hurt, losing business and people--many of them skilled and affluent--to the rapid rise of Amsterdam. This disruption, especially of the western commercial zones of the Southern Netherlands (present-day Belgium) was then complicated by further conflict into the early 1700s that involved the French and the English as well as the Spanish and the Dutch. Against this background, the Flemish regions moved first to violate religious prohibitions on marriage during Lent and Advent; and the countryside around Antwerp displays the highest level of non-compliance during the later 17th century. Were these people most unlikely to be pro-Spanish and Catholic? By the end of World War I, though, non-Catholic voting was *least* common in West and East Flanders and Antwerp, and likewise Limburg--the four Flemish areas. Lesthaeghe’s interpretation is that the industrialization of Wallonia secularized people (1977, 42-43). Yet it was not in the Walloon industrial villages that the 18th-century surge in secularization, a comparatively low one, appeared.

As of 1846, on the other hand, agricultural land was most likely to be *rented*, not cultivator-owned in the provinces of West and East Flanders and the neighboring portions of

Antwerp and Brabant (ibid., 24). The fortunes of these renters and their workers may have had more to do with marrying in religiously proscribed periods than did beliefs. Then, however, what generated a later G' surge of secularization, cresting in the second quarter of the 18th century, in non-industrial rural Wallonia (the French-speaking region) along with the Flemish people of the coast and the polders, the sandy soil region, and East Flanders? Was the path-breaking reproductive behavior of the northern French countryside first seeping into these border regions? How, in sum, did values, economic conditions, and demographic behavior interact in what is now Belgium?

Although national data are apparently not known before the 19th century, from 1846 forward to 1930 the frequently documented rate of illegitimate fertility in Belgium rose and fell with crest at 1872 (Figure 4.4b and Table 4.5). This movement parallels G' trends in secularization during the later 1800s for Brabant and rural Wallonia that appear in Figure 5.17 and is roughly resembled by surges of that index in the Antwerp campine and the western coast and polder region when these areas are separated out within Flanders.

This kind of apparent connection between secularization (as measured via the monthly distribution for marriages) and extramarital fertility can in fact be illustrated across two centuries for Flanders, and insightfully related to changes that were taking place in the economic environment of values and demographic behavior. Figure 6.1a illustrates and Table 6.1 summarizes average estimated trends for those two provinces (East and West) in the timing of marriages, percentages of births that were illegitimate, premarital pregnancy, the crude marriage rate, child mortality, and real wage in agriculture as stated in wheat (Figure 5.17; Lesthaeghe 1991, 266; Devos 1999, 116; Vandenbroeke 1988, 273-73, as cited in Devos 2003, 32,). Also included in the figure and the table are patterns of I_m and I_h (Lesthaeghe 1977, 57, 121) for comparison with movements in the crude marriage rate and the rate of illegitimate births.

The first observation from Figure 6.1 is how generally trends of G' shape appear, though toward the bottom of the graph several inversions of 1/G' pattern present themselves. All of these indices display periodic pulses, up or down, in the form of the derivative of G. Those kinds of movements, which were found to be so common in local migrations in Volume II, permeate several dimensions of fertility and its environment in Flanders across an epoch of almost three centuries. As in previous findings about migration, a relatively short-term demographic shock or impulse, or shift in conditions, leaves such a G' imprint, especially in relatively localized circumstances.

A second set of valuable findings from Figure 6.1, summarized in Table 6.1a, concerns how G' or 1/G' trends in the various indices paralleled or mirrored each other. In the 17th century, secularization, premarital conception, probably illegitimacy, and possibly the crude marriage rate all rose and fell quite tightly together in G' fashion. Secularization, premarital conception, and the marriage rate retained this repeated, close relationship to each other for another century and a half through two more G' surges from the beginning of the 1700s to the middle of the 1800s. There, the CMR parted company to move *opposite* to the other two indices. The Coale index of nuptuality (I_m), however, displays from 1856 through 1890 (Lesthaeghe 1977, 57) a G' trend that, with t_0 also at 1878, once more joins--and in timing again slightly leads--this persistent troika of linked rates, as the cruder marriage measure had tended to do during the previous three G' surges that these variables had shared.

Most consistently, marriage during the religiously proscribed months of March and December for the most part lagged a little behind premarital conception, which in turn ran contemporaneous with--or at least somewhat less behind--changes in the CMR. One possibility, for Flanders in the least, is that surges in the index that has been used for secularization resulted from bulges in young people coming of age to marry. In this scenario, while larger numbers could fulfill that ambition at such times, others in the age group generated pregnancy first--a behavior widely employed by the young historically in order to force the sometimes reluctant hands of family and community to make available the necessary resources for forming a household.[2] Another result of such recurrent strains in the opportunity to wed was an increased disregard for religious regulations about the church calendar for marriage. I have seen no evidence of such G' age clusterings for Flanders, however.

Alternatively, shifts in the conditions of living, perhaps inducing migration, may have appeared in this form. Volume II has shown many examples of migration and local urbanization in the G' pattern. As has been already argued, such changes--whether in urbanization or in the nature of work available within the countryside--freed up young people from controls that limited marriage. The shifts in socioeconomic context could also readily foster easier sex before wedlock and weaken the power of custom and traditional values more generally. It is suspected that this second line of interpretation will prove to be the more useful one. In its scenario, the average age at first marriage for women rose from the 1630s to highs in the 1650s and 1670s and then declined into the first years of the 1700s (Devos 1999, 118) because of difficulties in marrying within farm life, familiar delays caused by migration, and other socioeconomic adjustments that issue from a changing environment.

Child mortality, once the data become available (Vandenbroeke 1977 as cited by Devos 2003, 32), from the 1710s as far as the 1820s also flowed and ebbed along with the bulges in marriage, premarital conception, and secularization. Then, however, the measure went up *opposite* to a simultaneous 1/G' sag in real farm wages, both with zero years for the fitted curves in the early 1840s. Such an offset of child death and real wages had also characterized the period from about 1780 to 1830 in Flanders. This classic Malthusian pairing for a "positive check," though, does not appear during the bulk of the 18th century. In that earlier era, real agricultural wages and child mortality rose and fell in G' shape *together* and *along with* premarital conception and secularization--all somewhat behind the crude marriage rate. During this epoch from the 1710s into the 1770s, more marriage and reproductive increase in general may have pushed up premarital conception, child mortality, and weddings against church rules; but it did not thereby depress agricultural wages as happened in later periods.

What opportunity, in agriculture or in protoindustrialization (perhaps both), opened this demographic window--including, at first at least, pushing down the rate of illegitimate births in counterbalancing timing? The answer may be that the residents of Flanders *prospered* when food became easier to obtain, as--for example--a G' surge in real agricultural wages expressed in grain that could be purchased reflects between 1710 and 1770 in Figure 6.1 (Vandenbroeke 1988, 272-73, as cited by Devos 2003, 32). As argued by Rudolf Braun for the Canton of Zürich (1978; compare Devos 1999, 102), furthermore, along with farm wages that purchased more an expansion of the supplementary rural activity of cottage textiles could allow more ordinary people to marry and procreate. In these new arrangements, children were useful in family strategy rather than a threat to the household's future through excessive partition of land. Small farms could support more people--for a while. An ensuing dip of real wages in the late 1700s, nonetheless, illustrates the eventual limits of this kind of new opportunity.

Though the fit to G' form is only rough for the broad 25-year blocs of data available, it is likely that from the middle 1600s into the early 1700s the proportion of births in Flanders that were illegitimate (the bottom plot in Figure 6.1) rose and fell alongside the G' movements of secularity, premarital conception, and perhaps the crude marriage rate--as the top portion of Table 6.1 recapitulates. As of about 1715, however, the relationship reversed. Down then up 1/G' movement in illegitimacy now mirrored vertically G' upward surging in those variables, and also in real agricultural wages. Then, as the real wage dipped in 1/G' form against the next wave of G' humps in secularity, premarital conception, the CMR, and child mortality, illegitimacy from 1798 through 1873 now rose twice approximately via G', shortly behind the sags in real wages (t_0's at 1824 and 1858, Table 6.1a summarizes). Coale's index of extramarital fertility (I_h averaging East and West Flanders from Lesthaeghe 1977, 121), meanwhile, seems to have swelled in two only slightly increasing G' humps between 1846 and 1900. The first of these movements has its crest at 1858, just like the underlying G' trend hypothesized for the percentage of births that were illegitimate. Throughout, illegitimacy seems from the 1720s to the

1870s to have moved opposite from the real wage, with something of a lag, as if stressed living conditions fostered it--either directly, as through difficulty in marrying and forming households in the countryside, or indirectly, as by generating migration.

Further analysis of economic changes in the still more narrowly defined provincial area of East Flanders allows other G' and 1/G' movements in rural life to be related to demographic developments of that shape. The trends are summarized in the bottom three layers of Table 6.1a for comparison, but are discussed only in the next section of this chapter where the relevant graphings appear.

Though the contextual data around them are much more limited in the few secondary sources employed here, there are indications of G' surges in fertility in other parts of Belgium besides Flanders. Table 6.2 presents some estimated particulars of such movements in marital and extramarital fertility between the middle of the 19th century and the second quarter of the 20th across all the provinces of the nation and in some principal urban areas. Also included are some comparisons with patterns for Belgium as a whole and for the neighboring countries of France, the Duchy of Luxemburg, the Netherlands, Germany, and Denmark.

Marital fertility (I_g), as shown in the first column of Table 6.2, from 1846 or a little later up to the eve of World War I rose and fell in G' form with crests focused around the late 1850s in the urban areas of Antwerp and Ghent, Brussels, Liège, and the industrial towns of Hainaut (Lesthaeghe 1977, 116). This is just a little earlier than the G' pattern for Belgium as a whole (1863), as the next column of Table 6.2 indicates (from Figure 4.1a and Table 4.5). The Flemish provincial towns, meanwhile, from 1856 through 1900 display a surge of this shape that caps out rather later, in the middle 1870s. In the provincial towns of the Walloon areas of Belgium, however, no G' trend in marital fertility for this period is evident. Instead, from 1846 through 1910 the index falls off in accelerating C fashion. With t_0 around 1911 rather than 1933 or 1920, this trend is rather steeper than the C decline found in France for the years 1831 to 1911 or that likely in the Duchy of Luxembourg between 1900 or earlier and 1930 (Figure 4.1a and Table 4.1).[3]

The regional trends presented in the second data column of the top part of Table 6.2 (Lesthaeghe 1977, 103) elucidate how the Walloon towns display a different pattern of I_g from the other urban places. In the French-speaking provinces of Luxembourg, Namur, and Hainaut marital fertility from the 1800s into the early 1900s is best delineated in C form with zero year around 1939 for rural Luxemburg and in the 1910s for the other two provinces. Of the fully Walloon regions (half of Brabant is French-speaking) only in Liège--heavily industrial and nestled in next to Flemish Limburg, the southeastern tail of the Netherlands, and Germany--does the G' shape best fit the movement of marital fertility (with t_0 around 1861, resembling the patterns for Belgium as a whole, Brabant, East Flanders, Antwerp, and West Flanders, which all have zero years for the estimated curves between 1859 and 1876). For Limburg, the G' pattern is timed about two decades later, much as in the Netherlands next door (1893 vs. 1886), and commences a decade after the Dutch one. The German trend, meanwhile, resembles rather more the movement for the Flemish areas of Belgium, and the Danish G' pattern lags only slightly behind. In all, the French-speaking provinces along the French border followed, like the neighboring Duchy of Luxemburg, the overall French C trend in marital fertility between 1831 and 1911[4] while in the Flemish-speaking provinces and Liège I_g took the G' shape instead, resembling generally contemporaneous movements of this index in Germany, the Netherlands, England and Wales, Scandinavia, Switzerland, and also some parts of the Hapsburg domains in central Europe (Table 4.5). The regional distribution within Belgium, in short, helps strengthen the understanding of national differences advanced in Chapter 4. The many provincial series computed and collated by Coale and Treadway (1986) of course allow this kind of geographically finer analysis, for those who wish it, to be conducted comparably within and among countries all across Europe for the relatively modern era.

In European nations, *extramarital* fertility from the 1800s into the 1900s quite generally rose and then fell off in G' fashion, even in countries where the trend of marital fertility took C form instead (Tables 4.5 and 4.1). As shown in the bottom half of Table 6.2, the data for I_h in the provinces of Limburg. Liège, Namur, and Hainaut--in other words, the southeastern portion of Belgium--all behaved this way, with zero years not unlike the 1872 of the G' trend for the nation as a whole.[5] In East and West Flanders, Antwerp, and Brabant, on the other hand, the patterning was rather different, as the remaining columns of the bottom half of Table 6.2 indicate. By the end of the 1800s in each case the index of extramarital fertility decreased in $e^{-.03}$ fashion. This trend is the log-linear slope toward which G' converges with time. Previously, though, from 1846 through 1866 signs of G' movement with t_0 somewhere around the early 1860s (preceding the other provinces by a little) appear. Then in West and East Flanders and Antwerp from 1880 through 1900 new possible G' trends are evident with zero years around 1890.[6] Thus in the northwestern Belgian provinces a pair of G' movements might be said to bracket in timing the patterns shared by the Walloon areas, Limburg, and Belgium as a whole.

Such a succession of G' trends is not unknown in northwestern Europe during this era. For neighboring France, notably, from 1851 through 1876 one short G' surge with t_0 at 1863 occurred; the next, from 1881 through 1921 peaked at 1896. Denmark, England and Wales, and Scotland, meanwhile, all display comparable pairs of G' patterns in extramarital fertility (Table 4.5 and Figures 4.4d and 4.4a). In France and Belgium, furthermore, still earlier G' trends in I_h appeared--between 1831 and 1851, on the one hand, 1806 and 1846 on the other--with maxima around 1835 and 1820 respectively.

Whereas the causes and consequences of the observed G' provincial surges in marital and extramarital fertility must be probed with more diverse and more ample resources than can be brought to bear in the present analysis, two kinds of clues already offer themselves. In the first place, the proportion of the male work force engaged in agriculture in Antwerp and Brabant, Hainaut and Liège, and East and West Flanders between 1846 and 1890 or 1910 tended to crest somewhat in G’ fashion (around 1848, 1850 and 1863 respectively) before falling away in that pattern as farming became less and less central to Belgian life in the later 19th century (Lesthaeghe 1977, 31). In Namur, Luxembourg, and Limburg, in contrast, no G’ movement toward agriculture is evident as part of the 19th century transition in how families earned a living. The percentage of men in agriculture declined via D instead.

In East and West Flanders, both for men and for women the proportion of employment to be found in agriculture peaked temporarily in the middle 1860s (ibid., 21). As of 1910, though, the percentage for females crashed. It took a G’ surge of engagement in lace-making and embroidery, from 1866 through 1910 with t_0 around 1884, to make overall rural employment for women in these two provinces--agriculture and cottage industry together--sustain its G’ pattern as a proportion of all work from 1846 through 1910, peaking at about 1868. For men, meanwhile, cottage industry in the form of linen-weaving was, in contrast, *disappearing*. Its percentage of total male employment in Flanders declined approximately in $e^{-.03}$ fashion from 1846 to 1890, then was totally gone by 1910. In aggregate, the proportion of regional employment for men that was situated in the countryside took G’ form from 1846 through 1890 with crest in the middle 1850s only because the percentage in agriculture over these years followed a G’ path with maximum around 1865.[7]

In all, the recurrent G’ cresting of both marital and extra-marital fertility that Table 6.2 summarizes for various provinces of Belgium in the 19th century was associated with peaks in rural employment. The proportion of all male work that took place in heavy and mid-size industry, meanwhile, rose between 1846 and 1910 in H fashion, in Hainaut and Liège--the most heavily industrialized areas of Belgium--but also, on average, later and not as much via the same type of path in the remaining provinces (Lesthaeghe 1977, 31). This H movement is a familiar phenomenon of historical structural change in employment: for example, the pattern by which the percentage of work taking place outside of agriculture rose in the states of America’s Old Northwest between 1830 and 1900 (Harris 2003, 212);[8] the urbanization of the Netherlands between 1550 and 1700 and England between 1670 and 1750 (ibid., 225); increases in the proportion of rural people who lived off of activities other than agriculture in both England and France between 1700 and 1800 (ibid., 237); and percentages of employment coming from industry for all developed areas of the world between 1800 and 1930--and for later-changing "Third World" societies during the second half of the 1900s (ibid. 294-95).

The other insight into the dynamics of the observed G' surges in marital and extramarital fertility across the provinces of Belgium derives from the trends of secularization that have been noted in Figure 5.17. Generally, the index of secularity (based upon marriages in Lent and Advent) was low, in the 1840s and/or 1860s, when the proportion of employment found in agriculture was high. Such a dip is clearest for East and West Flanders and Antwerp (shown collectively in Figure 5.17) and for rural Wallonia. For the industrial villages of this half of Belgium, it was more that secularization consolidated its gains before rising anew in the 1870s, while in linguistically mixed Brabant a new G' trend of secularization began earlier, in the 1840s, at a higher level than its predecessor.

Both marital and extramarital fertility tended to crest via G' paths in most of the Flemish-speaking provinces with a little lag behind how agricultural employment maximized for the time being and secularity reached a trough.[9] Among the Walloon provinces, heavily industrial Liège most of all displays a comparable congruence of these trends, though the G' hump in extramarital fertility there comes rather late, in the 1870s, along with such movements for I_h in Hainaut, Namur, and Luxembourg, which have C rather than G' trends for I_g. For all the provinces, meanwhile, short-term surges or dips in nuptuality are slight; the trends are mostly long-term. Still, everywhere the 1850s--when secularity was low and agricultural worked witnessed a resurgence--mostly are years initiating upward movements of I_m that tend to crest in the late 1870s.[10]

According to the example of East and West Flanders from Figure 6.1 and Table 6.2, the midpoint of the 1800s appears to be a time of low real wages, high childhood mortality, and dips in the crude marriage rate and I_m. In England across the first third of the 19th century a proletarianization of farm employment has been indicated (Harris 2003, 241). Was a similar process taking place in Flanders in the middle of the 1800s? All Belgian provinces except Antwerp, for instance, saw the proportion of land that was owned by those who cultivated it decline between 1846 and 1895 (Lesthaeghe 1977, 23). In West Flanders, Namur, Luxembourg, and Limburg most of this shift towards concentrated ownership and renting occurred between just 1846 and 1866. Known for their advanced agricultural development, East Flanders and especially West Flanders began with and ended up with the lowest percentage of agricultural land owned by those who cultivated it. This was an important characteristic of the "agricultural revolution" in which these regions had been playing a leading part.

Was the evolving system using more hands but rewarding them less well, with the consequence that marriage became more difficult, premarital conception rose, young people paid less attention to traditional prescriptions about when to marry, and increasingly left the countryside to work in thriving Belgian industries? This is apparently what happened, that is, until real wages and nuptuality improved into the late 1800s as rural employers had to compete with urban ones for labor. Interacting dynamics like these, though, show up best in longer-term movements of the exceptionally well documented countryside of East Flanders.

THE ESPECIALLY RICH FINDINGS FROM EAST FLANDERS

Already, Figure 6.1a has opened up insight into longer-term movements in the environment of fertility in the general region of Flanders. First of all, whereas from the beginning to the end of the data series presented there the long-term level of secularity and child mortality remain essentially level, only having G' surges periodically along the way, substantial drifts are apparent in other measures. From 1710 through about 1850 the real wage (in wheat) trended downward. A comparable movement occurred in the crude marriage rate from the 4th quarter of the 17th century to the 3rd quarter of the 19th, while premarital conception rose fairly much inversely from the 1630s to the 1880s. Illegitimacy, on the other hand, though displaying the two 1/G' patterns of 1737-1798 and 1798-1854 drove relentlessly upward at about twice that pace, constituting the steepest long-term change in the graph.

What was happening to generate such movements? Scholars of East Flanders have, over the past several decades, made available a wealth of material that can be employed to demonstrate how demographic and socioeconomic changes related to each other. A G-based trending of at least some of this evidence reveals parallels, inverse movements, and--equally important--instances of apparently independent adjustment as the province developed from the 1400s to the 1900s.

Figure 6.2 begins, at its top, by demonstrating some probable patterns of *population increase*. Less frequently recorded movement in the demographic size of East Flanders (the solid upward triangles) is compared--for confirmation up to 1665, then in order to show contrasting development during the province's distinctive protoindustrialization of the 18th century--with calculations that have been made for the neighboring regions of Brabant and Antwerp (solid downward triangles) (Klep 1991, 505; Vandenbroeke 1984, 916).

After what the pattern for Brabant and Antwerp implies may have been relatively flat demographic increase subsequent to the Black Death across the 14th and 15th centuries,[11] followed by some more loss of population during the last years of the 1400s, the infrequent calculations for East Flanders seem to have resembled the population growth in G form that is indicated by data from 1525, perhaps 1500, through 1565 in those two neighboring regions. All three provinces then lost many residents during the wars for Dutch independence from Hapsburg rule, which split the Low Countries in two. Migration north contributed significantly to this demographic atrophy in the Southern Netherlands along with direct and indirect casualties of the prolonged combat. Then the numbers in both areas of the remaining Spanish (subsequently

Austrian) Netherlands recovered in G trends across the 17th century, in East Flanders rather more steeply than in Brabant and Antwerp (t_0 at 1594 rather than 1577). These movements are summarized in the first two columns at the top of Table 6.3.

Around 1700, in contrast, demographic expansion in East Flanders began to push upward in H fashion while the populations of Brabant and Antwerp, which lacked the support of the cottage linen industry, instead continued the G pattern of the 1600s and then gradually began to accelerate upwards in E form across the second half of the 18th century. The H trend in growth, Volume I has shown, has been associated historically with populations going through economic development, whether in England, Sweden, and the preeminent Dutch province of Holland in the 1500s and 1600s (Harris 2001, 149, 198) or in China and India or the United States in the later 1900s (ibid., 244, 250-51, 27). In East Flanders and parts of neighboring West Flanders in the 18th century the principal engine was not new woolens, naval stores, armaments, or herring fisheries--or computers, telecommunications, and pharmaceuticals--but the cottage production of linen cloth (an activity that flourished elsewhere in this period, as in Ireland).

By the early 1800s, however, population increase in East Flanders acquired the same type of upwardly accelerating E shape that had been emerging in Brabant and Antwerp, though in East Flanders that movement, the fourth column of Table 6.3 details, was about two decades later in its development. This growth transitioned into decelerating G shape as of the 1820s. Then across the later 19th century the population of East Flanders grew once more in H form (shown in Figure 6.2 but not Table 6.3). Hand-loom linens woven in the countryside had all but disappeared, however; now the engine of growth was the factory-based industrialization in which Belgium became a leader among the nations of Europe. The H trend shown in Figure 6.2 for the population of East Flanders from 1866 through 1910 had its t_0 in the 1760s compared with 1790 for the all-Belgium pattern of 1876-1910 (Harris 2001, 148).[12] The population of Belgium as a whole, however, had also previously expanded in H fashion between 1815 and 1866, with a zero year of 1717 (ibid.). Other provinces, notably Hainaut and Liège, were more industrial than East Flanders (Lesthaeghe 1977, 31).

Table 6.3 (but not Figure 6.2) includes particulars also for population trends in all of Flanders (East and West) in the 18th and early 19th century (Vandenbroeke 1984, 916, 928). These reflect comparable G-shape expansion in West Flanders during the first half of the 19th century, and generally similar involvement in the E-shape "population explosion" from the later 1700s through the 1820s that so widely accompanied the first stage of factory-type, mass-labor industrialization as it spread across Europe (and elsewhere around the world). Still earlier, during the H phase of demographic increase of the 18th century, the curve in Flanders as a whole is slightly later, and therefore steeper for the same years as far as 1782, than for the province of East Flanders only. Even stronger than for the province of East Flanders was the expansion of population during this era in its sub-region of the Pays d'Alost (Aalst), while H-type increase in Tielt was most marked of all (Vandenbroeke 1984, 919; Vandenbroeke 1987, 158; Mendels 1984, 950) as later and later zero years for the H curve across the same period of years indicate (1613 and 1638 for these two localities vs. 1600 in all Flanders and 1581 in East Flanders). The district of Tielt, which was situated in the eastern part of West Flanders next to Ghent on the western frontier of the cottage weaving zone as of the 1790s, had 71 percent of its workers engaged in linens by the 1840s. The Pays d'Alost (Aalst), which lay in southeastern East Flanders on the opposite end of the turn-of-the century protoindustrial textile area , had 62 percent (Vandenbroeke 1984, 917). Seemingly the spread of the home weaving industry into these regions from the 1790s forward out of Ghent and Oudenaarde, where it had been previously concentrated (Devos 1999, 106) was mutually supportive with the persistent, only slightly decelerating population growth that had been taking place in the 18th century and, probably most importantly, encouraged by an end to the changes--most likely advances of the so-called "agricultural revolution"--that had made such H-form demographic expansion possible. Having had steeper H trends of population increase than East Flanders in general, the families of Tielt and Aalst were now especially attracted to taking up weaving as the previous agricultural engine of local economic growth lost its steam.[13] As new areas engaged in weaving, however, we shall see how income to be had from this rural option then diminished.

Figure 6.2 next provides certain perspectives on how these patterns of population increase from the 1400s into the 1900s interacted with developments in the economy of East Flanders. The second level of plotting, with hollow circles as symbols for the data, presents movements of real *wages*, in liters of rye (the cereal of ordinary people), for day-laborers in agriculture (approximated from Figure 6 of Vandenbroeke 1984, 922; 1,000 signifies 10 liters of rye). Around 1700, before the introduction of the potato reduced grain consumption by about half, about one liter per person was eaten per day (Vandenbroeke 1987, 167).

Two kinds of trend are noted for this data series, and for some of those that follow below in Figure 6.2. The lighter lines, whose time spans are not given in the graph for reasons of space, capture apparent pulses of G’ or 1/G’ form. These are summarized in the middle and lower portions of Table 6.1 along with comparable movements from Figure 6.1. Later discussion will return such short-term trends and the relationships of those appearing specifically for East Flanders to trends of these types for all Flanders that have been encountered in Figure 6.1. The analysis first of all, however, focuses upon the underlying, generally longer-term trends of D, G, C, and E shape in these wages, which can be insightfully connected to the observed patterns of population growth and some other elements of economic change.

In the 16th century, as the population of Flanders swelled in G fashion, the real wage in agriculture declined in opposite D form. This would seem to be an example of the basic Malthusian model of demographic increase depressing living conditions to curb further growth. The timing of the 1497 to 1587 D curve of falling wages was about two decades later than the apparent contemporary G for growth in population, Table 6.3 summarizes from the visual presentation of Figure 6.2. One might say that as the rising number of children being born reached working age, earnings were depressed. From 1472 through 1492, moreover, a D trend of similar timing (1495 vs. 1498) had already begun to pull down wages before something shifted them up in the 1590s to continue a trend of similar shape and timing. After the 1460s, where the first population estimate for East Flanders separately is available (the filled upward triangle), the next calculation comes only at 1525; but the working hypothesis until better evidence is obtained should probably be that, as in neighboring Brabant and Antwerp, somewhere in the fourth quarter of the 15th century population dropped significantly in East Flanders--though probably not as steeply as wages in agriculture. I am not familiar enough with the history of the Southern Netherlands at this early point even to speculate what may have happened at that particular point in time; but local scholars should be able to make the connection.

A major drop in population during the fourth quarter of the 16th century in the areas retained by the Hapsburgs through the Dutch Revolt, however, is from many perspectives well documented. In this next period of demographic shock, the D curve of farm wages kept up its path as far as 1587 without reflection of the new disturbance. Unfortunately it is not known more precisely when between 1565 and 1615 demographic decline took place for East Flanders as a whole, though in the Aalst district a bottom is evident by 1580 and systematic G-shape recovery by 1600, while in Evergem the corresponding dates are 1590 and 1610 (Harris 2001, 308). During this population loss at the end of the 1500s, rural wages rose into the early 1600s--perhaps in the kind of G' pattern trended but not labeled in Figure 6.2, but in any case somewhat parallel with the G-shape recovery of population that is evident in Brabant and Antwerp and, rather more steeply, in East Flanders from 1615 or sooner to 1665. As the shock of war and the division of the Netherlands into antagonistic Dutch and Spanish zones first began to wear off, population and wages seem to have risen together. Then, however, while population grew in G fashion over the first three-quarters of the 1600s, wages were once more depressed in offsetting D manner à la Malthus--at least as far as the 1640s.

Between 1642 and 1687 the real wages for day-laborers in agriculture rose in G shape. Thereafter, there are sharp swings in these rural earnings that appear repeatedly to take G' form--for reasons that will be explored shortly. Across these ups and downs, however, the underlying direction and level seems to be that of the 1642 to 1687 G curve extended forward to the middle of the 1700s--as Figure 6.2 extends the curve. During this century-long period, significantly, the population of East Flanders seems to have expanded slowly in G manner to 1665 or a little later, fallen off slightly by 1700, but then taken up an H pattern of growth for perhaps a hundred years. In other words, the Malthusian counterposition of demographic growth and reduced quality of life was lifted off the shoulders of agricultural workers in East Flanders for quite a span of time. Most clearly, across the bulk of the 18th century that dire connection was broken. The 18th century, of course, was the boom era (in more than one European country) of protoindustrialization in the form of rural cottage weaving, of which there was a significant concentration in this particular part of the Southern Netherlands.

With this economic development, though, the population of East Flanders by no means broke free of the primal law of Malthus forever. In the later 1700s the number of inhabitants in East Flanders began to expand on to about 1830 in increasingly faster E fashion. As it did so, the value of the wages of day-laborers in rye--though still swinging around markedly--fell off over the long term between about 1747 and 1847 in a manner that can be summarized by a C trend with t_0 at 1857 compared with 1852 for the opposing E pattern of population increase in East Flanders between 1750 and 1831, as the next-to-rightmost column of Table 6.3 recapitulates from Figure 6.2. Following about 1860, in contrast, as the population of East Flanders enlarged in H fashion like the population of Belgium as a whole (and that of several developing countries of Northern and Central Europe), agricultural wages in the province swung upward in faster and faster E mode as far as the 1890s. Fertility control, as has been shown, was becoming entrenched in Belgium by now; and the Malthusian effect of population increase upon farm wages was blurred both by new opportunities for making a living in the spreading factory industry of the time and by the ability of farm families to limit their reproduction. Sufficient demand for agricultural labor relative to newly controlled supply, strengthened by competition from urban development, pulled the wages for day-laborers up out of the trough into which they had fallen by about 1850.

In all, agricultural wages between about 1500 and 1650, and then again from about 1750 to 1840, in the long term responded sensitively to change in the numbers of people who inhabited East Flanders. Between about 1650 and 1750, in contrast, as agricultural improvements and rural textile production developed and spread, residents of the province's countryside escaped the Malthusian trap thanks to better ways of making a living. Then once more, after about 1850, the growth of urbanized industrial employment and the spreading tendency to manage fertility in the countryside combined to free the people of this part of Belgium again from the uncontrollable collective trade-off between progeny and standard of living that had prevailed for all but 100 of the past 350 years.

As noted, increased linen weaving contributed substantially toward improving rural conditions during the century-long period of relief from elemental Malthusian constraints between the middle of the 17th century and the middle of the 18th. The next lower plot in Figure 6.2 (hollow squares) trends the equivalent wages in rye of linen weavers (Vandenbroeke 1984, 922, estimated from his Figure 6).

Unfortunately data are not available for weaving for the period between 1597 and 1662. All across the 15th and 16th centuries, however, it is evident that the earnings for this activity tended to fluctuate around a base level that changed little for the two centuries between 1402 and 1597 (100 represents 10 liters of rye). Four times within this chronological span wages were forced up markedly, only to sink back in trends that, on average, ran about $e^{-.03}$. The last 3 of these 4 sudden upward shifts produced, interestingly, G' surges in the ratio of the weaver's wage to that of the day-laborer (shown via hollow upward triangles in the next plot on the graph), which peaked at 1455, 1502, and 1563 successively. There are no comparable agricultural wages for the years of the first movement.

Between 1662 and 1847, then, the typical wage for weavers first rose in G fashion from about 8 liters of rye in the 1660s to an underlying average of about 20 liters in the 1750s. Across this fundamental trend are evident G' movements that resemble, but are not always identical with, those in the real wage for day-laborers. Then, from the 1740s into the 1840s the real earnings for a weaver in Flanders fell off, faster and faster, in C fashion. The G trend upward for weavers had its zero year over 30 years later than that for day-laborers (1665 vs. 1632), the C path of decline almost as much *earlier* (1830 vs. 1857). These differences made first the increase to the middle of the 18th century and then the subsequent decline for weavers both more substantial. The result was that the *ratio* of the weaver's wage to that of the day-laborer also rose via G and then fell off via C, each curve having a t_0 intermediate in timing (1655 then 1841) to that for the two series of real wages being compared. Since the rural people being considered mostly owned and worked at least a small amount of land even if they wove, it would seem that the rise then fall of the domestic linen industry did much to shape first the improvement then the deterioration of remuneration for ordinary people in the countryside quite generally, leaving an imprint upon the local agricultural day wage as well as what could be earned on the looms.

Earlier, across the 15th and 16th centuries, the underlying trend for the ratio of weaving wages to those for agricultural labor took H form. Across a series of G' fluctuations this movement raised the remuneration of weavers from only about 0.45 of what day workers earned in the 1430s to about 1.18 times their level in the 1590s. The implication of this H type of trend, which is so commonly associated historically with economic development (Harris 2001 and 2003), is that during these two centuries weaving constituted, in the least, an important element of fundamental economic change that made Flanders a prosperous region. The H pattern, as discussed elsewhere, simultaneously characterized the famous inflation that Europe experienced from the middle of the 1400s to the end of the 1500s. An increasing market for linens seems to have been one of the consequences of the accumulating riches of the new global trade of Atlantic Europe.

The marked decline in relative earnings for weavers from 1.18 in the 1590s to only around 0.60 in the 1660s, where the necessary data resume, would seem to reflect what happened to the markets of eastern Belgium as Amsterdam then replaced Antwerp as the leading entrepôt of northern Europe while the Dutch constricted trade out of the Scheldt and expanded their own linen production, especially in Haarlem (de Vries and van der Woude 1997, 291). Between 1600 and 1700 the formerly preeminent position of Antwerp within the trade networks of Europe had begun to deteriorate significantly (Harris 2003, 262); and textile centers like Ghent and Bruges lost substantial population from the later 1500s into the early 1600s (Harris 2001, 308). By the end of the incompletely documented period two-thirds of the way through the 17th century, weavers earned less than the level for 1402-1597 while day-laborers had begun to recover from the losses of the 1500s, presumably as Flemish agriculture began to develop its distinctive and profitable advances. Only with the crest of the linen industry in the middle 1700s did the wages for that activity regain an advantage comparable to that enjoyed around the middle of the 16th century, now up to as much as 1.50 times the remuneration of agricultural laborers.

The next to last plot in Figure 6.2 trends average *rent* for farmland expressed in days of work per hectare (divided by 10 for graphing) by agricultural laborers that would be necessary if they wished to advance their condition and operate their own land. From 1497 through 1577 (omitting the exceptionally low years of the 1540s) the number of days required increased in the complementary G fashion that one would expect with the real agricultural wage falling via D between 1497 and 1587. The timing of the two offsetting curves is about identical (with t_0's at 1491 and 1498), while the population of East Flanders probably increased via a G path based a little sooner, at 1479. Earlier, as agricultural wages rose between the 1430s and the 1470s, the amount of work needed for rent also declined, though the shape of the two movements is difficult to discern because of variability.

Next, rent fell markedly relative to farm wages between 1572 and 1612, during the bitterly contested Dutch Revolt. As had been usual to date in Flanders, as far as the first years of the 1600s a sharp change of some shape (upward) between 1582 and 1602 in what day-laborers earned was a source of relatively cheapening rent. As Figure 6.2 displays, nonetheless, the days of work necessary to have land declined much further than the agricultural wage rose. The years of conflict and relocation brought about noticeably cheaper rent of itself.

Similarly, the D-type decline in real wages between about 1602 and 1647 that followed, however, was now much *weaker* than the G trend of increase between 1612 and 1662 in days needed to pay rent. The zero year for the G curve in the labor cost of land, that is, sits at 1632 compared with as early as 1585 for the D curve in what day-laborers earned, Table 6.3 shows. The real rise in rent at this time, in other words, significantly exceeded how much the real wages of agricultural workers diminished, when both are calculated in rye.[14] As the division of the Netherlands became permanent, the increase in rent for farmland in Flanders that occurred as population in the eastern provinces of the Spanish Netherlands recovered from the struggle over Dutch independence, the top plots in Figure 6.2 show, was a major component in promoting the agricultural innovation and development for which the region became famous.

Thereafter, the wages of day-laborers rose in G fashion from the 1640s through the 1680s--and perhaps on to the 1750s, though quite erratically around such a projection--while the cost of land relative to farm work cheapened in D form between 1682 and 1757. Now the gain in real wage for laborers climbed between 1642 and 1747 only via a slightly flatter segment of the G curve (t_0 at 1632 vs. 1651). This increase amounted to about 25 percent between the 1680s and the 1750s compared with 31 percent for the decline in work necessary for rent over the same span of time, not as much of a difference as during the gain of rent in the previous era (in part because of the flatness by the 1680s of the G segments that are being compared). Again, change in the population of East Flanders apparently had something to do with the excess alteration in the value of land of itself. Between 1665 and 1700, that is, the population shrank about 6 percent before commencing its H-type expansion of the 18th century (Klep 1991, 505).

It should be remembered that in many parts of East Flanders close to half of the rural population was engaged in linen weaving by the 1790s (Devos 1999, 106)--well more than half by the 1840s (Vandenbroeke 1984, 917). In Figure 6.2 and Table 6.3 the t_0 for the G trend in weavers' wages for 1662-1757 comes at 1665 and that for the G pattern in the earnings of day-laborers between 1642 and 1747 falls at 1632. Thus, with zero year at 1651, the D curve for rent sits about midway between the timings in the two major sources of income for ordinary rural people; and it mirrors upside-down the G-form improvement in the wage of weavers relative to the earnings of farm workers. In all, farm rent overwhelmingly reflects the mix of earnings in the countryside, with weaving in this period leading the way to better terms for country folk.

Beginning in the third quarter of the 18th century, however, the ratio of rent relative to agricultural labor in East Flanders accelerated upward to 1791 via an underlying E trajectory that is far stronger than the much later timed C trend (1857 vs. 1782) along which agricultural wages started to come down. The cost of farm rent itself (in rye) now rose significantly: by about 75 percent between the later 1740s and the early 1790s, virtually all of that increase during just the 1770s. Had a limit been reached to the gains to be had from the current form of "development" in rural Belgium, which blended new forms of intensive agriculture with cottage weaving according to land quality?[15] In principle, though not in detail, this is what Malthus concluded: that agricultural change could go only so far and last so long in supporting population increase.

Another feature of "demonomic"[16] change in this period was the way that the *proportion* of the population of East Flanders that resided in *urban* centers between 1750 and the early 1800s rose in accelerating E fashion inverse to C-shape declines in rural wages, especially for day-laborers in agriculture. Somewhat steeper still (t_0 as 1849 rather than 1864, Table 6.3 recapitulates from the bottom plot--with hollow squares--in Figure 6.2) was the E-shape surge in the fraction of the population of East Flanders who lived in Ghent, the central place of the province (Vandenbroeke 1984, 916). All of this took place while the size of the population of East Flanders also mounted in E fashion from the 1750s to the 1830s (base year 1852).

Population pressure in the countryside in the later 18th century degraded living conditions there and pushed people toward where other opportunities might be available, now increasingly in the cities of the province. This phenomenon was scarcely unique to the region currently under intensive study. From England and Scandinavia to Russia, the Balkans, and Portugal no less than 12 European countries, including Belgium, in which the E form of urbanization apparently occurred in the later 1700s and/or the 1800s have been identified in Volume II of this study (Harris 2003, 277). Between 1800 and 1950, Japan experienced the same kind of E pattern in percentage of population living in cities .

Table 6.3 shows how in Flanders during this process of change the proportion of farms that were less than one hectare in size (Mendels 1984, 941) rose via E trends across the 1700s in the three localities of Schorisse, Lede, and St Kornelis Horebeke, each with zero year of approximately 1828 (graphed in Figure 6.3). Meanwhile, rural per capita income fell in slightly later opposite C form--focused in the vicinity of 1840--both in total and in terms of the two principal contributions of weaving and agriculture (Vandenbroeke 1984, 927).[17] For weavers, furthermore, the number of days it took to support a family (ibid., 925) likewise pushed upward in E fashion towards a t_0 in the 1830s, whether or not one calculates this measure to include assistance that the introduction of potatoes gave families in feeding themselves (also presented in Figure 6.3). These changes made Flemish linen production per capita fall off via a C trend that was somewhat flatter than the decline in that form for rural per capita income, including from weaving (see Figure 6.4; from Mendels 1984, 940, and Vandenbroeke 1984, 928).

Before the middle of the 18th century, too, the amount of work it took to pay rent or to support a family moved parallel with the proportion of the population who lived in cities and inverse to rural wages in both agriculture and weaving. In contrast, though, during this previous period rent and family requirements in the countryside became lighter burdens in D fashion along with weakening urbanization, while the earnings of day-laborers and weavers rose in opposite G form. Though the population of East Flanders did shrink between 1665 and 1700, it recovered from 1700 forward in H manner. Across the first half of the 18th century the numbers went up while the proportion who lived in cities declined significantly between 1700 and 1750.

The patterning of population size in this period does not parallel urbanization as it did in E shape after the middle 1700s--and also had done previously, in G manner, during the 1600s (with zero years for that type of curve around 1594 and 1579 respectively).

Further strengthened is the impression that the growth engine for the provincial economy shifted for a time to the countryside during agricultural development of the later 1600s and early 1700s that followed upon the advances of the “Golden Age” of the rural economy in neighboring Dutch Netherlands (de Vries 1974). The evolution of the linen industry, meanwhile, seems to have pushed economic growth in the same rural direction. Between about 1640 and 1700, in a not so distant example, the Dutch operatives of Haarlem in Holland, the center of that neighboring nation’s linen industry, moved virtually all their looms to rural Northern Brabant (a southern, inland province of the Netherlands) and progressively even bleached, processed, and exported less linen cloth (de Vries and van der Woude 1997, 291). Did Ghent and other Flemish centers suffer the same protoindustrial fate vis-à-vis their countryside during the next half century, across the first several decades of the 1700s?

In all, the ties between *linen production* per capita and other elements of change in the population and economy of East Flanders altered in various insightful ways between the 1600s and the first half of the 18th century and then again for the period of the later 1700s and early 1800s. The nature of developments in certain aspects of the linen industry, their relationships to each other and to the evolution of their demographic and economic environment, are illustrated in Figure 6.4 and summarized in Table 6.4.

In the first place, the top plot in the figure shows how linen exports from Flanders recovered from a nadir around 1590 during the Dutch Revolt into the first quarter of the 18th century, where volume was leveling out at about 120,000 pieces annually. In this plot, from 1675 forward the data are for exports of pieces from Flanders as a whole (divided by 10), as estimated by Vandenbroeke (1984, 928; 1987, 165, note 94). From 1570 through 1650 the volume is approximated from the index (1690 = 10,000 in Figure 6.4) of the *value* of linens on the market in the Pays d'Alost (Aalst) that is offered by Mendels (1984, 950, Table 1). Across the later 1600s the trends of these two series are very similar, apparently justifying such splicing. It is in the 1700s, later plots in Figure 6.4 indicate, that what one learns from the Pays d'Alost diverges from patterns for Flanders more broadly.

Flemish exports as a whole, by this method of approximation, from 1590 to about 1725 rose in G shape with base year at 1614. Then, for the remainder of the 18th century new increase in first slow then accelerating E form toward a target year around 1806 was the pattern. The trade, finally, displays what seem to be first a G' boom and then a 1/G' bust during the later phase of the French wars and the normalization of Europe that followed.

If the number of pieces of linen exported from Flanders is divided by the trend for population increase in that region, per capita trade in the cloth--the second plot in Figure 6.4--first increases in G manner from 1590 through 1690 through swings in the early 1600s that seem to reflect vicissitudes of the prolonged conflict with the Dutch. The zero year for this curve, based largely upon *tax* data from the Pays d'Alost (and therefore resembling the 1570 to 1670 evidence for per capita linen tax that is presented via hollow circles lower in Figure 6.4) comes at 1591. Per capita export of the cloth for Flanders as a whole, as presented by Vandenbroeke, then runs through to about 1800 largely flat near the level shared with the Pays d'Alost during the late 1600s . From perhaps the 1780s forward, however, the series trends downward. If one regards the high values at 1815 and 1825 as an ephemeral postwar spurt that could not be sustained, this movement on into the 1840s takes C form with t_0 around 1873, as Table 6.4 reiterates. The calculations of Mendels for the Pays d'Alost (the solid downward triangles), meanwhile, between 1690 and 1710 jump to a new level, but then take a course that is quite parallel with a projection forward of the 1590-1690 G trend for his mode of estimation.

If one next turns to the total *value* of linens being produced (the plotting across the middle of Figure 6.4, which comes from Mendels 1984, 950, and Vandenbroeke 1984, 928), it becomes evident that the worth of the aggregate product in this industry very generally rose during the 18th century in G form with base in the second or third year of the 1700s. The index from Mendels concerns the real value in terms of rye, the basic foodstuff for weavers.[18] The output of the Pays d'Alost, however, took up this G trend of rising value in the 1690s while it did not commence for Flanders as a whole until the 1720s. Previously, up to 1690, the increase in the gross real value of production in the Pays d'Alost rose in G fashion from a base at 1630, just a little more steeply than the G trends in total pieces exported from Flanders (t_0 at 1614), while data for 1700 and 1725 (the hollow circles from Vandenbroeke 1984, 928) suggest that for Flanders as a whole the aggregate value of linen exports grew in slightly flatter form, perhaps very much like the G trend for the number of pieces shipped in the top plot of the figure. The raw tax value from Mendels (solid upward triangles), meanwhile, rises from 1590 through 1670 in G fashion with zero year at 1616.

Even as late as 1796, it should be recognized, the Pays d'Alost (Aalst)was on the frontier of the development of linen-weaving in Flanders. The textile industry engaged 20 to 39 percent of the total effort in only the western third of the region, while the majority of Oudenaarde and much of the Ghent district benefited from 40 percent or more work devoted to this industry (Devos 1999, 106). To have an index of linen production in the Pays d'Alost, whether calculated by tax or by real value in rye, rise in fresh, steeper G fashion than is found in Flanders as a whole makes sense in terms of the district's position on the expanding margin of the Flemish linen industry. Much of what gave the Pays d'Alost the second heaviest local involvement in linen production as of the 1840s (Vandenbroeke 1984, 917) in fact took place only after 1800. Some of the argument over interpretation between Mendels and Vandenbroeke may hinge upon whether Flanders-wide or just Pays d'Alost evidence is employed, though I lack adequate French to be sure about this possibility.

If one next turns to the *value* of linens being produced *per capita*, the bottom set of plots in Figure 6.4, it is evident how between 1690 and 1710 the worth of linen produced per person in the Pays d'Alost jumped markedly, virtually doubling. Value per capita shifts upward even more markedly than pieces per person higher up in Figure 6.4 (which is in effect tax per person). From there, though, per capita value seems to have begun to fall off--in spite of a temporary lift around 1750, where Figure 6.2 has shown the earnings for hand-loom linen weavers to have attained their historical peak. It probably declined parallel with the C trend from 1700 all the way to 1845 (not including the spike at 1825, which is designated by a hollow diamond, in the fit) that is evident for linen value per population for all of Flanders, which is presented as hollow circles (Vandenbroeke 1984, 928). The two C curves proposed have target years at 1872 and 1855, respectively. Apparently the Pays d'Alost made a significant move into linen-weaving around 1700, but then as far as 1770 shared the tapering off in per capita income from that source that is evident for Flanders as a whole. The greater aggregate increase in linen income from the Pays d'Alost relative to all Flanders derives from greater population growth there across the 18th century.

Considering just the Pays d'Alost, where the sources of data for the 17th and 18th centuries are the same, it should be noted that the current *tax* value of *linens* per capita (the hollow circles in the next-to-bottom set of plots in Figure 6.4, composed from Mendels 1984, 950, Table 1) rose for two centuries from the 1570s to the 1770s along an H track with t_0 at 1536. This trend very closely resembles an H path generally followed in per capita form from the 1550s to the 1780s by the *land* tax that was imposed in Flanders, when this is calculated in liters of rye--which is plotted at the bottom of Figure 6.5 (Vandenbroeke 1984, 923). The increasing tax yield, in per capita terms, from both land and rural industry would seem to outline economic "growth" of H shape in East Flanders for two almost 200 years from the later 16th century into the later 18th.

Throughout the two preceding volumes of this study, the H form of population increase has been deemed, judging from where and when it occurred and by what is known to have accompanied it, to be a product of economic development that allows demographic expansion to continue more robustly than the more rapidly decelerating G pattern permits. In East Flanders up until 1700 the H mode of population growth is missing in spite of the economic changes indicated by the two taxes. From 1700 through 1806, though, population did expanded in H fashion, but with base year at 1581, about four decades later than the two H trends for taxes on land and linen. Apparently what made the demographic slope steeper this way was the adoption of the potato during the 18th century as a technique for obtaining more sustenance out of a given piece of land. Cutting across shorter-term G' swings, the number of days of work toward supporting a family that a weaver was typically saved by growing potatoes rose in H form from 1742 through 1847 with base year for the fitted curve at 1772 (the top plot of Figure 6.3 with hollow circles). The *proportion* of days needed to support a family that a weaver secured by raising potatoes, also graphed at the top of the figure (filled downward triangles), between 1717 and 1837 climbed instead along a G path with t_0 at 1742. It would seem that this G trend in proportion of household support available through the new use of the potato combined with the flatter 18th century H paths of per capita growth in linen production and more traditional farming to provide the resources to support H-type population increase in East Flanders that was rather steeper than the gains just from weaving and pre-potato mixes in agricultural activity.

With the H form gains in farming and weaving also suggested by the amount of taxes earlier on, from the later 1500s forward, why then was there no rise in population of H mode in East Flanders before the 18th century? Did the gains go into elevated standard of living instead of more people? The nearby Dutch example, for instance, suggests the possibility of substantial rural prosperity in the 1600s from agricultural advances that transformed the countryside (de Vries, 1974). Was there, on the other hand, perhaps a different relationship between real output and tax returns on linen and land in the 17th century than in the 18th? Experts in the history of the Southern Netherlands will have to provide the final answers; but the findings here promise to be fruitfully suggestive in how to approach the issues.

It is also reasonable, however, to trend the per capita land tax series at the bottom of Figure 6.5 with two G-shape movements from 1552 through 1627 and from 1622 through 1792 respectively. The latter curve, with its zero year at 1632 is virtually identical with the underlying G trend for the wages, also calculated in rye, of day-laborers from the 1640s into the 1740s that was established in Figure 6.2 and Table 6.3. The earnings of agricultural labor and the per capita value of land, as estimated from taxes, went up side-by-side in G fashion over the long term from the second quarter of the 17th century to the middle of the 18th.

Figure 6.5 and Table 6.5, finally, reveal some further insight into the relative prosperity of the *countryside* compared with *urban life* at the time. The real wage in rye for urban workers (Mendels 1984, 950, value in wheat adjusted by the ratio of wheat to rye prices) also rose from 1663 as far as 1738 approximately along a G path with base year in the 1630s. So did the ratio of the agricultural wage to the urban one, when both are calculated in rye. The real value in wheat, which was perhaps somewhat more available to urban dwellers than to those who lived in the countryside (though unlikely at this time to be the basic grain for the ordinary residents of cities?), moved in parallel fashion from the later 1600s onward. Prior to that point, however--particularly between 1613 and 1663 (1600 and 1675)--is evident a marked difference in the trends of real wages via the two grains due to a decline then upward shift in the worth of wheat relative to rye, whose movement is depicted in the top plot of Figure 6.5.

Trends for values in wheat are included in the figure for the urban real wage and its ratios to wages for weavers and agricultural day-laborers by means of light lines. The duration of each movement, however, is only specified in Table 6.5. The wage for urban workers in terms of silver, meanwhile, declined very slowly between 1613 and 1763 along two relatively flat C segments before recovering into the early 1800s and then rising markedly from 1838 through 1888, both in E form. The prices of rye and wheat altered roughly in the patterns approximated (without curve fitting) at the bottom of Table 6.5 (Mendels 1984, 950; Vandenbroeke 1987, 167).

At the same time, between 1663 and 1738 (1650 and 1750) the earnings of a farm hand gained relative to those of an urban worker also in a G trajectory with t_0 in the 1630s. (The height of the calculation in wheat at 1688 keeps the information from the two grains generally parallel across this whole period in spite of different trend shapes that are more precise for parts of that time span.) Rather more steeply, with zero year in the 1650s instead of the 1630s, the weaver's wage rose in G fashion relative to that of the urban worker, in rye from 1663 through 1763 and wheat across a slightly later period (1688 to 1788). As land values per capita in the countryside went up, the agricultural worker gained more than the urban worker but the weaver gained upon both of them.[19]

Then the air oozed out of the rural boom. Wages for day-laborers and for weavers both fell in C fashion. Losing more steeply in such a pattern (t_0 at 1830 rather than 1857, Table 6.3 has summarized) the weaver suffered relative to his neighbor (or family member) in agriculture (the ratio falls via C with target year at 1841). Meanwhile, Table 6.5 and Figure 6.5 show, while the real wage for urban workers also came down via C, calculations via wheat--which in the debate between Vandedbroeke and Mendels are available later than those in rye--depict reductions relative to remuneration in the cities for both weavers and farm workers. The "action" in the economy of East Flanders had first shifted to the countryside with the decline of major nearby centers of trade like Ghent and Antwerp and the rise of cottage linen production into the middle of the 18th century. From there until the middle of the 19th century, in contrast, wages, income, population, and economic development shifted back to the cities of the region as competition in linen-weaving from Germany, Ireland, and Scotland expanded and factory industrialization took hold in Belgian life, replacing rural protoindustrialization as the new engine for economic growth.

Across these longer-term trends in the particular provincial area of East Flanders are also evident some *swings in G' and 1/G' form*. Summarized in the bottom two-thirds of Table 6.1a and in Table 6.1b, these can be related insightfully to movements of those shapes for the whole region of Flanders that were encountered in Figure 6.1 and discussed in the previous section.

Most notably, as Figure 6.2 presents with light lines and solid downward triangles for the fitted t_0's, real wages in rye for both agricultural workers and weavers, and for the ratio of these two earnings to each other, tended to vacillate up and down across the long-term trends that are identified, mostly in movements of G' shape. In the earliest records, from the 1430s into the 1590s, quite sharp shocks in the real wage for weavers interacted with the mostly D-type movement for agricultural day-laborers to produce a series of G' humps across the H trend that for almost two centuries underlies the ratio of earnings in weaving to those from agricultural labor. One can suspect that the cresting of these surges around 1455, 1502, and 1565 (Table 6.1b) and the timing of the jumps in weaving wages that underlie them reflect opening and closing of the export market for linens, which was doubtless affected by familiar historical changes such as the infusion of New World wealth into the Hapsburg domains, by the subsequent bankruptcy of this regime, by the international inflation of the later 1500s, or--earlier--by the emergence of Antwerp as the leading entrepôt for northern Europe marketing, among other things, new Portuguese trade from Africa and Asia and the goods that these imports could buy.

An important insight from these patterns, it should be underscored, is how the sharp shocks in wages for weavers--in this case markedly positive stimuli--when related to trends for day-laborers, generated relatively smooth G' curves instead. Volume II has identified many instances of G' trends in migration--free and forced international relocations and also domestic movement into cities. Did quite sharp shifts in perceived opportunities trigger, then become absorbed, in the G' shapes of change in these contexts, too, as they diffused through a population? Examples might include: learning (sometimes as the result of aggressive recruiting) in Ireland or Germany that land and work were available in the Middle Colonies of 18th century British North America--or in the trans-Allegheny United States of the 1800s; an often rapid switch from less labor-intensive investment like tobacco into sugar in a New World colony, which among other things sent merchants scrambling for slaves in order to hold or to expand their trade, a process that on the other side of the Atlantic could entice an African society to enter into or to open a new frontier for slaving; or an attraction of urban capital toward new crafts or industries (from the North Sea herring of 1500 to the hand-phones of 2000) that pulled labor out of other activities into innovative ventures.

Certain other early relatively short-term trends reflecting the derivative of the G function also stand out in Table 6.1b. For one, between about 1540 and 1580 the number of days of work that it took an agricultural worker to pay rent rose in G' form parallel in timing with a surge of that same shape for the ratio of the wage of a weaver to that of a day-laborer. Did demand by an increasing number of weavers in the countryside, whose earnings were now catching up with those of farm workers, push up rural rents? Agricultural laborers and cottage weavers lived in much the same places and often came from the same families--or were even the same persons, shifting back and forth with the seasons or changes in the economic environment.

Then from the later 1500s into the early 1600s (the fourth column of Table 6.1b), real wages in rye for day-laborers swelled via G' as the price of rye sagged according to 1/G'--each maximizing or minimizing in the 1610s. As far as 1612, these rising real wages in rye for farm workers markedly reduced how many days they had to work if they wished to rent their own land, along a 1/G' track with a bottom estimated about 1619. A G' surge in the price of wheat between 1570 and 1610 appears to have occurred independently of the other movements recorded for this era. The next G' increase in the price of wheat, however--between 1610 and 1650 (in the last column of Table 6.1b)--was for some reason roughly the reciprocal of the urban real wage as calculated in rye across this period. This is one of several open ends in this analysis where the search for further answers must be left to experts on the economy of Flanders, applying the best and fullest data now available to tease out the dynamics at work. Hopefully the evidence and the interest for that endeavor both exist. If rye and wheat compose the standards for real wages, it is especially critical to know who consumed which grain from place to place and time to time, and from where these crucial cereals came (for instance, Baltic imports vs. local harvests).

Beginning in the middle to later 17th century, such swings in economic variables can be compared with movements in the kinds of demographic data that are graphed in Figure 6.1. The wages of agricultural workers and weavers--and, because of some lags in those two series, also the ratio of one to the other--tended for a considerable period of time to go up an down together. As the top part of Table 6.1a shows, moreover, secularization, premarital conception, and the crude marriage rose and fell mostly in step with these movements in wages--though so did childhood mortality--while illegitimacy around 1700 switched from following the wage trends to moving opposite to them.

The price of rent, in terms of days of agricultural work required to pay it, generally moved reciprocally against the wage for day-laborers. It did not do this, however, via counterbalancing G' and 1/G' trends. Instead, the low zone between the G' trends of 1612 to 1682 and 1672 to 1732 embraces the G' crest for the real wage for these workers at 1675. Then the high for rent in the vicinity of 1700 arrives when agricultural wages are low preceding the G' surge of 1707 to 1732. Finally, the G' crest for rent at 1797 comes as earlier G' movements in the wages of day-laborers and weavers both plummet to 1800 or so.

As one would expect from the wage trends, meanwhile, per capita income in the countryside--from agriculture, from weaving, and all together--crested via G' in the late 1730s and again in the 1810s.[20] This meant that secularization, premarital conception, the crude marriage rate, but also child mortality pushed up along with income. Earlier, between 1670 and 1725, per capita earnings of these three rural classifications dipped then rose in 1/G' fashion. This makes them move inverse to the wage of weavers during this period, and to the work that was required from agricultural laborers to be able to pay rent. Population declined in East Flanders between 1665 and 1700, the top portion of Figure 6.2 has shown. It appears that falling income per capita in the countryside in general, which made it harder to rent land, may have encouraged this demographic contraction in an era during which urbanization was advancing in the province (the bottom of Figure 6.2). The G' surge in wages for weavers during this period (did a sag in population join market demand in pushing up their level?), seems to have generated more of this activity in the countryside (Figure 6.4), though it was only during the first decade or two of the 18th century that increased per capita income resulted. Meanwhile, the proportion of births that were illegitimate seems to display a hump that was inverse to the slump in per capita income.

If one graphs the days of supplementary work that tenants, on the one hand, and farm owners, on the other, had to do in order to sustain a minimum standard of living on a hectare of land, for each kind of agriculturalist a sequence of two successive 1/G' sags appears between the middle of the 17th century and the middle of the 18th as rural conditions broadly improved (not presented in the figures but estimated from Vandenbroeke 1984, 920). The second, deeper declines of this shape, after 1700, are timed along with the reciprocal G' surges of this period that have been noted in laborers' and weavers' wages and in per capita income in the countryside. Earlier, between 1660 and 1700 the 1/G' dip for owners of small holdings closely offsets the G' in wages for day-laborers, with t_0's at 1676 and 1675 respectively; but for some reason the improvement for tenants lags about a decade, more parallel with the falling rural per capita income of the period.

Later, after 1750, as wages for weavers fell over the long term while the Flemish linen industry declined, shorter-span G' trends of the sort estimated at the bottom of Table 6.1a appear in how many days of work it took a weaver to support a family, with or without the supplement of growing potatoes, and the number of days and their proportion of the total worked that potato culture saved weavers. The data are graphed in Figure 6.3. Curves for the potato reductions are fitted and plotted; short-term bulges in the days of work needed to support a family from the 1780s into the 1820s are just estimated and not graphed.

In all, the analysis of these various kinds of movements and their demonomic interactions in East Flanders from the 1400s into the 1800s is rough and tentative, and must in the end best be considered suggestive. The involvement of more and better data would help, but especially the engagement of those who know the history of the region well. Hopefully, however, applications of the long- and short-term trendings offered here, which seem to fit some of the current interpretation while carrying insight fruitfully further, will induce those who know the history of East Flanders best to think about the value of such analysis, and will illustrate for others how the approach relates demographic change to dynamics of the economic environment of populations that are generally considered connected with demographic development.

THE CONTRIBUTION OF G-BASED DEMOGRAPHIC TRENDS TO ECONOMIC UNDERSTANDING: THE INSIGHTS OF ONE EUROPEAN REGION

These perspectives on the demonomic evolution of western Belgium from about 1400 through 1900 are often based upon thin data and/or just approximations from evidence that is presented in graphic form in the debates of the secondary literature rather than from the primary sources compiled in French and Flemish. The intent, *deo volente*, is next to explore such dynamics further with more complete and precise information on this particular part of Europe alongside, and in comparison or contrast with, what the histories of contemporary development in the Netherlands, England, and the Atlantic colonies of certain European powers have revealed.

The Belgian outlines identified here, however, especially the detail on East Flanders, would seem to illustrate importantly how the kinds of G-based trends found in the historical demographic changes of the region, the focus of the present study, also permeated economic evolution, and how one form of change affected the other. The latter is a topic long of central concern to historians and social scientists. The findings appear to make some interpretations more likely than others, to clarify where authorities seem to have talked past each other, and to demonstrate the necessity of looking at both population and economy in the new terms of recurrent G-related trends and determining the origins and the consequences of movement in such forms.

Demographic Growth Reducing Economic Welfare: The impact of population increase upon socioeconomic change of many types, a central topic of the social sciences since the debates of the middle 1700s and their famous reformulation by Malthus, is exemplified and clarified in several ways by the trends of East Flanders. First of all, in the familiar Malthusian mode, demographic expansion for most of the time between 1500 and 1900 repeatedly depressed rural real wages and other conditions of living for the majority of people, who lived in the countryside, bringing further expansion of population to an end. Quite closely, across the 1500s and the first half of the 1600s as the number of residents in the province twice swelled in G fashion following troubles at the end of the 15th and then the end of the 16th centuries, rural wages were pushed down in reciprocal D form. As this tightly joined *pas de deux* between demographic growth and rural standards of living played itself out, hand-loom weavers--unlike day-laborers--right through the ups and downs of war, urban disaster, trade interruption and recovery, and other shocks managed to retain (at least as far as 1600, where a break in the evidence occurs), the long-term level of real wage that they had enjoyed around 1400. Paired with long-term losses for day-laborers, this equilibrium in earnings for linen production meant that the ratio of what weavers earned relative to wages for farm work rose over the long term in H mode from less that half of what rural day-laborers were paid to roughly 20 percent more, multiplying in excess of two-and-a-half times (from 0.45 to 1.2). This substantial change in relative remuneration undoubtedly encouraged country people to take up the loom--especially, for example, when the number of days that an agricultural hand would have to work in order to move up and rent his own land rose persistently across most of the 16th century, and then again to the 1660s following temporary reduction by a surge in farm wages during the turbulent years of the Dutch Revolt.

Later on, from the middle of the 1700s into the early 1800s population increase in East Flanders again drove down the earnings of agricultural laborers. This time, however, population "explosion" of accelerating E shape was occurring instead of decelerating G growth. The reciprocal pattern according to which rural wages fell therefore took ever faster downward C form. Now, moreover, the weaver fared worse than the day-laborer, reducing the ratio of these two most common incomes of the countryside in C shape as well (from an underlying level of about 1.3 during the middle of the 18th century to as little as 0.47 by the 1840s). The number of days a weaver had to work in order to support a family, meanwhile, pushed upward in E manner, whether or not the new contribution to be gained from growing potatoes is counted. Total rural income per capita, and also its major components of day-labor and weaving, shrank in C mode; and population, which had gravitated away from the cities of East Flanders during the first half of the 18th century, shifted back toward them in E fashion. With falling wages, the labor cost of renting land rose in E form. So did the percentage of farms in this part of the Southern Netherlands that contained less than one hectare of land.

Demographic Expansion Accompanied by Economic Gain: Twice between 1400 and 1900, however, the long-term relationships of economic change and population increase behaved quite differently. During these periods, first between about 1650 and the later 1700s and then across the second half of the 19th century, demographic growth occurred *alongside*, not at the expense of, prosperity in the countryside of East Flanders.

Between about 1650 and 1750, first of all, real rural wages improved noticeably: for day-laborers, even more for weavers, and therefore also for the ratio of earning power of weavers relative to agricultural workers (climbing from as little as 0.60 in the early 1660s to about 1.3 on average between 1730 and 1775, or slightly above the weaving/agriculture relationship of 1.2 when the 17th century began). Cutting across some ups and downs of G' shape, these tendencies all generally followed underlying G paths. By the 1680s this improved remuneration made agricultural rent cheaper in reciprocal D form, even though the tax on land per capita--while swinging about noticeably--rose approximately via G from the 1620s to the 1790s. Between 1700 and 1725, meanwhile, real income per capita for both farm labor and weaving shifted upward (Figure 6.3). Improved earnings, especially when the household food supply could be supplemented by the new activity of growing potatoes, between the 1660s and the 1750s likewise reduced in D fashion the number of days it took a weaver to support a family. The improved opportunities of the countryside, furthermore, led population growth there to outstrip the expansion of the cities of East Flanders, drawing down the proportion of all people with urban residence between about 1700 and 1750 or, judging by details for Ghent, two or three decades later. Total population for the province, meanwhile, after falling off somewhat somewhere between 1665 and 1700, from there to about the end of the 18th century took up the H pattern, which has so widely been found to be associated historically with economic growth in Volumes I and II of this study.

Later, from about the middle of the 1800s to World War I, population increase in this distinctive H form returned to East Flanders, now as agricultural wages surged in ever-faster E fashion. Up through the last quarter of the 19th century, meanwhile, the urban wage likewise accelerated upward in E shape. Presumably the simultaneous combination of population increase in H form and rising wages in the E pattern during this era could be sustained by the industrial growth that was now significant as Belgium became a leader in the development of the modern European economy while spreading control of fertility kept population growth steady, slowly decelerating via H rather than accelerating in E form.

The Linen Industry and Protoindustrialization. Flanders had been famous for its textiles since the middle ages. Weavers of *linens,* as distinguished from several forms of wool cloth, were active at least by 1400, and across the 15th and 16th centuries--in spite of periodic lifts and depressions--tended, as noted, to maintain a stable wage level in their real wages in contrast to contemporary decline in what agricultural workers could earn. This discrepancy may have encouraged a dissemination of linen-weaving into and across parts of the countryside before the 17th century, aided by and/or contributing to a decline between 1465 and 1525 in the proportion of the population of Flanders that resided in town and cities.

The marked economic *rise* of the linen industry in the form of rural protoindustrialization, a spreading network of cottage weaving that through regional centers of capital and marketing fed substantial international demand, was, however, a feature of the period from the early 1600s through the 1700s. Until the middle of the 18th century, weavers' wages went up in G form, helping agricultural wages rise in similar shape--though more flatly, so that the ratio of earnings for weavers relative to day-laborers also improved in G fashion. Real income per capita increased more between 1700 and 1725 for effort in rural industry than for work in agriculture. Better wages made it cheaper to rent land and required fewer days of work to support a family, particularly where the new food crop, the potato, was employed.

As warfare with the neighboring Dutch simmered down, for the reminder of the 17th century or from about 1630 forward, the total value of linens exported and their worth per capita rose in G fashion with base year in the early 1600s. This G path was slightly steeper during the period than that for the way the local population was increasing and Ghent, the central place of East Flanders (where most of the linen-weaving was being done as late as the 1790s), was regaining population relative to the countryside (before cottage industry itself helped shift proportion of the population into rural areas).

By the middle of the 18th century, however, per capita output of linens in Flanders--judging from exports relative to population--began to experience C-type accelerating decline. This was true in terms both of pieces exported and of the aggregate value of this trade. Though the number of linens sold and their estimated worth increased as far as the 1820s, the flow did not keep up with expansion in the population of Flanders. These C-shape losses in per capita value and volume in the linen industry, in part under pressure from international competition out of Germany, Ireland, and Scotland, occurred as real wages in the countryside degraded and real rural income per capita atrophied, both in C fashion (though rather more steeply). Weavers, meanwhile, needed more and more days of work to support a family, with or without resorting to potato culture, more and more farms became small, and the cities and towns of East Flanders held an increasing rather than decreasing proportion of the people of the province.

Local linen production, estimated both directly from the linen tax and adjusted for its worth in rye, looks more robust in the 1700s if one calculates trends for just the Pays d'Alost, as Mendels (1984) did rather than Flanders on the whole as Vandenbroeke (1984) looked at it. Locally, a fresh G trend of expansion appears. Held against change in the population of this particular district, per capita output shifts upward somewhere between 1690 and 1710. Then, however, up through 1770 where these data run out, it seems principally to parallel the flat equivalent movement for all of Flanders, where the C trends of the later 1700s and early 1800s were beginning to take shape. In all--unless I have through limitation in languages mishandled the evidence somehow--it would appear that the Pays d'Alost in the early 1700s was one of the localities within Flanders to which the cottage linen industry was spreading from its historic origins in the districts of Ghent and Oudenaarde (which still led in weaving during the 1790s), even though by the 1840s the Pays d'Alost joined Tielt in West Flanders as the two districts of the region most engaged in this activity during its waning phase. These portions of the evidence over which Mendels and Vandenbroeke argued are seemingly not so incompatible after all.

A broader setting for how demonomic change spread across western Belgium can be gleaned from data on linen weaving, population growth, fertility, infant mortality, and nuptuality in various parts of East and West Flanders during the 18th and early 19th centuries. Table 6.6, for simplicity of comparison and contrast, just ranks the 14 districts of these provinces, and 3 communities a little over the border into Antwerp, Brabant, and Hainaut provinces on various dimensions that are available in the secondary sources upon which this discussion has been drawing. The measures are static, mostly for just one period in time; and in some cases they cover only a handful of better-researched districts. Nonetheless, they usefully extend an understanding of how demographic change and economic development evolved across western Belgium.

To begin, the strongest population increases recorded between 1700 and 1800 took place in Ghent and the neighboring districts of Tielt, Oudenaarde, and Aalst. Deprez stated in an essay that summed up the evidence available four decades ago (1965, 628) that demographic expansion and population pressure to divide land holdings after about 1740 was even more severe in the Vieuxbourg area within Ghent just west of the city, with its large proportion of sandy soil, than in the more fertile Pays d'Alost (Aalst) in southeastern East Flanders, which displays the second highest demographic expansion for the 18th century as a whole after Tielt in Table 6.6. The slowest population gains between 1700 and 1800 reported by Vandenbroeke (1984, 918) occurred in northern Eeklo (somewhat more so than in the part of that district lying next to Ghent--the two locales are averaged for the rank in Table 6.6), Sint Niklaas, and Dendermonde --districts all situated in northern and northeastern East Flanders.

As of 1796, the area where 40 percent or more of the population was engaged in the textile industry was composed of the western half of the district of Ghent, almost all of Oudenaarde to the south, and a sliver of territory on the eastern edge of Kortrijk. Roughly the western quarter of Aalst, the eastern third of Kortrijk and Tielt, a small southeastern slice of Eeklo next to Ghent, and a third more of Ghent's territory that surrounded the main concentration of textiles in that district joined the remainder of Oudenaarde in having 20 to 39 percent weaving. In the other 8 districts of Flanders significant zones of textile protoindustrialization did not yet exist (Devos 1999, 106; 10.5 represents the average for 7th through 14th since there is no evidence with which to rank within this group). Thus, in all, population increase had been greatest where weaving had spread the most, diffusing out of Ghent and Oudenaarde. ("Pajottenland" was just over the border from Aalst in Brabant.) By the 1840s, the continuing diffusion of weaving across the Flemish countryside created the greatest involvement in textile industrialization in Tielt and Aalst, which now pushed ahead of Oudenaarde and Ghent in this respect, while Roeselare, Kortrijk, and Diksmuide--extending westward into the heart of West Flanders--developed into a secondary zone for linen-making (Vandenbroeke 1984, 917).

Levels of nuptuality (I_m) and of infant mortality (Devos 1999, 106; Vandenbroeke 1984, 934) around 1800 are associated with these geographical concentrations of population increase and protoindustrialization across the preceding century. To begin, the lowest (1, 2, etc.) loss of infants occurred in the 5 leading areas of weaving as of 1796, places that had had the greatest population increase across the 18th century. Kortrijk, Eeklo, and Roeselare, which suffered the next fewest infant deaths, were parts of what became a secondary zone for linens in the early 1800s. The dissemination of weaving seems broadly to have generated better conditions for infant survival. Whereas in Aalst and Tielt generally high nuptuality at 1796 could persist following strong population increase over the 18th century, in Ghent and Oudenaarde the level for I_m was noticeably below average for the 14 districts of Flanders. The suggestion is that while gains from taking up weaving still contributed to friendlier living conditions for local families in those districts, any added opportunity from protoindustrialization to marry and remarry had by now largely been used up in these areas of older development in cottage linens.

On the alluvial soils along the North Sea coast in West Flanders, meanwhile--in the districts of Verne, Ostend, and Bruges--the reverse was the case. Nuptuality there was the highest in Flanders; but infant mortality levels were among the worst. Weaving was largely absent here, even by the 1840s. People formed families and died against a background of agriculture. As of 1846, moreover, West Flanders was the province of Belgium in which the lowest percentage of agricultural land was owned by those who cultivated it. In 7 of its 8 districts 80 to 89 percent of the agricultural land was rented--in contrast to more like 60 percent in the southeastern districts of Oudenarde, Dendermonde, and especially Aalst in East Flanders. At the same point in time, 20.2 percent of agricultural enterprises in West Flanders comprised 15 hectares or more, compared with 11.2 percent for Belgium as a whole and just 12.4 percent for the province with the next most concentrated ownership, Luxembourg (Lesthaeghe 1977, 23-25; though by less of a margin, West Flanders also had the fewest farms under 5 hectares).

Inland within West Flanders, where the soil was more likely to be sandy or mixed in character (Deprez 1965, 612), Diksmuide and Ypres display poor infant mortality along with relatively low levels of nuptuality. As of 1796 neither district was much into linens, though Diksmuide became part of the secondary area of such activity by the 1840s. Apparently a lower quality of farming was available in these two areas under conditions that did not encourage supplementation by cottage weaving. The same pairing of comparatively heavy infant death and low I_m appears in Sint Niklaas and Dendermonde, districts in northeastern East Flanders. The soils of this region also do not appear to have been good (except right next to the Scheldt), yet weaving was not a significant factor as of 1796.

Frustratingly sketchy local evidence on fertility for women 25 through 34 and the I_g index for marital fertility (Vandenbroeke 1984, 932-33) together suggest that reproduction was high in these 4 regions that had both elevated nuptuality and more severe infant morality (the Antwerp campine is across the Scheldt from St. Niklaas) compared with places like Ghent, Aalst, and perhaps Oudenaarde, in spite of stronger 18th century population increase in those weaving zones. Fertility may have been relatively high in Diksmuide, Sint Niklaas, and Dendermonde for those who could be wed. But it was comparatively hard to marry and/or stay married in these districts; and the families that were formed lost more infants.

In all, the western two-thirds of West Flanders and the northeastern quarter of East Flanders appear as of 1800 to have been areas where fertility was classically paid for in infant mortality, even when the better farming assets of Veurne, Ostend, and Bruges allowed higher nuptuality. The areas of early 19th century protoindustrial expansion in Tielt and Aalst could prosper with both high nuptuality and low infant mortality, in part by supporting faster-growing populations than identified elsewhere, in part by having what seems to have been lower fertility.

Did reproductive control and protoindustrialization spread together across Flanders as part of a calculus of family management? In the older protoindustrial districts of Ghent and Oudenaarde population increase could be quite rapid, also with low infant mortality; but nuptuality seems to have been curtailed more than where cottage industry was *expanding*. In Eeklo, Roeselare, and Kortrijk, which lay on the western edge of the Flemish weaving zone toward the middle of the 19th century, meanwhile, middling levels of both infant mortality and nuptuality were typical. Unfortunately, evidence on fertility and population increase in these areas is not sufficient to conclude much about those dimensions of demonomic change.

Adding crude ratios of births to marriages as Deprez (1965, 620) collated them for certain locales within Flanders expands our grasp of variations in fertility a little further. Table 6.7 summarizes three aspects of his findings: the comparative levels of births vs. marriages which areas had at 1710 and then at 1790; the percentages of eventual increase in this ratio over that time span; and the shapes of movements, both up and down, that the ratio displays between the beginning and the end of the 18th century.

As suspected from the fertility evidence of Table 6.6, the Pays d'Alost (and the Pays de Schorisse, which Deprez treats as demonomically similar) had a high ratio of births to marriages among the regions studied. This estimate of fertility, however, just barely increased between 1710 and 1790: 2.4 percent in Alost and 7.0 percent in Schorisse. On the sandy soils of the Vieuxbourg of Ghent, in the meantime, the ratio, while starting not quite so high as in these two places, moved to the top by the end of the 18th century, rising 21.1 percent. The reason that for the whole district of Ghent I_g in the late 1700s was instead down in the middle of the pack was due to the city of Ghent, which at that point ranked 6th of 7 locales in the ratio of births to marriages. The bottom lines of Table 6.7, however, separate the urban core from the edges of the city (Deprez 1965, 622), making 8 areas to be ranked rather than 7. Here one sees that the central parishes of the city came last in level of fertility at 1790, the peripheral parishes 2nd--behaving more like the communities of the Vieuxbourg in both level and amount of change across the 18th century.

Sandy-soil villages of Flanders had the highest fertility next to the Vieuxbourg of Ghent by 1790. But their ratio of births to marriages had increased twice as fast--45.5 percent--pulling them up from last place in 1710. In villages of zones with intermediate and fertile soils, the ratio rose 30.3 and 30.0 percent. Such movement elevated the relative rank for the intermediate group only slightly, while families on fertile soils by 1790 had lagged enough to have the fewest births relative to marriages (except for the center city of Ghent).

The way the ratio increased so significantly over much of the century in the villages with sandy soil was to climb in E shape from 1710 through 1760. This trend is estimated to have targeted a zero year around 1794. Whereas Volume II (Harris 2003, 206-07) graphed and summarized the fitted trend for areas with sandy and intermediate soils together, for Table 6.7 they are just approximated by template as the "?" denotes. This same form of accelerating increase, furthermore, characterizes what happened in villages with intermediate soils and in the Vieuxbourg of Ghent between 1710 and 1770, in each case with t_0 around 1815--rather later and flatter change. Flattest of all, with zero year at 1837, was the 1710 to 1750 trend in the most fertile zones. Whereas after 1760 or 1770 the E trend in the sandy and intermediate areas and the Vieuxbourg dropped before some sort of new increase began, in the villages with fertile soils a new E trend with almost identical target year as its predecessor, at 1835, followed. (Harris 2003, 206, graphs these two fitted trends. Unfortunately the summary of the second's particulars on page 207 should read 1760-1790 rather than "1766-1790.") In the city of Ghent, meanwhile, in both the central and the peripheral parishes the ratio of births to marriages declined during the first third of the 18th century, perhaps in D form, contributing to the loss of population according to such a trend that occurred there between 1700 and 1760 (Harris 2001, 308). Then, from 1730 to 1790 it recovered, but in decelerating G manner rather than the E fashion of the countryside.

In Alost and Schorisse, in contrast, the E pattern is again evident in the ratio: in Schorisse with t_0 around 1815 for the years 1710 to 1750, like the Vieuxbourg and villages with intermediate soils; for Alost from 1710 through 1740, the steepest climb of all areas studied, with zero year in the vicinity of 1782.[21] Thereafter, however, unlike the second E trend in the group of villages with fertile soils or the somewhat sharper drop then recovery seen in later years elsewhere, in the Pays de Schorisse the level mostly remained flat across the remainder of the century while in the Pays d'Alost from 1740 through 1790 an actually downward accelerating C trend seems appropriate. This C trend with t_0 around 1840 closely resembles what was happening in East Flanders to the per capita income of people in the countryside, mostly through decline of this shape in the real wages of both weavers and agricultural workers (Table 6.3). It was also approximately the inverse of movement in how many farms became small in Schorisse and other areas and how many days a weaver had to work to support a family (with or without the aid of potato culture), aspects of the economy that in turn reflected the E-type increase of the population of East Flanders from 1750 through 1831 with its zero year at 1852. Alost and perhaps Schorisse, in short, appear by the middle of the 18th century to be returning to classical Malthusian conditions in which high levels of fertility were reduced by an increasingly strained economic environment.

Did other areas of Flanders (and of Belgium more broadly) undertake the same transition only somewhat later? Were these people starting to control fertility? After all, for France from 1742 through 1807 the total fertility rate fell via a C trend with t_0 at 1855 , a path that the birth rate in the country was following from 1680 to 1806 with zero year at 1849. While marital fertility in Normandy came down in a rather earlier C path, I_g for the Southwest and for the southeast portion of the Paris Basin declined according to a somewhat later C--with zeros years at 1828, 1864, and 1868 respectively (Figure 5.3 and Table 5.1).

On the one hand, the similar French patterns strengthen the likelihood that fertility decline was indeed also permeating the Pays d'Alost to hold down I_g there in the later 1700s as that region saw its population expand the second fastest of 8 places recorded in Table 6.6, and do so in H form (Table 6.2). On the other hand, knowing what happened to income, wages, farm size, and the like in this part of Flanders from the 1740s forward into the early 1800s indicates demonomic processes that may have been taking place both currently and somewhat earlier, too, in the French countryside as well.

On the whole, then, readily available local details on demographic change and economic development within Flanders further fill out the picture of how the two interact. Did the same dynamics operate a comparable way in other protoindustrial contexts such as the north of England, parts of Ireland and Scotland, the eastern end of Belgium, the Swiss highlands, or Lusatia?

Urbanization. The Flemish demographic and economic tendencies under consideration also reveal more about the history of urbanization in this particular corner of Europe. Previous portions of this study have shown how from the middle of the 1500s into the early 1600s, including the years of the Dutch Revolt, many urban centers of the Spanish or Southern Netherlands lost residents. A period of broadly shared recovery across much of the 1600s followed; but then further widespread decline in population is evident before growth returned for the second half of the 1700s. Series of evidence from Bruges in West Flanders, Ghent, Evergem, and Alost in East Flanders, and Mechelen in Limburg (Harris 2001, 307-08) have displayed trends that are more durable and less episodic in interpretation than, for example, the early reasoning of Deprez (1965, 611).

The compilation of de Vries, meanwhile, has been used (Harris 2003, 266) to demonstrate how urban decline between 1550 and 1650 involved mainly centers across the northern portion of the Spanish Netherlands (Bruges, Ghent, Antwerp, Leuven, Mechelen/Malines) but not cities which were generally situated further away from the revolting territories (Ypres, Lille, Valenciennes, Brussels, and Namur). Losses between 1650 and 1750, on the other hand, were located in the largest cities (Antwerp, Brussels, Ghent, Bruges), once again Mechelen, and now Ypres in southern West Flanders, while the populations of secondary centers in the Antwerp-Brussels-Ghent triangle (Sint Niklaas, Lier, Leuven, and Alost increased) (ibid., 268). While the conflict with the Dutch and its social and economic consequences did the damage in the later 1500s and early 1600s, the next wave of declines in city populations, though undoubtedly affected by the war of fortress reduction that was conducted in much of the Southern Netherlands between 1687 and 1713, was more one of demonomically systematic de-urbanization.

The detail from East Flanders elucidates what was happening during this second era of urban decline in what is now Belgium. Across the first half of the 1700s rural wages, especially for weavers but also for agricultural workers, rose both absolutely and relative to urban earnings; and they did so via trends that mirrored inversely the decline in the proportion of population living in cities. The value of land (judging by the tax on it per capita) rose in similar G form, even as the wages of rural people made it easier to rent. In all, the economic action shifted toward the countryside with the agricultural changes for which Flanders was famous and the diffusion of the long familiar practice of linen-weaving out through rural areas. Then as land became scarce and required more work to rent because rural earnings fell, responding to accelerating population pressure of E shape, rural wages--for both weaving and farming--shrank via C, both absolutely and relative to what could be earned in cities; and more members of the population located themselves in these urban centers across the later 1700s and early 1800s as new ways of making a living emerged while Belgium became an industrialized nation.

THE DYNAMICS OF FLANDERS IN BROADER HISTORICAL CONTEXT

This sometimes back-and-forth urban development was one part of a broader pattern of change that was taking shape not just within Flanders but across several regions of Europe. Less detailed but more far-reaching outlines of these tendencies appear in what is known of the history of Belgium more broadly, including other provinces, and also in what has been established concerning the development of other European nations. Similar and contrasting movements are evident especially in the Netherlands and in England, and to some extent France and other places, as discussions in Volumes I and II have illustrated. Comparisons of available trends from place to place clarifies the nature of the processes at work, especially the relationships between the demographic changes observed and the economic developments with which they interacted.

Beginning with overall *population size*, it is first possible to sketch out trends for the Spanish (then Austrian) Southern Netherlands, or present-day Belgium, earlier than the limited estimates (beginning only in the 1800s) of which I was aware when composing Volume I of this study (2001, 148, 199). As suspected from its history as a relatively early industrializing region of northwestern Europe and from successive H trends in population size between 1815 and World War I that resembled movement in England, Scotland, Denmark, and the Netherlands, Belgium shared with England, Ireland, the Netherlands, Denmark, and Germany (and also France belatedly and more briefly between 1792 and 1837) the tendency for the country's population to expand in E form from the middle 1700s into the early 1800s. This was a phenomenon not witnessed in Norway or Sweden, or in nations to the south or east across Europe until later in the 19th century as the conditions of a modern industrial economy eventually diffused across the continent (ibid. 148-49; Harris 2003, 258, for Germany 1700 to 1800 after de Vries). Table 6.8 summarizes the demographic growth patterns of countries involved in comparatively earlier development.

The population of the Southern Netherlands, moreover, between 1600 and 1665 and then between 1700 and 1784 expanded in H form not unlike trends of that shape in England, though rising both steeper and lasting later in this manner during the 18th century. While the area that became Germany likewise experienced H trends twice between the late 1500s and the middle 1700s, population loss there in between--in this case thanks to the Thirty Years War and its consequences--was more severe than the setback of the Restoration years in England. In

Norway, the H pattern from the 1660s into the 1730s joined the German and English trends of this period in being flatter than the Belgian one, while in the path-breaking coastal province of Holland in the Netherlands and in Sweden (which both formerly had been outstanding zones of economic development and H-type demographic increase) population expansion in that mode disappeared for a long time after about 1700. Ireland, ironically, stood out in that her H-form growth in people from the 1670s into the 1720s was noticeably stronger than the comparable movement in Belgium, not to mention England, Germany, and Norway. Swift's "Modest Proposal" (1729) was actually written as the flat part of an E trend supplanted this H movement (much as Malthus wrote his 1798 essay while the E-shape population explosion in England was actually topping out). The work of Louis Cullen suggests accompanying diversification and vitality in the Irish economy in spite of occasional hard times.

Klep (1991, 505), finally, has produced estimates which suggest that between some form of demographic crisis that occurred toward the end of the 1400s and the disasters of the Dutch wars for independence in the later 1500s, the population of the Southern Netherlands also expanded in H shape between 1500 and 1565. This, of course, was while Antwerp emerged as the entrepôt for northern Europe, linking Hapsburg possessions from Iberia to the North Sea and the Balkans, and from the Americas to the East Indies, together in trade. This Belgian H trend from 1500 through 1565 began perhaps slightly earlier, though flatter (t_0 around 1362 compared with 1445 and 1412), than the patterns for the Dutch province of Holland and for Germany, so far the earliest examples of H-form population growth identified. The second Belgian H trend from 1600 to 1665 is comparable to the movement recorded in England over the first six decades of the 17th century. Still prior demographic increase between 1430 and 1465 is indicated in Belgium; but its shape can only be speculated, though the Southern Netherlands is known to have been by then one of the most urbanized and economically developed parts of Europe for some time.

With respect to *urbanization*, for Belgium as a whole the kinds of losses of population that have been observed in particular cities not surprizingly led to declines in the proportion of people living in urban conditions overall, first between 1550 and 1600 and then between 1700 and 1750. For the earlier of these periods, De Vries (1984, 39), working with percentage residing in cities of 10,000 or more, calculated stronger decline than Klep (1991, 504), who employed the 5,000 threshold. Both analysts, however, then identified similar recoveries across the later 17th century in the proportion of the population who lived in cities. Integrating these two perspectives with their distinct definitions of “urban” and somewhat different dates of estimation (1650 and 1700 vs. 1665 and 1700), indicates very parallel trends of G form with base dates in the 1590s. Such G patterning for urbanization in the Southern Netherlands as a whole, while later and steeper than the evidence for just the provinces of Brabant and Antwerp in Table 6.3 and Figure 6.2, nonetheless resembles the timing of this kind of change in East Flanders. Volume II (Harris 2003, 275), meanwhile, has shown from de Vries how in neighboring Germany between 1650 and 1700 and in France from 1650 to 1750 the proportion urban likewise seems to have risen in G fashion with t_0 near 1600. In short, though at a higher level, the further urbanization of Belgium in this period followed a pattern than was common in that part of Europe.

D-type decline in the significance of cities during the 17th century, on the other hand, had been shared by Spain, Northern and Southern Italy, and Switzerland. The Belgian atrophy was flatter and also earlier, between 1550 and 1600 (Harris 2003, 275). These losses in the era of the Dutch wars had kept Belgium from sharing with Spain, France, and the Netherlands H-type urbanization from the later 1500s to the early 1600s (ibid.) even if some gain in Brabant and Antwerp appears between 1525 and 1565, before the set-backs of a bitter and protracted military conflict commenced (Table 6.3 and Figure 6.2).

There followed in Belgium a second era of de-urbanization, now more clearly in D shape, across the 18th century. According to de Vries, working with a threshold of 10,000 for an “urban” place, the zero year for the D trend of the period from 1700 to 1800 came at 1658

(Harris 2003, 275); via Bairoch, who employed a cut-off at 5,000 instead, the base year for a curve that fits 1700 to 1800 comes at 1676 (ibid., 277). De-urbanization in D shape between 1700 and 1800, meanwhile, was also a salient feature in the history of the Netherlands next door, with t_0 around 1635 for proportion inhabiting places with 10,000 or more and 1651 including towns down to half that size (ibid., 275, 277). The Low Countries in general experienced in tandem a relative weakening of their cities in this period, while Portugal, formerly a leading trading partner of theirs, also de-urbanized in parallel D form--as did Poland, which had shipped much of the grain that had supplied the famous Dutch bulk commerce. How far were the forces seen to change the balance between city and countryside in Flanders at work in all of these territories? In what ways were these international cases of de-urbanization connected?

In Germany, between 1700 and 1750 some decline in urban proportion appears at the 5,000 level; for towns of 10,000 and over, however, growth in G fashion from 1700 to 1800 was the pattern. In France, some weakening of urbanization occurred between 1750 and 1800 if one defines via the level of 10,000 but not from just 5,000 up. Were bigger centers in Germany pulling action away from smaller ones during the first half of the 18th century while in France the reverse occurred during the decades preceding the Revolution? How might each shift have taken place?

The E-shape increase in percentage of the population that was urban that appeared in East Flanders between 1750 and 1806, finally, closely resembled trends of that accelerating shape in France, Switzerland, and Germany from the 18th century across the early 19th, though it was not as steep as the E patterns for England and Scandinavia that ran up to 1800 or so (t_0's around 1870 rather than the 1835 of those latter two regions). Urbanization in Belgium as a whole adopted an E track like that of East Flanders, but only after 1800. In the Netherlands the 1750 to 1910 E trend was appreciably flatter, delayed in its proportional rise even more than those of Italy, Spain, and Russia (in part because of the high level of city-dwelling from which the

Netherlands started). Subsequently, in the later 19th century, most of Europe experienced H-shape expansion in the proportion of population that lived in cities. This pattern of urbanization accompanied the diffusion of industrialization across the continent (Harris 2003, 277).

The Belgian record provides some insightful detail concerning the settings in which these patterns of urbanization emerged, beginning with divergent experience across the various provinces of the country during certain periods. Table 6.9 collates some of those local particulars from the estimates of Klep (1991, 498).

The changes are most alike from province to province across the 18th century. In the majority of regions, the rightmost column of the table shows, starting about 1700 the percentage of the population that was urban declines in D form from a base year estimated to lie in the vicinity of 1670. That is where the t_0 for the whole Belgian population between 1700 and 1831 comes. In the meantime, the "potential" or inter-urban connectedness across Europe of Antwerp, the leading center of trade for the country, has been observed to shrink over the 18th century in D fashion with zero year about 1646 (Harris 2003, 262). In one of two local variations from the majority of provinces that are evident in this era, the decline in Limburg begins early and is flatter across the 18th century while the D trend probably does not appear in Liège until the middle of the 1700s and, with a base year only around 1720, is appreciably steeper across the second half of the 18th century. In an insight as to what lay ahead, on the other hand, between 1750 and 1806 the percentages of people within both East and West Flanders who lived in cities or towns of 5,000 or more inhabitants began to rise in E fashion toward target years in the 1860s, a pattern that was assumed for centers of 10,000 or more from 1800 through 1890 by Belgium as a whole (Harris 2003, 277, from de Vries 1984). Flanders apparently led the way out of the de-urbanization of the 18th century that for most provinces of Belgium, though it was decelerating, nonetheless lasted to 1806 or even 1831.

Previously, before 1700, there is some difficulty in patterning the paths of urbanization in the Southern Netherlands. For the country as a whole, for example, Klep (1991, 504) estimates gradual decline in the percentage of people living in cities all the way from 1465 through 1665, perhaps in very slowly accelerating C fashion. De Vries (1984, 39), in contrast, sees significant increase between 1500 and 1550, then more substantial atrophy between 1550 and 1600, the era of the Dutch Revolt, followed by slight recovery to 1650 then gain parallel to that calculated by Klep onward to 1700. Part of the problem is that evidence on urban population is almost entirely lacking for the provinces of Namur and Liège prior to the late 1600s, while estimates are absent for Hainaut between 1550 and 1700; and for Limburg they exist only at 1600 during the long span between 1500 and 1650 (Klep, 498). For several provinces, nonetheless, it is possible to grasp some reliable sense of the movements of urban gain and loss between the later 1300s and the early 1800s.

From 1375 through 1465, emerging from the darkness of the Black Death, the regions of Antwerp and Brabant became more urban together, each in G fashion with t_0 in the vicinity of 1340, inspection estimates. Across the next century, however, until unpaid Spanish troops sacked the city in the mutiny of 1576, Antwerp experienced a fresh phase of urbanization as the city of that name emerged as the leading commercial and financial center of Europe, drawing upon its role as the preeminent entrepôt of the North and the link of this part of Europe with flourishing, world-venturing Iberia and with the continuing economic activity of the Mediterranean. Perhaps the simplest trending is to posit that the percentage of the population in this province of the Southern Netherlands that was urban increased in H form from 1465 to 1565 (with base year around 1330), though successive G trends for 1465 to 1525 and then 1525 to 1565 (with zero points around 1421 and 1488) offer an alternative patterning. For Brabant, in contrast to Antwerp, the share of the population living in cities held to its old, increasingly flat G trajectory begun by 1375 all the way to 1565.

Urbanization in the province of Antwerp then atrophied in D manner between 1565 and 1700. With t_0 around 1514 this pattern of decline closely resembled the way the city of Antwerp surrendered its connectedness to other centers of Europe. From 1600 to 1700 this measure, which geographers label "potential," sank in D form with base year at 1532 (Harris 2003, 262, from de Vries 1984, 159), principally as Amsterdam, aided by refugees from the south, rose to ascendancy. As Antwerp faded, not only Amsterdam gained. Table 6.9 shows how the estimated G trend for increasing urbanization in the province of Hainaut (to the south along the French border), with t_0 in the vicinity of 1520 for the period 1565 to 1700, was virtually the reciprocal of the D pattern of de-urbanization in the province of Antwerp (perhaps Brabant did, too, between 1565 and 1600), while Brabant, East Flanders, and Liège all became more urban across the second half of the 17th century. Adjusted, filled in by projection, and collated, these mixed provincial movements led Klep (1991, 504) to produce urban proportions for Belgium as a whole that decline, perhaps in the D manner proposed in Table 6.9, between 1600 and 1665 (probably 1650) before recovering thereafter (in G mode?) to 1700 or so.

Certain kinds of *economic development* accompanied these patterns of urbanization, both across the provinces of the Southern Netherlands and internationally. First at work was protoindustrialization, for which East Flanders has produced much insight. Then, during the 19th century spread the growth of production in factories and mines, the next widespread form of economic innovation.

Just north of Belgium, in the Netherlands, areas with substantial cottage weaving are also known to have supported more population increase than those which remained more completely engaged in agriculture. Summarizing some of the earlier Dutch literature Deprez (1965, 628), looking at the area east of the Ijssel, contrasted Twente, where linen production was substantial, with Salland and Friesland during the 18th century. It has been shown how the eastern areas of the Netherlands de-urbanized across the 1700s even more significantly than commercial Holland (Harris 2003, 222). In Friesland the D trend for this change between 1714 and 1796 (t_0 near 1655) is only slightly flatter than the comparable movement from 1723 through 1795 in Overijssel (t_0 around 1665) while the three largest cities in Overijssel surrendered share of the region's population via a D based on 1675. For East Flanders, in comparison, the percentage of the population that was urban fell between 1700 and 1750 in a manner that would fit a D trend with zero year also in the vicinity of 1675, Figure 6.2 and Table 6.3 have indicated, while from 1710 through 1780 Ghent shrank as a proportion of the whole province via an even steeper D path (t_0 at 1699). De-urbanization in at least some eastern parts of the Netherlands, in other words, proceeded very much like this 18th century transition in East Flanders.

Figure 4.8 in Chapter 4 as shown, furthermore, how from the 1730s to the 1760s wages for unskilled workers in the maritime western areas of the Netherlands declined relative to those in more eastern and inland parts of the country. They did this in D fashion, based upon a zero year around 1690. Turned upside down, this finding means that the relative wage power in the Dutch region whose cities were most losing share of the local population (Harris 2003, 222) and had substantial rural protoindustrialization in at least some of its areas, rose via G inverse to what is known of de-urbanization in these areas. Having a D-type decline in urban proportion between 1700 and 1750 or so with t_0 around 1675 (Table 6.3 and Figure 6.2) and G trends in the ratio of the wage for weavers and for day-laborers to that for urban workers between the later 1600s and the later 1700s with t_0's generally around 1660 (whether one calculates in rye or in wheat, Table 6.5 and Figure 6.5), East Flanders--another, more fully documented center of cottage weaving in the Low Countries--has displayed these same relationships.

In England, meanwhile, real wages for farm laborers in the North and the Midlands climbed in E form relative to those in the Southeast and Southwest from 1675 through 1755 with t_0 at 1806 (Figure 4.8). The North and the Midlands were where mining and factory-focused industrialization began to take off. Since this activity tended to pump fresh life into existing cities or to create whole new ones where power for machinery was available, the wage relationship of the North and the Midlands to the South had much to do with where the fastest growth of cities in England--and in Europe--was occurring (Harris 2003, 270). A second movement of E shape in the interregional wage ratio followed from 1775 through 1815 with target year at 1848. Then, from 1805 through 1865 still further increase decelerated in G fashion. What does comparison and contrast of these English movements with familiar economic and demographic trends for that country reveal about the nature of development there? What, also, do we learn about how dynamics and relationships that have been observed in Flanders may be specific to particular conditions that existed in that particular region in the 17th, 18th, and 19th centuries or be quite general features of early modern demonomic change?

As an illustration of where and how continuing analysis might profitably probe--for instance in a systematic compilation of the Dutch data, perhaps in France--Table 6.10 presents summaries of trends encountered in East Flanders paired with outlines of movements that the literature displays in the population and economy of England. Some movements are parallel; others markedly diverge. Both relationships appear to be insightful. The table is divided into three chronological parts: I, the pivotal period from the early 1700s into the early 1800s; II, some more limited information about subsequent 19th century trends; and III, particulars available for the preceding span from the early 1600s into the early 1700s. Because they benefit from the most ample evidence in the discussions upon which this study has focused, the outlines from the early 1700s into the early 1800s have been subdivided into movements that were generally comparable in England and in Flanders (“A”) and those that visibly diverged (“B”). The analysis also commences with this much-debated middle era, starting with what seems to have been common in Flanders and in England.

In both places, from about 1740 or so into the early 1800s the real rural wage and the real urban wage declined in C form. In Flanders, the 1747-1847 trend for weavers had its t_0 at 1830; for day-laborers over the same years it fell at 1857 (Table 6.3). In England (Figure 4.8), the 1735-1775 average trend for agricultural workers in the North and in the Midlands (where industrialization thrived) aimed at a target of 1828 (before getting a G’ lift during the war years from the 1770s into the 1800s) like the 1830 for Flemish weavers, while in the Southeast and

Southwest the C pattern from 1675 to 1805 had a t_0 at 1856 like the day-laborers of East Flanders. Whether calculated in rye or in wheat (Table 6.5), the real Flemish urban wage from the second quarter of the 18th century into the later years of the 1700s declined via C with target years in the 1810s. In England, two sets of evidence yield C forms with t_0 at 1839 or 1849 (respectively Harris 1997, Table 12.1, 1731-1813 from Phelps Brown and Hopkins; and 1750-1804 from Crafts and Mills 1994, 179-82, "cost of living" real wages).

In both Flanders and England rural and urban wages alike were driven down in the period by an E-shape acceleration in population growth. This movement opposite to the C trends in wages both began a little earlier and was rather steeper over the later 18th century in England than in East Flanders: 1726 to 1806 with t_0 at 1822 (Harris 2001, 148) vs. 1750 to 1831 with zero year at 1852 (Table 6.3). Many of the extra people in each place went to cities. In East Flanders (Table 6.3), the percentage of the population that was urban rose in E fashion from 1750 through 1806 with t_0 at 1864 compared with E movement between 1700 and the early 1800s in England that had a target year somewhere in the 1850s (Harris 2003, 286, from Bairoch for centers of 5,000 or more between 1700 and 1850; Lawton 1991, 360, displays parallel curvature from 1801 through 1821 from the earliest census data). Not enough people were siphoned off, however, to keep wages in the countryside from being depressed in C-shape response.

In each economy, meanwhile, the urban wage gained on the rural one. It did this, too, in E form, E-shape change that was parallel with trends of that trajectory for current urbanization in East Flanders and England. The 1715 to 1795 E trend for England cited in Table 6.10 relates rural wages from Tsoulouhas (1992, 198-99, before Clark's analysis of 2001 was available) with the standard Phelps Brown-Hopkins series. With t_0 at 1848 as opposed to 1851, the ratio of wages for unskilled workers in the countryside between the North and the Midlands and the South from 1775 through 1815 takes comparable E shape, reflecting the impact of a more active urban economy in the North and the Midlands.

The last matchings in section I.A of Table 6.10 concern what happened to marriage while these economic changes were taking place. In East Flanders, both I_m and the crude marriage rate (Devos 1999, 125, 116) declined in C fashion that lagged somewhat behind weakening of this shape in both kinds of rural wages, and moved inverse to E trends in urbanization and the ratio of urban to rural wages (Table 6.3). Nuptuality (as summarized in the top line of section I.B in Table 6.10) lessened from 1796, perhaps as early as 1700, to 1856 with t_0 around 1884; the CMR simultaneously fell from 1750 to 1848 with target year around 1870, cutting across the G' movement that was emphasized for comparison with such trends in other variables in Figure 6.1. In England, meanwhile, C-type change in the crude marriage rate from 1761 through 1841 with target year at 1895 (Table 5.1 and Figure 5.2) sustained the same relationships with these other aspects of demonomic development from the early 1700s into the early 1800s. I_m in England, though, in marked contrast from 1758 through 1818 instead *rose* in oppositely accelerating E fashion with t_0 at 1860. This reversed its ties to the other variables being considered.

That divergence between England and Flanders raises some interesting possibilities. I_m reflects not the number of marriages taking place to the number of people of all ages in the population, which is registered by the CMR. Instead, this index of nuptuality assesses the proportion of women currently married. I_m, therefore, can rise if more women marry at some time in their lives, if women marry sooner, if marriages last longer because fewer husbands die relatively young, or if more females who have lost husbands remarry--or some combination of these changes.

Table 1.1 and Figure 1.1 of Chapter 1 have shown how life expectancy rose in England from 1761 to 1831 in E fashion toward a zero year at 1892. This trend is almost exactly inverse to the 1761 to 1841 C path of the CMR in England with its t_0 at 1895, while it is a little less steep than the E-form increase in nuptuality between 1758 and 1818. Were people living longer in England while East Flanders lacked such change? That is probably *not* the case. Evidence from the Vieuxbourg of Ghent indicates that the proportion succumbing between ages 25 and 54 among all males who died over the age of 15 was declining in C form from 1730 through 1788 with t_0 around 1818. The comparable percentage for females 20 through 44 shrank via C from 1710 through 1788 with zero year in the vicinity of 1827 (Deprez 1965, 625). Implied is an increase in life expectancy not unlike that in England. In each country, the propensity of husbands to die and leave unmarried women would have atrophied in a way that lowered the CMR, since the population past the normal age of marriage increased, but supported nuptuality by leaving relatively fewer women to finish their lives without spouses. The source of the difference between England and Flanders must lie elsewhere.

One such place seems to be the age of marriage. In England, from 1687 through 1787 the average age at which women married decreased from 26.6 to 24.7, or 1.9 years (Wrigley and Schofield 1981, 424). This is not as large a contribution to nuptuality, the proportion of women of all ages involved in marriages, as it is to fertility via the tendency of young women to bear the most children. The recorded decline, nonetheless, could be captured by a C trend with t_0 in the 1820s or somewhat later, which would at least help the upward E pattern in I_m. In Flanders, meanwhile, fragmentary evidence on the average age of marriage for females displays some tendency to *increase*, thereby contributing to the C-shape decrease in I_m. Most of this rise, however, seems to have occurred only during the first half of the 19th century, and local differences appear to be significant. Between 1755 and 1795, for example, in the Vieuxbourg of Ghent and a selection of parishes from West Flanders (Deprez 1965, 615, adding 25 years to obtain approximate year of marriage) average age at first marriage declined: by as much as 4.3 years in the Vieuxbourg, where weaving expanded significantly to help support rural households, but by only a few months in West Flanders. Taking, for purposes of rough analysis, just an average of averages for districts of East Flanders (Devos 1999, 120), moreover, between 1765 and 1795 the female age for recorded parishes in Oudenaarde, Sint Niklaas, and Eeklo drops about a year while for those in the arondissement of Ghent there is an increase of about 8 months.[22] Then between 1796 and 1840 the average for Ghent climbs 3.23 years, for Eeklo, Sint Niklaas, and Oudenaarde just 0.72 years. Evidence collated by Vandenbroeke for communities of Flanders and Brabant (Devos 1999, 118) comparably shows no sustained increase in age of marriage for women between 1715 and 1775. Though one could say that from 1755 through 1805 age trended up about 1.6 years in E fashion with zero year in the vicinity of 1870, decline by 1815 set back this movement to start over for 1815 to 1855 with target year located only in the early 20th century. Altogether in these data, an increase of 3.4 years appears between 1755 and 1855, rather like for the Ghent parishes. To focus primarily upon East Flanders, however, it is impossible to estimate the influence of communities outside that area upon this series, while within the province other parishes clearly behaved differently than those of Ghent; and even within Ghent the Vieuxbourg displays equally significant decline from 1755 through 1795. In all, though these movements contribute, it seems unlikely that rising age of marriage in Flanders and falling age of marriage in England did most to generate the C trend of nuptuality in the one setting and the E trend in the other.

Instead, apparently an increase in the proportion of the female population who *never* married was what most of all separated the pattern of I_m in East Flanders from that in England. The percentage of women who were single at age 50 in East Flanders rose between 1750 and 1846 along an E path with t_0 in the vicinity of 1879 (which is just about how I_m moved in the province from the 1700s into the 1850s with target year around 1884).[23] To compare with economic trends that can be expected to have affected the chance to marry, the 1750 to 1846 trend for celibate women age 50 in East Flanders is set back 25 years to adjust for the fact that, on average, women tended to marry about age 25. This makes the E movement for marriages that failed to take place at the typical time in the female life cycle run from 1725 through 1821 with t_0 around 1854, as shown in the last line of part I.A of Table 6.10.

In England, in marked contrast, the proportion of women who never married *declined* strongly, from 13 percent to 4 or 5 percent among women 40 to 44 between 1731 and 1791

(Wrigley and Schofield 1981, 360). Adjusted by 17 years to reflect (as in Flanders) the fact that women on average married around 25, the trend ran from 1714 through 1774 in C form with t_0 in the vicinity of 1765. This path pushes much more sharply downward across the 18th century than the trajectory for I_m in England drives upward (with its zero year in the 1760s rather than around 1860) and can be expected--even when followed by some rebound into the early years of the 19th century (a modest G movement to 1814 is indicated)--to have contributed strongly to the upward curving of nuptuality between 1758 and 1818 as many fewer women lived out permanently celibate lives.

Whereas demographic historians of England and Flanders will have to confirm or reformulate the implications of the fragmentary evidence offered here, for the present it does seem likely that change in celibacy, primarily, and in age of marriage, secondarily, drove the trends of nuptuality in Flanders and England in their strikingly opposite directions from the early 1700s into the early 1800s. What, then, in these two societies might have shaped failure to marry and age of marriage this way?

The difference in I_m that we have been exploring is only one of several divergences that characterize how the two societies and their economies evolved across the crucial era from the early 18th century into the early 19th. How were these other contrasts related to the distinctive patterns that have been noted in nuptuality? Section I.B of Table 6.10 relates movements that have been established in marriage and to certain economic tendencies that also distinguished East Flanders from England in spite of basic similarities in urbanization and sector wages that have been presented in section I.A.

In the first place, protoindustrialization, upon which East Flanders relied heavily across the 1700s and into the early 1800s, eroded substantially in C form--whether in terms of pieces of linen produced per capita or as income from this business per person (Table 6.5). In England, meanwhile, *industrial* production swelled significantly via E between 1730 and 1810 (Jackson

1992, 19). These movements in cottage industry and factory industry, furthermore, each within their own country paralleled the paths taken by I_m and composed reciprocal inversions of the E and C trends in proportion not marrying and age of marriage that distinguished East Flanders from England. The rise of industrial employment in England allowed earlier marriage and left fewer females without spouses (Wrigley and Schofield 1981, 255, 260). The decline of cottage industry, meanwhile, made it more difficult to marry or to marry young in East Flanders.

Per capita income, meanwhile, fell via C in East Flanders but increased in E manner in England (Figure 6.3; Crafts 1984, 440). This happened because East Flanders from 1725 through 1835 relied increasingly upon agriculture for per capita income, while in England this percentage of GNP, in contrast, declined in C fashion between 1700 and 1840 (ibid.). That movement, with t_0 at 1864, was not only inverse to the E trend for agricultural income in East Flanders, with virtually the same timing; it also mirrored upside down the E movements of overall per capita income and per capita private consumption in England across the later 1700s and early 1800s (Crafts 1983, 198). Significantly, the diffusion of cottage industry in the 18th century allowed Flemish families to stay on farms of which more and more were becoming small, while in England there are indications from increase in labor per farm that operating units were, in contrast, becoming larger (Harris 2003, 241; trends for per capita income and spending in England were fitted for Harris 1997, a revised version of which is in preparation).

Section I.A of Table 6.10 has been used to argue that population pressure drove down wages and promoted urbanization in this crucial era of modern development from the early 1700s into the early 1800s in a generally parallel manner in both East Flanders and England. With age of marriage, failure to marry, and I_m trending in opposite directions in the two societies, by what means could the populations grow in basically parallel, if somewhat lagged, E fashion?

The first insight as to how that might be is the fact that in each socionomic setting I_g, fertility for women while married, stayed level from the middle 1700s through the middle 1800s (Figure 5.1a; Lesthaeghe 1977, 101, 103, for 1775, 1806, and 1846). Meanwhile the death rate in both societies has been seen to decline via C. The crude death rate for all ages in England shrank from1761 through 1831 as life expectancy rose in E mode (Table 1.1), while infant mortality shrank in C fashion from 1765 through 1805 (Table 5.1). In Flanders, while child mortality in all increased somewhat between the 1770s and the 1840s (Figure 6.1), evidence from Deprez (1965, 625) has indicated that the mortality of adults declined in C form across the later 18th century, comparable to the movement in England.

In both countries, in other words, better survival pushed up the size of the population--a familiar phenomenon in the history of early stages of demographic transition. It allowed people to stay in marriage longer and helped them in aggregate to produce more children, even when fertility within marriage did not change. With both more adults and more children, the crude marriage rate fell as its denominator, the whole population, grew. The population pressure in both East Flanders and England pushed wages downward and encouraged urbanization in a search for better options.

The difference between the two societies was how such demonomic pressure was handled. In Flanders, the countryside expanded a form of protoindustrialization that had been familiar in the region for some time. Especially with the aid of the potato, more people could cling to country life this way, though with time their income fell (from weaving as well as from farming, as more households drew upon cottage industry) and more operating units became small. Simultaneously, innovative farming among those who were better off joined the supplement of cottage weaving among less substantial households to make agriculture grow as a source of per capita income. While under these conditions it became more difficult to marry at all or to marry young, especially in the countryside (from where the data on these points tend to come), changes of these sorts, though affecting nuptuality, were not sufficient to offset the combination of steady marital fertility and increasing life expectancy. The demographic pressure persisted until conscious family limitation became a factor in Belgium in the middle of the 19th century.

In England, in contrast, the growth of the new industry raised income and allowed younger marriage while significantly reducing celibacy. More of the economy shifted to industry, not agriculture. Within the countryside, meanwhile, farming became more intensive and shifted toward large rather than small units as the rural wage was depressed. In both societies population pressure in the countryside encouraged people to change. In Flanders they tried to prolong their ways with the supplement of cottage weaving. In England, with her more advanced industry, new wage labor on larger farms could be accompanied by the work required by the new factories and their need for resources and transport. Between the early 1700s and the early 1800s, in East Flanders demographic pressure eroded the welfare of the people because the economic changes that were made did not suffice. They only postponed. In England, comparable population increase, which appeared for the same reasons, was used to feed the 'new economy' of that era, industrial production by factories and also gains of scale in agriculture. Innovation was the key. The issuing of patents surged from the 1750s into the 1800s, in both industry and agriculture, and did so in G form with t_0 around 1790 (Sullivan 1989, 448-49, trended in Harris 1997).

Much of this international narrative is far from new--particularly the English case, which has been worked over intensively for decades. More novel is the synthesis, made possible by the recognition of G-based trending, of how population and economy interacted in demonomic change. Which drove which, and how, becomes more clear. The analysis, among other things, would seem to have much to teach us about what has or has not happened economically to accompany modern, recent and even current, manifestations of E-shape "population explosion" that have been observed all around the globe (Harris 2001 and 2003), one of the most pressing social science issues of our time.

For the later 19th century, however, as industrial development became fully established and diffused across Europe and other parts of what now is called the "developed" world, the relationships of demographic and economic change altered fundamentally. Though more limited than the evidence employed for the period from the early 1700s into the early 1800s, the material garnered for that comparison of East Flanders and England nonetheless suggests the nature of new connections that can serve as guidelines for fresh assessments of the literature on more modern developments than those just addressed, and for new research that could profitably be undertaken. Part II of Table 6.10 presents some outlines for how the interpretation might build.

In the first place, for both East Flanders and England the size of the population and the percentage of it that lived in cities rose together. The difference was that in Flanders from the 1810s to the 1860s (using the proportion living in Ghent as a surrogate for all urbanization in the province) the changes took G shape with base years in the late 1700s[24] while in England from about 1820 forwards for several decades the more slowly decelerating H pattern characterized the trends, with t_0's in the vicinity of 1750 (Lawton 1991, 360, for urbanization from 1821 through 1901).

In East Flanders an increase in marital fertility evident from 1846 through 1880, via a G trend with zero year in the vicinity of 1800 compared with 1778 for the rather shallower movement of that shape in population growth, probably did much to generate that G-type demographic expansion and initiate the 1876 to 1910 one that followed (Harris 2001, 199). Though E-shape increases in both rural and urban wages encouraged gains in nuptuality and the crude marriage rate in approximately parallel E form (Devos 1999, 126, 106), the impact of elevated I_g--more children being born to women during the aggregate years they were married (Lesthaeghe 1977, 103)--can be expected to have been the decisive dynamic for population growth. For Belgium as a whole, in comparison, as the crude death rate gradually began to decline in typical "transition" C fashion through the middle of the 19th century, the crude birth rate actually rose in E form (parallel with the elevation of I_m for East Flanders in that shape from the 1850s to the 1880s) before restoring demographic stability by coming down via a C path from 1872 through 1942 that, aided now by diffusing family limitation, closely matched the decline of that pattern in the CDR (Tables 2.1a and 2.4a; Figures 2.1b and 2.f).

Meanwhile, the proportion of the Flemish male work force that was engaged in agriculture or cottage weaving shrank from 1846 through 1890 (Lesthaeghe 1977, 21) in C fashion with zero year around 1916. This, interestingly, was the opposite of E-shape movement in East Flanders for I_m and, over the long haul, also for the CMR (via the succession of two such trends between 1848 and 1913). The more people left the countryside--especially cottage weaving, whose share of the work force plummeted--the easier it was to marry and stay married in the province as a whole. The relative drag on life chances in rural areas is further illustrated by a decline of C form between 1856 and 1895 in the percentage of land in East Flanders that was owned by those who cultivated it (ibid., 23). Already by 1846 the province having the second lowest percentage of cultivator ownership (after West Flanders), East Flanders saw the loss of such control go even further. Large and middle-sized industry, on the other hand, did not expand significantly in Flanders until after 1866 (ibid., 31). The proportion of the male work force there that was engaged in this activity then increased from 1866 through 1910 in H fashion with t_0 around 1854. In the provinces of Hainaut and Liège, where most industrialization evolved in Belgium before World War I, the H for growth in manufacturing, had its base year around 1820. The H trend that captures industrial development in terms of labor for Antwerp and Brabant, on the other hand, is later than that for Flanders, with t_0 estimated around 1881. As Belgium industrialized later than England, during the 19th century, there is no sign of the close parallel in the H trends of population growth and shift in the work force that had existed while England made her move toward industry (in that case similar E trends) between about 1730 and 1810 (part I.B of Table 6.10).

Nor does the follow-through industrialization of England in the 19th century display such close parallelism between demographic growth and occupational transformation. Now H movement in population increase was accompanied by more rapidly decelerating G change in employment and contribution to GNP (Crafts 1983, 450; Gemmell and Wardley 1990, 301). In Flanders, meanwhile, in a reversed difference of rates of deceleration from the current English experience, G-shape demographic expansion took place in spite of industrialization in the more slowly slowing H form. Population gain across the 19th century of H shape in England (resembling expansion in Belgium as a whole but unlike East Flanders or any other individual province of that country), moreover, took urbanization along with it (though via a somewhat flatter H trajectory). Gross national product per capita from 1840 through 1910 (Crafts 1984, 440), meanwhile, similarly increased in H form in timing very parallel with population growth between 1861 and 1939. Adding these movements to the preceding approximate pairing of E trends in these two series that is presented in section I.B of Table 6.10 indicates that all the way from the early 1700s into the early 1900s demographic increase and per capita GNP moved together in England. In this societal case, however, the proportion of GNP that derived from manufacturing and construction and the percentage of the male labor force engaged in these activities expanded via G rather than the H paths observed in Belgium. The rural wage, the urban wage, and the ratio of the one to the other, meanwhile, all increased through the middle of the 19th century in G fashion with base years in the late 1700s (Tsouhoulas 1992, 198-99; Clark 2001, 496; Phelps Brown and Hopkins in Tsouhoulas?) resembling what the percentage of the male labor force in manufacturing and construction did between 1800 and 1870.

In the meantime, marital fertility in England essentially did not budge (Figure 5.1a, from Wilson and Woods). Instead, up to 1871 nuptuality and the crude marriage rate (Table 5.1) increased in G manner parallel with the shift of male labor into industry and construction. Those movements fed population growth even if the percentage who never married also tended to rise as far as 1839 (Wrigley and Schofield 1981, 260). As the result of having more marriage while sustaining level I_g, the crude birth rate in England, though coming down from a peak reached in the early 1800s, retained its height of the 1700s while the death rate began to fall in the C form characteristic of the demographic transition, first from 1761 through 1831 and then from 1831 to 1923 (Figure 1.1). The result was sustained population increase across the 19th century. This growth, however, thanks to more work in industry and more general opportunity in the urban context as well, could be sustained with increasing per capita income and elevated wages in both rural and urban employment even if the latter tended to outstrip the former. Population increase and economic growth worked together, fulfilling the often elusive golden promise of "development."

It is also possible, finally, to compare insightfully evidence from East Flanders and England *before* the heavily debated period from the early 1700s into the early 1800s. Part III of Table 6.10 presents some readily available details.

From the later 1600s into the early 1700s the two societies largely shared movements in the size of their populations: first decline, then recovery. In England, with ample quinquennial data, it is clear that a D trend was followed by one of H form (Harris 2001, 150-51). In East Flanders, it is possible only to tell that significant loss occurred between 1665 and 1700 (figure 6.2). From there to 1806 a considerably later H than the English one appears. The evidence at just 1700 and 1750, however, would fit the kind of E trend that is estimated for 1675 through 1750 for Flanders as a whole from representation by Vandenbroeke (1984, 916). This particular alternative for the shorter and rather earlier time span has special relevance for understanding the demonomic dynamics in East Flanders during the later 17th century and the early 18th, and how differently the two societies experienced comparable population growth.

In East Flanders, the crude marriage rate tailed off from 1685 through 1750 in C fashion with t_0 at 1773 (Devos 1999, 116), mirroring vertically the upward movement of the population, which would fit an E trend with target year around 1778. The age of first marriage also rose via just slightly later E paths, evidence from the Vieuxbourg and the two communities of Adegem and Elversele indicates (Deprez 1965, 615). The proportion of deaths composed of relatively young adults among both males and females who survived to 15, meanwhile, declined in C fashion with somewhat further delayed target years (ibid., 625). The average age at death among those who reached 15 for males, on the other hand, rose in the Vieuxbourg between 1710 and

1788 in what may have been G form with base year around 1650, for females rather sooner (ibid., 624). Fertility, in aggregate terms of births relative to marriages, meanwhile, in the Vieuxbourg and on the sandy and intermediate soils that characterized most of East Flanders increased in E fashion toward target years in the 1810s (ibid., 620, graphed in Harris 2003, 206-07).

Virtually no available economic measure for East Flanders, however, followed the accelerating E or C paths noted in these demographic changes of the period. Only total linen exports did so. That was simply because the production of linens per capita remained level--in pieces of cloth, and almost as flatly in terms of their value. In all, the fortunes of the economy, rather than reflecting population pressure, took a relatively independent course during these years--in marked contrast to the era from the early 1700s into the early 1800s that followed.

Instead, real wages rose in G form across the countryside, for both agricultural workers and weavers. So did the urban wage in terms of rye. Though contradictory E and C movements appear in terms of wheat and silver, no matter which grain is employed real wages in the countryside gained on urban earnings in G mode with t_0's in the vicinity of 1660 (Tables 6.3 and 6.5). These advances in wages made it easier for country people to rent land for themselves rather than work for somebody else, and to support their families. For each objective, the number of days of effort required declined in D fashion with base year in the middle of the 1600s (Table 6.3). These improving conditions in the countryside held people in rural life at the expense of the cities and towns of East Flanders, reducing the proportion of the population that was urban also probably in D form with t_0 in the vicinity of 1675 (ibid.).

It was undoubtedly the agricultural improvements for which Flanders became famous that from the later 1600s into the 1700s allowed the rural population to raise their condition for a while, into the early 18th century. Encouraging this development, quite abrupt population loss between 1665 and 1675 or so had created some elbow-room for economic growth. Subsequently, on into the 1700s, the upwardly accelerating E trends of marriage and fertility began to take their toll, producing more and more people to live off those gains--probably expanding in H fashion to 1806. As argued by Malthus, the temporary reprieve from demographic pressure before long came to an end; and the era of continual response of economic conditions to population increase that has been observed in East Flanders from the early 1700s into the early 1800s followed.

In England, meanwhile, after systematic D-shape decline between 1656 and 1686, the population expanded in H manner into the second quarter of the 18th century. A decline in the death rate across the last two decades of the 17th century helped renew growth; but this was followed by increase in the CDR over the next 30 years, in all constituting a 1/G' shaped dip and recovery between 1681 and 1731 (Table 2.1a). Marital fertility remained virtually constant across this period (Figure 5.1a), unlike what may have been some increase in East Flanders. The age of first marriage for women likewise remained quite flat, though the crude marriage rate and the I_m index of nuptuality rose in G fashion from bases in the early 1600s, even if this movement was much weaker than the G trend of the crude birth rate, with its t_0 at 1682 (Figure 5.1a; Wrigley and Schofield 1981, 255). Most markedly, the percentage who never married fell in C fashion from those aged 25 in 1664 to those of that age in 1714 with zero year around 1717 and extramarital fertility expanded in relentless H style between 1653 and 1758 (Wrigley and Schofield 1981, 260; Figure 5.1a). Population turned around and began to increase primarily because fewer women never married and secondarily because more births were produced outside of marriage, reversing the reduction in illegitimacy than had occurred across the first half of the 17th century.

The economic improvement that made it easier to marry, in sharp contrast to what supported improving life expectancy and some population increase in East Flanders, for England took place in cities and towns, not the countryside. The real rural wage held mostly flat from the early 1600s into the early 1700s (either a G trend with zero year as early as 1550 is possible for 1615 through 1725, or an E trajectory for 1595 through 1735 with target year only at 1789). The real urban wage, on the other hand, improved via G with t_0 at 1676 so that from 1695 to 1725 it strengthened relative to what was earned in the countryside in G form with zero year at 1653 (Tsoulouhas 1992, 198-99, vs. Phelps Brown-Hopkins). The G curve of improvement in the urban wage resembles the rise in that form of the crude birth rate for England (Table 2.4a). From 1670 through 1750, meanwhile, the numbers of people in English agriculture (Harris 2003, 232-33) declined in D fashion with a base year around 1606 that made the loss inverse to gains in the crude marriage rate and I_m (Table 5.1). Innovation in English agriculture seems to have diminished the same way, judging by the D-shaped decline of patents for agriculture between 1625 and 1755 with zero year at 1617 (Sullivan 1989, 448-49).

In contrast, *all* processes affected by patents increased in H fashion from 1665 through 1755 (ibid.). Its t_0 at 1563 makes this trend parallel with the rise between 1650 and 1750 in the percentage of English people who lived in substantial towns and cities. The proportion of rural residents who were not engaged in agriculture, meanwhile, likewise was expanding in H manner between 1670 and 1800 with zero year around 1540 (Harris 2003, 237). Within agriculture, furthermore, between 1599 and 1793 the number of workers per farmer was enlarging in parallel H mode, anchored in the 1550s (ibid., 241). Proletarianization of the countryside advanced even more strongly than these changes of scale in farming. Between 1599 and 1705, hired laborers expanded as a percentage of all farm workers in an H path with t_0 around 1637 (ibid.). That was parallel with the H trend in extramarital fertility for England between 1653 and 1758. The latter pattern probably reflected not only more insecure work in agriculture but increased migration to cities as a consequence of simultaneous rural discouragement and encouraging urban development.

This combination of rural and urban change produced slow-starting but accelerating increase in per capita national income for England in E form between 1600 and 1700 with t_0 in the vicinity of 1740 (Mayhew 1995, 244). That movement helped reduce the proportion of young English people who could not marry (which took a steeper C trend for 1664 through 1714 with zero year around 1717). Unfortunately, it is unclear here what pattern per capita income took from the later 1600s into the early 1700s. As of the second quarter of the 18th century, however, population increase in E form for several decades could then be harnessed to produce economic growth in much the same pattern, as seen in part I of Table 6.10. East Flanders, instead, fell back into the Malthusian trap where population gain of the same shape as in England only depressed living conditions.

There would seem to be some insight in this comparison of England with Flanders, what was common and what was not, for understanding the varying dynamics of population explosion in recent years, not only into corners of Europe that saw population increase in accelerating E form appear at later times than in England and East Flanders, but around the world from continent to continent. Volume I has identified two to three hundred trends of demographic increase in that form in national and regional populations, mostly in quite recent decades.[25] Long since the early modern era, some of these E movements have been precursors of H trends of demographic expansion whose historical context indicates economic growth--as in India, pivoting in the 1960s. Some have not, as in Peru (at least up through 1990), where threatening constant proportional demographic increase followed instead (Harris 2001, 251, 116). Then there is the unusual case of Japan (251), where a series of E-shape surges in population from 1872 through the 1930s were accompanied by economic growth, as in England during the 18th century.

Recognizing the G-based trends imbedded in both demographic and economic movements, and their relationships to each other, helps us understand better not just the development of two particular societies like Flanders and England but certain shared categories of human experience during a demonomic revolution that has spread globally since early modern times--and continues in many parts of the world today. Insightful anomalies to more common types of development that are identified likewise extend and enrich the interpretation.

Obviously the propositions put forward in this chapter call for much wider application. The intent, time permitted, is to expand on-going work upon what is offered here, both with more complete and better evidence bearing upon the two cases discussed and concerning other societies. Most of any adequate comparative inquiry, however, will require many hands--just as the preliminary analysis offered here has depended upon research conducted by many others over the past several decades. Hopefully enough readers are stimulated to explore the value of this kind of thinking more extensively. The preliminary fruits, even from this limited investigation of one or two societies, would seem to justify some commitment.

Notes

1. Previous connections between demographic movements observed and the social and economic settings to which they have been related appear throughout Volume I by identifying the historical contexts in which the distinctive repeated forms of growth and decline have emerged and in discussions of migrations in Volume II.

2. Research by Imhof (1975, 1: 549, 474) reveals that in the German community of Heuchelheim the proportion of babies born 7 to 8 months after marriage surged in G' manner from 1795 to about 1880 with peak around 1832. The percentage for all births under 9 months also crested via G', first in the late 1830s for the period 1785 to 1845 and then in the vicinity of 1862 for the span of 1845 to 1895.

3. Though from 1861 through 1891 France can be said to display a G' trend with crest around 1868, following an even less vigorous segment of G' surge between 1831 and 1851 (Table 4.5). This peaked in the vicinity of 1832, somewhat later than the early G' movement in marital fertility possible for Belgium between 1806 and 1846 (around 1821).

4. Though a G' is possible for the years from 1861 through 1891 within that longer span, as Table 6.2 recognizes.

5. Alternatively, though, in the two persistently rural provinces of Luxemburg and Limburg one might summarize some of the movement via C instead: 1856 to 1920 and 1890 to 1947 with base years around 1944 and 1934 respectively.

6. More of a quick jump to 1880 takes place in Brabant.

7. As of 1910, furthermore, the proportion of male employment in Flanders backed up above that G' trend somewhat.

8. This H trend had its t_0 in the vicinity of 1820, which makes it very parallel with the 1846 to 1910 movement in Hainaut and Liège (base year around 1822).

9. Movements in Limburg are unclear.

10. Within the province of Liège, the community of Sart in (Alter and Orvis 1999, 138) provides another example in which from 1864 through 1892 I_m rose and fell via G' with peak around 1875 (like the percentage of women who were married). In the Herstal region, down the Meuse below the city of Liège (Leboutte 1991, 283), nuptuality swelled in G' form between 1856 and 1880 with peak likewise in the 1870s, but also from 1812 through 1846 with crest in the 1820s--as has been estimated for Belgium (compared with a crest probably in the 1830s for Sart between 1836 and 1864).

11. The 1375 through 1465 estimates for those two neighboring provinces appear to have followed a G path with zero year around 1312. It is unknown at what point after the main inroads of the plague were over that they began to assume such a trajectory.

12. For East Flanders, Volume I (199) estimated, from other data, a G trend for 1876-1910 instead.

13. Deprez (1965, 628) singled out the Pays d'Alost in the 18th century for having some of the best soil and most advanced agriculture in Belgium and therefore less uneconomic division of land and shift into industry. Actually, he argued, during the second half of the 18th century people there left rural industry to engage in the new, intensified farming of the period. He also said, however, that the population of the Pays d'Alost had grown less rapidly than elsewhere, which appears *not* to be the case, unless he is referring to an era before 1700.

14. Between 1610 and 1650 the price of rye rose 63 percent, mostly before 1630, compared with a 38 percent reduction in the rye value of a day-laborer's wage between 1602 and 1647 (Mendels 1984, 950; Vandenbroeke 1984, 922). Rent, in other words, of itself increased about 25 percent in this era.

There occurred a 38 percent gain in the price of wheat between 1613 and 1638 .

15. For a comparable local mixing of rural activities according to type of land during the 18th century, and some of its demographic consequences, see Rudolf Braun (1978) on the Canton of Zürich.

16. Connected demographic and economic developments. See Harris 2003 for the introduction and use of this term.

17. The C decline for agriculture halted in the early 1800s. That is how total rural per capita income followed a flatter (later) C path from 1725 through to 1835 than either of its major components did as far

as 1806.

18. The trend for the tax value, shown in solid squares in the next level of plotting in Figure 6.4 (which for 1690 to 1770 takes G shape with zero year slightly earlier at 1695), is not adjusted by the price of rye, which--Table 6.5 shows--was falling in C form across the first half of the 18th century.

19. Gains of weavers compared with day-laborers are graphed in Figure 6.2.

20. Estimated by template from the data presented in Figure 6.3.

21. These two areas were averaged for discussion in Volume II before the significance of certain aspects of Flemish developments were better understood.

22. Three parishes of Aalst, for which no data is available at 1840, likewise display 0.42 of a year decrease in this period.

23. Fragmentary data from the community of Rumbeke (in a near part of West Flanders) in years around 1835 and then 1872, meanwhile, indicate the possibility of an E trend there in the percentage of women at age 50 who had never married that has its zero year in the similar neighborhood of 1886. Projected backwards, this hypothetical curve comes close to the percentage calculated for women aged 50 to 54 in Flanders as of 1796-98 (Devos 1999, 127).

24. For Belgium as a whole, though not a single province, demographic expansion took H shape (Harris 2001, 148), first from 1815 through 1866, more flatly than in England (base year at 1717 rather than 1758) and then again from 1876 through 1910, now parallel with English demographic increase (1790 vs. 1794).

25. Though possibly a few cases occurred in a few provinces of Ming China, roughly between the 1490s and the 1570 (Harris 2001, 266). Chapters 5 and 6 there deal with nations and regions within Europe, Chapter 4 with Latin America, and Chapter 7 with Asia and Africa. A few regional cases appear in North America in Chapters 2 and 3.

CHAPTER L

How G-Related Trends Shape Demographic Replacement and Renewal: Some Characteristics of Human Mortality

What can have generated so many different G-related movements in populations? These have appeared in demographic growth and decline (Volume I); in migration, urbanization, and the structure of migrant populations (Volume II); and in fertility, nuptuality, and mortality as presently examined. The origins of such repeated curving, it turns out, appear to lie in certain very general characteristics of human life tables, involving how people die off with age. These continual patterns of deletion regulate the processes of demographic renewal, how new individuals replace prior generations. That characteristic of renewal in turn shapes how many forms of change--demographic, but also cultural and economic--pass through populations over time.

Life tables are based upon observed rates of death for persons of certain ages in populations, typically distinguishing males and females, who make different contributions to demographic processes. Upon this evidence from actual populations are built tables of survivorship and life expectancy and related measures of how successive cohorts would die off and dwindle in relative numerical significance given these age-specific death rates.

Though the Roman calculations of Ulpian (ca. 225) may have constituted such an effort (Trennery 1926, as excerpted in Smith and Keyfitz 1977, 7-9), the modern development of life tables was pioneered in England by John Graunt in 1662, working with London evidence, and Edmund Halley, in 1693, using high-quality data from the Silesian city of Breslau (now Polish Wroclaw). Other noteworthy early but accumulating contributions toward constructing life tables were presented by Johan de Wit (1671), Antoine Deparcieux (1746), Daniel Bernoulli (1766), and Émmanuel Étienne Duvillard (1806) (Smith and Keyfitz 1977, 1-5).

From the start, the desire to compute more accurate risks and pricing for annuities did much to motivate advances. This interest bred attempts to model in a general way how mortality changed across the life cycle, in survivorship to particular ages or in age-specific rates of mortality. Analyses of this sort by Benjamin Gompertz (1825) and William M. Makeham (1867) laid the foundation for periodic re-explorations, which continue today. These two early treatments are still thought to retain much value in outlining the behavior of contemporary evidence, though various forms of logistic change are advanced to account rather better, it is argued, for movements over the whole adult life span (for example, Bongaarts 2005, 24).

It is proposed here, however, that modeling life table values in terms of the G-based patterns that repeatedly appear in them depicts change through most of the human life span--especially during its most significant stages--more simply and more generally than recent logistic interpretations as well as the original, fundamental insight of Gompertz, of which the new curving represents a special modification. It captures in a very parsimonious and very general way how, in population after population, across the years of reproduction, household formation, child-rearing, education, and most lifetime production and consumption cohorts die off and are replaced by new members of society. This one shape of bending in curves, in other words, regardless of departures among the very young and the very old, governs the renewal process and has vital implications for how all sorts of change pass through populations. That is why G-related forms are so ubiquitous not only in demographic development but in social, cultural, and economic trends as well.

SOME COMMON PROPERTIES OF HUMAN LIFE TABLES

{Please note that the "L" Figures and Tables referenced in Chapter 11 are not included at the end of the text (notes) as in the preceding chapters because none of them were in the printed-out notes. Harris produced the manuscript of his *History of Human Populations* on PCs, using word processing and graphing programs that were no longer available or supported when I attempted to retrieve them from the hard drives of his PCs or from the diskettes on which he meticulously backed up his work. As a consequence, I could not produce those Figures and Tables that he had already prepared but not printed out. MSW 31 July 2015}

While most attempts to pattern mortality across the life cycle have focused on age-specific death rates and survivorship to certain ages, T_x (the total number of years lived past age x by a birth cohort of 100,000) provides the simplest and most significant insight into how G-related trends emerge so universally out of human mortality. It depicts the manner in which the aggregate weight of the old peters out, giving way to the new.

Figures L.1a through L.1f portray how in 22 modern populations at 31 dates T_x for females progressively declined from birth through those 85 and older. Women are chosen for emphasis because of their role in reproduction. For 9 countries, values by age at more than one date are plotted to show how the patterning of this life table measure shifted historically. For such multiple representation, cases with a wide spread in time were chosen--except for the 'colored' population of South Africa, which illustrates how within just two decades mortality patterns could also alter significantly. An effort was made to sample different global settings and distinct types of populations. To this end, earlier available dates for developing countries in Africa, Asia, and South America were chosen in preference to recent ones. Table L.1 summarizes the trends identified through most of the length of each of these 85-year series and adds estimates (denoted '*')[1] for 27 other populations (including Mexico in 1960) to comprise a total of 58 examples.

In all, T_x for females falls in C fashion (G reversed with respect to time) from about age 5 or 10 as far as 65 or older.[2] It is a constant, single pattern of change with age from childhood or puberty into old age. What alters from place to place, and over time within a single population, are the age at which t_0 comes and the height of the curve at that point (the sum of years left to live in the cohort). Shifts outward and upward this way over time are noted for England and Wales, Sweden, Italy, Japan, Taiwan, the 'colored' population of South Africa, the United States of America, New Zealand, and Chile. Because the range of ages conforming to C shape has to be estimated in advance as a parameter for the curve-fitting, the spans given in the figures do not always identify exactly the spans of age most accurately aligning with the curve. In the end, the best C may begin a little later or a little earlier, or run longer or shorter than what is indicated. But the eye reveals quite well where the data actually join or depart from the proposed C shape.

From birth into childhood (at latest adolescence) T_x falls instead in some *decelerating* form. Then toward the end of the life cycle, from the 60s or the 70s onward, it slips away below the C trend that suits most years of existence. Where early and later populations of the same country have been examined, moreover, the effect of modern developments in controlling mortality has been to make the C path both start younger and last rather longer--to reduce infant and childhood losses before the C curve commences (making the trend run higher relative to the starting number of births) and to elevate aggregate survival during old age closer to the projection of C. The shape and significance of these early and late movements, before and after the bulk of the life span through which C-shape change prevails so universally, is best understood as other measures of the life table are considered.

With age, life expectancy (e_x) also tends through most of the life span to fall in C form. A few illustrations appear in Figure L.2a. While from age 1 or 5 forward e_x converges with the C path from above, like T_x,[3] late in the life cycle it diverges above rather than below the C trajectory. In France as of 1926 this departure was negligible. In 1911 Australia, and even more so 1981 China, after age 70 more marked separation appears. Estimations for Greece in 1928, districts of Canada that had adequate registration in 1921, Argentina in 1964, and Madagascar in 1966 in Table L.2 provide other examples of historical populations in which C-shape decline characterized reduction in life expectancy from age 20 or before into the 70s, with little departure from that basic path by 85.

The righthand panel of Figure L.2a, however, presents cases in which after about 65 a new trend lifts e_x systematically above the C path for the remainder of the life span. These curves in 1960 Tunisia, 1962 Trinidad and Tobago, and 1950 El Salvador take C’ rather than C shape, C’ being the first derivative of C. Similar second movements are estimated in Table L.2 for 1961 Sarawak after age 60 and 1975 Fiji beginning at 55.

Figure L.2b and Table L.3 indicate how such successions of C then C’ patterns in life expectancy, for males as well as females, have been common historically--though so have C paths without any significant C’ follow-up. The exceptionally high-quality early historical data from Breslau for both males and females with which Edmund Halley worked, for example, declines from age 25 through 75 along a C trajectory that also just barely runs below the calculation for age 80 (Figure L.2b; Halley 1693, in Smith and Keyfitz 1977, 24, 5). John Graunt’s calculations for London in 1662 and Johan de Wit’s Dutch computations of 1671, in contrast, are estimated--in Table L.3--to follow C form to about age 40, then C’ shape thereafter (Smith and Keyfitz 1977, 5). A comparable two-stage pattern, but with very steep, early-based C’ decline during the 40’s, characterizes what may have been the life expectancy conclusions made by Ulpian for Romans in 225, though just what his calculations represented is still debated (ibid., 7-9; Figure L.2b).

Similar two-step patterning--C through 50, C’ from there through age 80--seems, Table L.3 shows, to fit change in life expectancy in Norman Crulai around 1700 (Gautier and Henry 1958, as represented by Smith and Keyfitz 1977, 5). In the Chinese imperial lineage studied by James Lee and others (Campbell 1997, 196-97), however, the succession of trend shapes was different. For males born between 1644 and 1739, and also from 1740 and 1839, for some reason C-type decline in life expectancy with age from 5 into the 40s was followed not by new C’ movement but by second trends of C shape. Among females born between 1644 and 1739, on the other hand, somehow the familiar order of patterns was reversed, with C’ decline up to about age 50 and C decrease thereafter. How Chinese attitudes about the sexes and about aging might have shaped such departures from the more usual historical patterns would seem worth considering.

Several sets of data from the 17th and 18th centuries in North America, meanwhile, indicate mostly C-type declines in life expectancy with age followed by C’ trends later in life.

The shift of pattern appears at earlier ages among groups from Maryland and Virginia than in populations of New England. Eighteenth-century evidence from the Northeast, furthermore--with just C patterns for Wigglesworth's Massachusetts life table of 1789, for married Yale graduates of 1701 through 1805, and for Andover females born in the first quarter of the 1700s[4]--presages what 19th-century studies in the United States have found: in the 1800s C trends alone suffice to pattern data from Salem, Boston, several New York counties, the city of Schenectady, and some counties of Pennsylvania--as they do for females in all registration areas of the United States in 1900 and Canada as of 1921 (Tables L.3 and L.2; Preston et al. 1972, 726).

In parts of western Mexico studied by Cook and Borah (2: 1974, 384, 388, 393, 397), however, secondary, C'-shape decline lingers in evidence on life expectancy by age for the years between about 1880 and 1960. That is not the case for early 20th-century Peking (Beijing). Instead, for both males and females of the First Demonstration Health Station in that Chinese city from 1929 through 1933, e_x tapered off between childhood and about 70 in simple C fashion (Campbell 1997, 198).

A final, but perhaps insightful, perspective on changes of trend types by life expectancy with age by time and also by implied health conditions appears in Figure L.2c and at the bottom of Table L.2. In a recent study of Americans of 'average' socioeconomic standing and health condition from 1991 through 1997 (Rogers et al. 2005, 283, 285), females and males who currently smoked two or more packs of cigarettes a day surrendered expectancy across the life cycle, first via C and then in C' fashion, not unlike people in less developed countries of the 20th century (Table L.2)--or inhabitants of western Mexico between 1880 and 1960 (Table L.3) and 17th-century populations of New England, the Chesapeake, London, Holland, and Normandy.

At the other extreme of the evidence, men and women who had never smoked, experienced dwindling life expectancy with increasing age not only at higher levels but according to the only slowly bending H trend reversed with respect to time, H_r (as C is the chronological reverse of G, or G_r). Does this indicate that--given modern medical intervention to suppress or treat diseases and traumas, and absent negative actions such as the use of nicotine, alcohol, and other drugs or risky behaviors--the ‘natural’ path for decline in life expectancy under optimum conditions as the human organism ages is H reversed in time? How might this hypothesis be tested; and what would its confirmation imply?

The measure l_x calculates how many of an original birth cohort (100,000--sometimes a base of 1,000 or 100 or 1 is used instead) would survive to particular ages given the age-specific death rates evident in a population. Generally, the shift from C-shape decline to atrophy in C’ form is more evident here than in e_x or T_x. Indeed, all 16 plottings of l_x for modern populations in Figures L.3a through L.3h and all 36 estimations added to them for broader comparison in Table L.4 display this succession of curves, whereas in life expectancy and the aggregate number of years lived by a cohort past a certain age (T_x) a later C’ phase has been shown rarely to be essential before the 70s, and sometimes not necessary all the way through age 85.

Plots of l_x for England and Wales, Japan, Chile, and New Zealand in Figures L.3a through L.3d show how, after an ever-shorter initial period of heavy infant and early childhood mortality, through a century or so of demographic change into the 1980s the C trend of survivorship with age up to later adulthood (on average, about age 50) historically both shifted upward and flattened out, to have a much later zero year as well as a higher level through adolescence, young adulthood, and middle age. Least change took place in New Zealand, where survivorship was already relatively high in the 1880s, most in Chile. Comparable shifting is estimated for the United States between 1900 and 1985 and Italy between 1881 and 1983, while evidence for Mauritius at 1966 and 1980 and for Taiwan at 1920 and 1966,[5] whose trendings are estimated in Table L.4, demonstrates how change in this manner continued well through the 20th century.

The ubiquitous later-stage decline of l_x in C’ fashion, meanwhile, likewise shifted outward as well as upward over time in these national populations. It did not, however, generally displace the preceding C trend any earlier, as the starting ages for C' trends in Table L.4 indicate (mean of 47.5, standard deviation of 6.88, using the first C' trend of West Cameroon). Such stability in transition suggests that the aggregate increase in mortality from various causes that generates the C' trend in survivorship during later years of life is sensitive to biological age, and is not altered all that easily. The relatively tight range of zero years for this form of change--mostly between 35 and 50 with mean of 42.3 and standard deviation of 6.3--evident in the right side of Table L.4 signals the same. The implication is that mortality between about 5 and 50, like earlier death in infancy and childhood (which determines the level where C-shape decline begins), has been more malleable to modern health-related practices than losses later in life. This is hardly a novel proposition; but identification of repeated C-to-C' transitions of curve in one population after another offers a simpler and more general way of making comparisons and contrasts across populations and of pursuing causation. It seems, among other things, to assist in analyzing what are sometimes termed 'background' and 'senescent' mortality (Bongaarts 2005).

As noted in Table L.4, this C-to-C' succession deals with the course of survivorship only from some point in childhood forward. That is why these movements are labeled "second" and "third" trends within the life cycle. During the first decade, however, the general *level* from which such sequential changes in l_x will unfold is established by the strength of infant and childhood mortality, which together fall in some decelerating fashion. Illustrations in populations covered in Table L.4 and its related figures L.3a through L.3h involve such early losses for females by age 5 or 10 that range from 42.4 percent of total births in 1881 Italy, 40.8 percent in 1920 Taiwan, and 37.7 percent in 1909 Chile, through depletions of between about 24 and 30 percent in 1964 West Cameroon, 1966 Madagascar, 1861 England and Wales, the 'colored' population of South Africa in 1941, and 1899 Japan, to very limited casualties (by historical perspective) in the 1980s for places such as New Zealand, England and Wales, Chile, Japan, and only slightly greater early attrition for 1981 China and 1966 Kuwait (in contrast to Tunisia as of that decade). Losses like these through infancy and childhood establish the level where the second or C phase of decline in life expectancy with age begins.

The height at which the *third* or C' phase for shrinking l_x starts to depart from its predecessor in turn depends upon the target year for the prior C decline. This determines how much such a curve will have reduced life expectancy since childhood before the C' trend takes over. While the typical age of transition from C to C' has been relatively stable in modern times, the new trend can begin at quite varying points along the C' curve itself. In 1985 England and Wales, for example, the C' path becomes relevant near its zero year around age 49; in 1861, for the same population the C' trajectory takes over after about age 65, some 35 years following its t_0, where survival is decreasing very steeply. Along with the tendency of zero years for C' patterns in all populations of Table L.4 since 1940 to cluster around the lower 40s,[6] this suggests a fairly common way in which modern medicine and living conditions, though they extend life, do in the end confront limits with age.

Some earlier evidence on patterns of survivorship helps to clarify similarities and differences across eras and cultures, and to highlight likely reasons for them. Figures L.4a and L.4b plot some additional trends in l_x from the 17th century into the early 20th and compare these to certain already familiar national patterns. Table L.5 summarizes the findings.

In Graunt's calculation for mid-17th-century London (males and females), no less than 75 percent of those born died by age 26. Dated 1662, this analysis preceded the plague of 1665 and the great fire of 1666. Such a cut is twice as deep as losses in England and Wales by age 25 as of 1861, and half more relative to casualties of around 50 percent over a comparable segment of the life span in 1881 Italy, 1909 Chile, and 1920 Taiwan (Preston et al. 1972, 224, 226; 384, 386, 144, 146, 700, 702). The middle 1660s, it has been shown (Harris 2003, 187--from Wrigley and Schofield 1981, 167-69), marked the crest of London's deficit of births relative to deaths, a G' surge apparently not dependent upon shocks from the famous plague and fire. A big city like this, notorious for its destruction of lives, does not, of course, compare equitably with trends for whole, more diversely composed national populations.

Similarly distinctive is the way what was probably a short C-shape decline in London between ages 26 and 46 then seems to have reduced survivorship from 25 to just 10 percent of the original birth cohort. The most comparable national pattern in Table L.4 is for Taiwanese females as of 1920. There, however, the base year for the C curve came only at age 44 in contrast to the 23 of London, and l_x sank from 49 to 31 percent between ages 25 and 45 (or lost 37 percent of the number surviving at 25 vs. 60 percent in London over the comparable span). Young adults, most frequent among in-migrants, are famously vulnerable to the health threats of big cities.

More freshly insightful may be some demographic comparisons between England's capitol in the 17th century and other historical populations. The third or C' movement in life expectancy for 1662 London, though starting with an appreciably more decimated population at age 46, is in fact quite similar in *timing* to the C' patterns of 1964 West Cameroon between ages 30 and 60, 1881 Italy or 1861 England at the end of the life span, and 1920 Taiwan from 45 through 75 (with a t_0 of 20.0 as opposed to 23.3, 26.0, 30.6, and 29.2). The implication is that before local dissemination of the medical advances and economic development of the late 1800s and the 1900s reduction in survival with age among older adults, internationally, was shaped by much the same forces--just as l_x for surveyed populations in Table L.4 since the 1920s tends, in the wake of modern improvements, to follow C' paths anchored in the 40s, or 15 to 20 years later in the life cycle.

That all cities were not so deadly as London is evidenced by Halley's data on smaller Breslau some thirty years later (1693). He calculated that here about 34 percent of a cohort (less loss by this age than in 1881 Italy, 1909 Chile, or 1920 Taiwan) died by age 10, and 44 percent by age 26. The C curve for Breslau (which started much earlier in the life cycle than the London one) targeted age 52, and closely resembled, in height as well as t_0, the 5-to-55 C pattern for 1909 Chilean females and the 10-to-45 C trajectories in 1966 Madagascar and 1920 Taiwan. The C' path along which survivorship in Breslau then contracted after age 55, once again is--in both parameters--much like patterns in 1966 Madagascar, 1920 Taiwan, and 1909 Chile, and resembles in timing, though not in level, now widespread declines of this shape in 1861 England and 1881 Italy, the 1900 registration areas of the United States, 1964 Cameroon, 1899 Japan, 1961 Indonesia, and the 1966 Indian and Pakistani population of Malaysia. The way in which those who survived into older adulthood died off with further aging in late-17th-century Breslau was, in short, already comparable to the pattern of survivorship in several much more modern settings.

The work of James Lee and others on members of the Qing imperial lineage, who resided in Peking in northeastern China between 1644 and 1911, adds yet another useful early historical perspective on survivorship in cities (Campbell 1997, 196-97). Among all three broad groups of males in this study--those born from 1644 through 1739, from 1740 through 1839, and from 1840 through 1899--C-type decline in l_x from age 10 to 40 or 45 closely resembles the 10-to-55 pattern in 1693 Breslau (males and females) in both timing and level (Figure L.4b; Table L.5). For females, evidence on survivorship is not offered for those born after 1739. For the early period that is documented, the C trend from 10 to 40 comes down more steeply than the comparable decline for males, as the top plots in Figure L.4b most clearly indicate. The subsequently C' phases for Qing males in all three eras, on the other hand, while beginning at a much higher level, all share a base year of about 20 with the 1662 population of London. For females born before 1740, in contrast, the timing of this decline through later adulthood, while at a lower level reflects, the curvature observed in the C' pattern for Breslau. In a sample of the general population of Peking around 1930 (Campbell 1997, 198), once again a more moderate C curve of loss after age 10 again separates the attrition of males from that of females. Was this amount of divergence particularly Chinese? On the other hand, are patterns during the first few years so similar between the sexes because infanticide simply eliminated girl babies from the base from which l_x is calculated, though preference for males still displays an impact via the allocation of resources on trends for l_x after childhood?

SPACE

Historical improvements in survival are best understood through viewing l_x across the life cycle as having three phases. These each repeatedly display their own characteristic pattern of reduction.

During the opening stage of *infant and early childhood mortality*--the first decade, for example[7]--attrition in the Qing lineage eliminated 45 percent of males and 48 percent of females born from 1644 through 1739. In a big city to big city comparison this loss resembles approximately 52 percent by age 10 for the overall population of London in 1662.[8] The Chinese imperial family, needless to say, probably experienced better living conditions than the large majority of residents in Restoration London, and the mid-point year for *births* in this group came three decades later, only in 1692. One implications is that Graunt's very early computations are not wildly inaccurate. Another is that large cities, whether East or West, have historically had comparable levels of infant and childhood mortality. In contrast, casualties during the first decade of life even for the general population of Breslau amounted to only 34 percent, or an appreciably healthier record that for even the elite in contemporary Peking. Was the good record-keeping that attracted Halley to employ these data associated with superior public health management in that Silesian city? Or, did Breslau's smaller scale simply make it a safer place, with less congestion and less poverty?

Among the males of the Chinese imperial lineage born later, from 1740 through 1899, the degree of early loss contracted to about 30 percent. For one area of the city in the period 1929 to 1933 (served by the First Demonstration Health Station, Campbell 1997, 198), however, attrition by age 10 for both males and females of the *general* population was still a little higher (36 percent) than found among the male lineage members born from 1740 through 1899 and greater than what was found in Breslau already by the 1690s, more than two centuries before.

These early-20th-century losses in Peking by age 10 represent some improvement relative to the 41 percent for all Taiwanese females as of 1920, but remain appreciably more than the under 26 percent prevailing among Japanese girls in 1899. That latter Asian historical example of attrition during the first decade of life approximately matched loss by age 10 for females in seven New York counties 1850-1865 and bettered the 28 percent for girls in England and Wales as of 1861 (even more, the 42 percent for Italy in 1881). While in the 1880s some 32 percent of children died during their first decade in the middling-size New York city of Schenectady, by the early 1900s the attrition there had contracted to the low 20's, as in all the states of the United States that had registration and seven Pennsylvania counties examined by Haines; and by about 1930 this early paring away of lives in Schenectady shrank to 10 percent, on its way down to the 1.1 percent characteristic of the United States and of England and Wales in the 1980s (Wells 1995, 420; Haines 1976, Appendix).

Though those with more generous resources (like the Qing lineage) fared better than other members of their society, and residence in a major city could increase the risk, the historical tendency since the 17th century has been for infant and childhood survivorship, for example by age 10, to increase (Table L.5 and populations of Table L.4 selected for comparison). This first, decelerating, pattern of decline in survival with age sets the place from which subsequent C and C' trends during the life cycle begin, thus doing so much to determine overall levels of mortality for a population.

Furthermore, estimates from graphing (not shown) of the extent of female attrition during the first decade of life--in England and Wales from 1861 through 1960, the United States from 1900 or sooner through 1950,[9] and Italy between 1881 and 1985--follow C trends targeting about 1920. This is the shape of change *through time* found widely in preceding chapters for death rates in general, and for infant and childhood mortality in particular, during the transition to modern demographic regimes. Somewhere between 1908 and 1940 Japanese losses assumed contemporary C-shape reduction as far as 1970, while Taiwanese girls died off in parallel contracting fashion from 1920 through 1965. In New Zealand across the first half of the 20th century (1901 to 1950), the proportion for young female losses came down in C form somewhat more tardily, with t_0 the middle 1930s. Still later C-type decline between 1920 and 1970 in Chile had its zero year only near 1950.[10] How much these improvements during early life have come from rising living standards as opposed to better public health and sanitation, an ongoing debate in the literature (for instance, Campbell 1997, 181-82), has to be left to detailed studies of particular populations and their environments.

Figures L.4a and L.4b and Table L.5 next show both some contemporary variations and some changes through time in the C trends along which survivorship *after childhood* (the second phase in the life cycle for l_x) eroded among populations and within them. For Qing males born from 1740 through 1839 and from 1840 through 1899, these patterns altered little in either timing or height from the C path for the earliest or 1644-1739 group. The constantly accelerating erosion of survival through adolescence, young adulthood, and middle age barely improved across two and a half centuries. The general female population of Taiwan as of 1920, on the other hand--which displays the steepest attrition during this phase of the life cycle among the several dozen national examples in Table L.4--endured losses scarcely more severe that these elite men of the imperial lineage. By 1899, meanwhile, the C-shaped trend of l_x for females in Japan already extended to age 60 with a target year as late as 70 (contrasting to from 44 to 53 for the three groups of Qing males). This more mortality-resistant kind of pattern, however, was also attained by females in the First Demonstration Health Station of Peking by about 1930, while even later and flatter contraction of survival with age (t_0 only coming at 88) characterized males there. Did significant improvement in survivorship after childhood, already present in Japan, come to at least parts of China in the 1920s? To what extent did big cities like Peking now take the lead in improving health rather than being especially dangerous for survival?

In the West, evidence from Europe and North America indicates C-shape decline in survival between childhood and old age that repeatedly foreshadows later developments in Asia. In Silesian Breslau as of 1693, the trend for males and females together already resembles those of males in the Qing lineage born from 1740 though 1899 and Taiwanese women as of 1920. Among females, the Japanese trend at 1899 is much like that for England and Wales and several

New York counties four decades before, around 1860, and this pattern in timing (at a lower level) still characterized the experience of Peking residents a generation later, around 1930, though survivorship for males there now tapered off more flatly--as among females in Schenectady during the first years of the 20th century. As improvements in l_x during the first years of life advanced with time across the historical records sampled here--with the West leading the East and Japan preceding China, but parts of Europe and the United States moving closely with each other--much the same temporal and cross-cultural relationships applied among trends of the subsequent stage of survival from childhood through middle age. Everywhere, meanwhile, the pattern by age always took C shape--as has been found for many modern populations in Table L.4.

The C' trends that repeatedly characterized the third phase of declining survivorship across the life cycle, for *mature adults*, also generally improved historically. For Graunt's London population of 1662, for Qing males born in the three periods of 1644 through 1739, 1740 through 1839, and 1840 through 1899, though the starting point moved higher because of the way that the C phase of l_x grew flatter with time, the C' pattern according to which survivorship now dropped off more rapidly through older ages tended to be based near 20. In 1693 Breslau and in several New York counties and also England and Wales in the middle of the 19th century (much as in Italy at 1881), and in Taiwan as late as 1920, the zero year of the C' curve was appreciably delayed: into the later 20s. (For some reason, this was the timing also for Qing females born between 1644 and 1739, perhaps in large part because they died off so much more steeply during the preceding C phase from childhood to 40 than males, suggests Figure L.4a.) In Schenectady, the registration states of the United States, and Japan in the vicinity of 1900 and in Peking around 1930, on the other hand, the t_0 for the C' trend came only in the middle to later 30s, much as in Chile at 1909 or several populations that still well into the 20th century were modernizing rather more tardily, such as Portugal at 1920 or Madagascar, Indonesia, the Indian and Pakistani females of Malaysia, and the inhabitants of Guyana in the 1960s, indicate fitted or estimated illustrations in Table L.4.

In all, curtailment of survival in C' shape during the later years of life not only was common among populations from the 17th through the 20th centuries. It also tended to shift outward gradually over time as health and welfare improved. The patterns for local populations before 1900 in Table L.5, for instance, have a mean zero year at 24.5 compared with 36.7 for Schenectady and Peking in the early 1900s, and 42.3 for the several dozen national populations of Table L.4. These include earlier cases such as 1861 England and Wales, 1881 Italy, 1899 Japan, and 1920 Taiwan as well as later populations living in 'less developed' conditions like those of West Cameroon, Madagascar, and Indonesia in the 1960s--instances whose C' trends paralleled those of Schenectady and Peking early in the 20th century. What was it about the kinds of mortality that harvested older persons this way that has collectively taken C' rather than C form with increasing age and has held this shape over three centuries as survivorship has widely been improved by better living conditions and practices?

MORTALITY BY AGE: PATTERNS OF ATTRITION ACROSS THE LIFE CYCLE

The basis of the human life table is M_x, or the observed age-specific death rate. All other properties, including T_x, e_x, and l_x, are constructed directly or indirectly from it.[11] Across the life span in actual populations this measure can be quite volatile. Figures L.3a through L.3h present some suggested trends for relatively modern populations. They offer alternative patterns of E', on the one hand, and (more simply but less exactly) E on the other, to represent movements of M_x during successive phases of the life cycle following childhood.

The first tendency is for age-specific mortality to drop very steeply from high levels in the first year to a low at approximately age 10. This plunge halts the typical initially sharp but decelerating fall in l_x during early childhood that is observed in populations before the late 20th century[12] and sets the stage for flatter subsequent decline. Since M_x approximately equals q_x, and ${}_np_x$ (the proportion surviving from l_x to l_{x+n}--or across a slice of the age range with n width) equals 1-$_nq_x$, 1-$_nM_x$ generally shapes the decrease of l_x across the life cycle. Because of the subtraction from 1 that is involved, however, increase in M_x, though ultimately determining l_x, does not--except perhaps at the very end of life, where change is very steep--simply curve upward reciprocal to its downward path. The impact is more indirect.

The figures indicate how, after the early decline in childhood and some abrupt equilibrating bounce back for mortality rates during the next few years, the tightest G-based modeling for M_x during the rest of life (starting for the most part between ages 15 and 30) is generally provided by successive curves of E' shape. E' is the first derivative of E (which is the upside-down reciprocal of C, or the inverse of G). In Figures L.3a through L.3h for 16 selected populations since the later 19th century, and 7 more cases that are estimated in order to increase historical variety, mostly 2 or 3 E' trends capture the course of adult age-specific mortality rates.[13] The age ranges of these E' patterns in M_x, their zero years, and the heights of the curves at that point are given in Table L.6 along with summary particulars for trends in T_x and l_x from previous analysis. The table, like Figures L.3a through L.3h also includes fitted or estimated E-shape alternative patterns that are possible in $M_{x.}$ While the sharper bending of E' repeatedly hugs the data most closely, the E pattern itself can sometimes offer rather simpler, if less precise, representation.[14] Where both types of fit are given in the figures, the E curve is represented by a stronger line with "X" at its t_0 to help distinguish it through the preferred E' patterns.

Of the 8 illustrative populations displaying more than 2 E' trends in adult age-specific mortality it should be noted, only 1921 Canada dates before the 1960s. The extra pattern at the beginning of adult life, in short, reflects modern reduction in disorders that can strike down young adults severely (like typhoid fever, influenza, or respiratory tuberculosis). These early additional M_x patterns, however, rise from a very low base. In England and Wales, for instance, the E' curve for mortality in early adulthood for 1861 starts from a level that is 58 times as high as the extra first movement of that shape in 1985. Coming to bear on populations only through 1-M_x, such low levels of mortality do little to reduce survivorship for the time being.

Three phases of increase in age-specific mortality with E' shape emerge in Table L.6. First, all 7 populations of the 1980s display early E' movements from age 20 or sooner into middle age. They are joined in the 1960s by Mexico, Ecuador, and Fiji--and, starting a little later in the life cycle, by Kuwait, and Cameroon for an average t_0 of -3.2 years. All 8 illustrative populations before the 1960s along with Tunisia, the Malays of West Malaysia, and Madagascar in that decade lack an early E' trend in M_x of such timing.

Second, no less than 21 of 23 populations in Table L.6 display E' increase in mortality across the life cycle from middle age into the beginnings of old age. The exceptions are the females of West Cameroon and Fiji, whose early first E' movements seem to continue through this second stage of adult mortality. The average zero year for these mostly similar curves is 14.6. This second, very general, phase of E'-shape increase in adult M_x tends to begin rather later in life for the half of populations in Table L.6 where an earlier trend of this type is also identified.

A third set of E' trends, finally, appears during the waning years of life, from the 60s or age 70 onward, in 15 or 16 of the 23 illustrations. The one exception before the 1960s is for Italy in 1881 (though 1909 Chile is questionable). In that decade, Tunisia, Fiji, and Kuwait also lack such a trend. Postponement of any late, further, steep rise of age-specific mortality until after 75 or 80 in New Zealand, Chile, and Japan among the most modern populations viewed in the 1980s makes these exceptions as well, though not terminating the calculations at age 85 might change that picture. These 14 estimated E' trends for age-specific mortality during later adulthood have an average zero year of 29.8.

Figures L.5a and L.5b provide a few cases that extend insight from the West and from China back further in time than the evidence of Figures L.3a through L.3h and Table L.6. Among monks in the northern English region of Durham between the end of the 14th century and the early 16th, while an E trend from age 25 through age 80 broadly approximates the rise of mortality rates across the adult life cycle, a more accurate representation is provided by two successive E’ trends, from 25 to 60 then from 60 to 80 (Hatcher et al. 2006, 681). For later England, in the 1850s, William Makeham’s 1867 improvements upon Gompertz’s calculations estimated for adult females[15] rates of age-specific death between 30 and 70 that, Figure L.5a shows, accelerated upward in E’ fashion (Smith and Keyfitz 1977, 285). This is very much what modern analysis indicates for England and Wales as of 1861 from 30 through 70, indicates the figure. For roughly the same period, meanwhile, M_x for women in several New York counties rose in E’ form successively between ages 30 and 60, then from 60 to 80 (Haines 1976, Appendix).

Figure L.5b, on the other hand, plots age-specific death rates for certain Chinese populations, all of which dwelt in Peking. In the elite Qing imperial lineage, males and females together who had been born between 1644 and 1739 from 30 to 65 saw their mortality increase in E’ form. Table L.7 shows that with base year around 20, the timing of this pattern closely resembles those for the first E’ curves among 15th-century Durham monks between 30 and 65, English women at 1861, and females in 7 New York counties between 1850 and 1865. The difference is that mortality per 1,000 during the first two decades of life was so much heavier in Peking that as of about age 20 the rate began its initial E’ upward movement at twice the level of these three earlier and later western and less urban populations. For Qing males starting life between 1740 and 1839, a comparable similarity of timing but contrast in level for E’ increase appears between the ages of 40 and 65. Among those born in each era, furthermore, a late E’ gain between 65 and 80 is timed once more like the English data in Table L.7 and Figure L.5a while the level is more than twice as high.

For the two groups of Qing males born after 1740, however, an additional, even earlier E’ segment appears before age 40 or 45. With an average base year somewhat below zero (projected before birth) and a death rate of about 7.5 per 1,000 estimated for that point, these trends resemble early E’ patterns of M_x for populations of the 1980s in England and Wales, Italy, New Zealand, the United States, Japan, China, and Chile that are displayed in Table L.6 and

Figures L.3a through L.3d and L3.h. In these quite recent populations, furthermore, later E' movements similarly approximate patterns of that shape found during the later years for members of the Qing lineage, more ordinary residents of Peking about 1930, and the English and American examples in Figure L.5a. In all, evidence from the 15th through the 20th century supports a patterning of successive E' increase in age-specific birth rates, first through middle age then across the remainder of life.

The implications are that this shape of increase in mortality across most of the life cycle, which is the foundation of G-related trends in the life table, in many other kinds of demographic developments, and in social, economic and cultural changes that are sensitive to replacement in populations, may be biological in origin.

THE IMPACT BY AGE OF PARTICULAR TYPES OF MORTALITY

One avenue for probing potentially biological origins is to examine the patterns in which different types of mortality claim persons of various ages. Does the E' form also dominate them?

There is considerable evidence that it does. While other G-related types of trend do appear, they are in the minority. In aggregate, they are overridden by E' movements in the causes of death that do most to shape age-specific mortality overall. This phenomenon prevails cross-culturally, and from era to era. It persists through historical changes both in intensity of harvesting by particular threats to life and in variations in the timing of these effects by age.

Drawing examples once more from the classic 1972 international survey by Preston, Keyfitz, and Schoen, it is possible to show how particular causes of death have contributed to make mortality for females increase with age in E' fashion. While most patterns in Table L.8 are only estimated, they should suggest fairly faithfully what actual fittings of the proposed curves will demonstrate. For more exact illustration, Figures L.7a and L.7b(?) do fit the proposed curves for England and Wales at 1861 and then at 1964. Along with these two examples, eight other populations (including estimates for Japan and the United States both around 1900 and in 1964) are covered in Table L.8 for eight major causes of death. Figures L.7a and L.7b for England and Wales include death from violence and, separately, its modern form due to motor vehicles.

Though there are insightful exceptions, for most groups of disorders mortality in these ten selected populations over a substantial portion of the life cycle increased with age via one or more E' trends. The most uniform changes in that shape appear in *other and unknown* causes of death, which--as Table L.8 indicates in the 'CDR' column--made the greatest contribution to overall crude death rates up into the early 20th century, and were among the leading sources of mortality thereafter. Even as such ambiguous or miscellaneous losses declined from between .006 and .010 in 1881 Italy, 1861 England and Wales, 1909 Chile, 1920 Taiwan, and 1899 Japan (representing a quarter to a half of the total crude death rate) to more like .001 in developed populations of the 1960s (and one sixth to one tenth of all female deaths), this universality of the E' form persisted. Table L.8 contains both some long, single E' patterns in this category of mortality and also some cases with two or three successive movements in that shape.

Gains in mortality rates with age from *parasites or infections* other than respiratory tuberculosis almost as consistently took E' form. By the 1960s, overall loss rates from these causes had shrunk to between .00004 and .00008, or just 1 to 5 percent of earlier levels in 1861 England and Wales, the United States of 1900, and 1899 Japan. As the impact of such ailments fell from among the most to among the least significant causes of mortality, thanks to modern medicine and public health practices, in England and Wales and in the United States at 1964 their increase with age shifted to take decelerating G' rather than accelerating E' form. In contrast, for some reason that may be worth exploring, in Japan of that period successive E' changes persisted.

Mortality rates from *diarrheal disorders* and from *influenza, pneumonia, and bronchitis* were also greatly reduced internationally by medical advances of the 20th century: the former down to from 3 to 11 percent of earlier levels in the United States, England and Wales, and

Japan; the latter from 12 to 36 percent. For each type of casualty, through middle age the loss rate predominately increased in E' fashion (just 4 G' exceptions appear in 21 trends of the early and middle phases). Late in the life cycle, however, for these two classes of disorders decelerating G' patterns were almost as frequent as accelerating E' trends. The way that G' movements were just as likely to occur in populations up through 1920 as thereafter, however, suggests little role of medical improvement in changing the *shape* of the pattern.

As is well known, overall rates of *cardiovascular* mortality, in contrast to the types of causalities previously discussed, *increased* in later 20th-century populations relative to earlier ones. In England and Wales, the United States, and Japan by the 1960s this became the leading source of death among women. For populations at all points in time examined, during early adulthood cardiovascular mortality expanded mostly in E' fashion. This pattern was repeated across a middle phase of increase in such deaths for the three populations of the 1960s: England and Wales, the United States, and Japan, a trending across middle age anticipated by patterns in England and Wales, the United States, and Italy by 1900. Through *later* years of the life cycle, however, in all eras this type of mortality tended mostly to have slowing G' increase--implying, perhaps, that those who were vulnerable were being weeded out.

One question that should be addressed to data since the 1960s is how much improved prevention and treatment since that point has in fact finally altered the timing of the G' trends in cardiovascular mortality through later life, which across a century of data in Table L.8 so far display tendencies to be largely contemporaneous in zero year even while varying from .003 to .335 in *level* at t_0. Does the exceptional E' surge of rate between 65 and 85 for the United States in 1964, on the other hand, mostly reflect keeping heart and stroke patients alive longer? Also, why do 1909 Chile, 1920 Taiwan, and the 'colored' population of South Africa in 1941 stand out for also having decelerating G' patterns in cardiovascular death up through middle age rather than E' movements? Did diet play a role?

Neoplasms, as is also well known, like cardiovascular disease caused more deaths by the 1960s than in earlier times. In the three twice-recorded countries such problems moved from one of lowest to the second highest source of mortality for females. Except for possible early span to age 35 in 1881 Italy and England and Wales as of 1964, moreover, all trends took G’ not E’ shape. The timing of these G’ patterns, furthermore, was even more homogenous than for the late G’ movements in cardiovascular rates by age. Before extra trends toward the very end of life, their zero years all clustered between 80 and 92. While actual fitting may change these estimated timings somewhat, the likely similarities are striking. Rather later t_0’s are indicated for second G’ patterns during old age in England and Wales and Japan as of 1964, 1941 South Africa, and 1920 Taiwan. These timings, however, closely resemble those for late G’ movements in cardiovascular mortality.

Though less significant for total death rates, even in the 1960s--and declining rather than rising with time in England and Wales, the United States, and Japan--losses from certain *degenerative diseases*, like those from neoplasms, across the adult life span also increased overwhelmingly in G’ fashion.[16] The zero years for trends of this shape across middle age again hover around a mean in the middle 80s while the zero years for the G’s of old age average about 109, not unlike the mean of such curves for cardiovascular disorders and neoplasms during this stage of female life.

In short, these three causes of death--neoplasms, degenerative disorders, and cardiovascular diseases (after middle age)--display types of mortality whose rates of increase have tended to decelerate with maturity via G’, while for death from parasites and infections other than respiratory TB, miscellaneous and unknown disorders, diarrheal diseases, and (up to the late years of life) influenza, pneumonia, and bronchitis mortality has accelerated with age in E’ fashion.

Mortality from respiratory tuberculosis, on the other hand, first followed its own distinctive historical age pattern. Stereotypically a young person’s ailment, in populations from

England and Wales in 1861 through 'colored' South Africans in 1941, it mostly *fell* in C' manner, into middle age or beyond.[17] As modern treatment largely did away with the disease in developed countries (until drug-resistant forms appeared)--with loss rates in the 1960s as low as 1 or 2 percent of earlier levels (12 percent in Japan)--however, remaining mortality from tuberculosis has tended to *increase* with age in E' fashion, as foreshadowed after 50 in the United States as early as 1900. Such trends, and the alternative G' late in life for Chilean women of 1909, may largely reflect how those exposed to the disease earlier in life have been dying off as tuberculosis was curbed historically--at least for the 20th century.

Several other types of mortality are involved in the national totals of Preston, Keyfitz, and Schoen. Deaths from certain disorders occurring in infancy declined with time in England and Wales, the United States, and Japan--both in absolute rate and as a proportion of all female mortality. As many have noted, however, in the United States the improvement in loss rate stalled at almost twice the level for the other two developed countries. Maternal mortality associated with childbirth, which fell much more over time in proportional terms, is in turn also concentrated in only part of the female life cycle, albeit a longer segment. Altogether it accounted for about 1.5 percent of all female deaths toward the end of the 19th century in England and Wales, the United States, and Japan and more like just 0.1 to 0.5 percent by the 1960s.

Various forms of violence have constituted a more significant factor, even for women. This rate, about a quarter of which by the 1960s came from motor vehicle incidents, remained about the same for women over time in the three doubly documented countries. As the total crude death rate roughly halved with time, the proportion from violence roughly doubled. At about .0004 in the 1960s, it exceeded mortality from categories such as infant disorders, maternity, degenerative diseases, respiratory tuberculosis, other infections and parasites, diarrheal illness, and (except in England and Wales) also influenza, pneumonia, and bronchitis.

Among the three countries examined, motor vehicle mortality for women in 1964 increased mostly in E’ fashion with age, as Figure L.7b illustrates for England and Wales.[18] Both at 1900 and in the 1960s other forms of violence--including suicide, homicide, fire, natural disaster, and all forms of accident other than motor vehicle--culled American women in E’ fashion with age. The same was true for other fatal forms of other violence among Japanese females of 1899 and 1964 into their 60s, though as of the latter date a G’ appears from 65 through 85. For women in England and Wales for some reason, both at 1861 and at 1964, through middle age such losses took G’ form while across the remainder of life they followed E’ shape, as Figures L.7a and L.7b show.

The predominately E’-shape trends of increase in age-specific death rates across the adult life cycle that are observed, whether for specific major types of disorders or from miscellaneous and unknown causes, all conform to the generalization--established in Table L.6--that the pace of mortality accelerates this way with age. The fairly frequent exceptions among particular causes of death that take G’ form also increase vigorously with age, whether one G’ surge replaces another of follows an E’ trend instead. In contrast, though, this advance slows down, especially toward the end of life but also sometimes during earlier stages.

The nature of the causes of death that most frequently follow this exceptional pattern--neoplasms and degenerative diseases from youth forward, on the one hand; on the other, cardiovascular, diarrheal, and lung or bronchial problems in later life and residual non-tubercular infections and parasites (often where losses have been greatly reduced by modern medicine)--suggests mortality rates that are guided by the nature of the disorder itself, not just a general wearing out of the human body with age that entails an increased vulnerability to any threat present in the environment. The way that especially comparable zero years for these G’ patterns appear, particularly for neoplasms, degenerative disorders, and cardiovascular deaths suggests a winnowing out before very old age of those especially at risk because of their underlying biological makeup. So does the way that the timing of these G’ trends does not shift in the 1960s relative to earlier periods the way that most E' movements do. Something inherent in the nature of certain individuals seems involved, a tendency that becomes more evident as other, more consistently age-related causes of death come under control. These distinctions may be more insightful than the 'background' and 'senescent' categories favored by much of the literature (Bongaarts 2005, 26-28). In essence, all age-specific mortality is 'senescent.' After youth, it rises in E' fashion across the life cycle, though mostly in two or three steps or stages. (From birth into youth, mortality is negatively related to age.) True, the levels of the aggregate E' paths do importantly vary--from population to population and within populations over time. But those changes are not related to the *shape* of increase over time.

Increasing but decelerating mortality rates in the G' shape for certain disorders, furthermore, help start new E' movements in total age-specific mortality and shape successive stages in that form by slowing down increase for the time being. Increasingly frequent late decelerations in G' rises for particular types of mortality, meanwhile, tend to push up life expectancy in old age above the long C path that is characteristic of young adulthood and middle age, an often evident phenomenon (Figures L.2a and L.2b; Tables L.2 and L.3).

SUMMARY: THE BIOLOGY OF| HUMAN MORTALITY SHAPES DEMOGRAPHIC AND RELATED CHANGE

In the early 19th century Samuel Gompertz (1825) proposed a simple parametric model for the force of mortality at age *x*. In Latin letters (rather than the Greek sometimes employed), he proposed that $M_x = ae^{bx}$. The symbol *e* represents the base of the natural logarithm. The parameter *a* "varies with the level of mortality, while *b* measures the rate of increase in mortality with age." In fact, a "wide range of populations" display approximately such an "exponential rise with age for adults" (Bongaarts 2005, 24).

> For many purposes, the Gompertz model provides a satisfactory
> fit to adult mortality rates. However, a close inspection of the

difference between model estimates and observed death rates often reveals systematic underestimation of actual mortality at youngest adult ages (younger than 40) and overestimation at the oldest ages (over 80). (ibid.)

In the proportional presentations of Figures L.3a through L3h, L.5a, and L.5b and in other examples added for Table L.6, an exponential straight line, as proposed by Gompertz, can sometimes roughly represent the gain in adult mortality that accompanies age. Notably, for all the illustrations from the 1980s, for Mexico, Fiji, and the Malay population of West Malaysia in the 1960s, and for Canada as of 1921, sequences of E' increase with age in M_x for females merge toward log-linear advances from younger adulthood to old age. The average slope of this type for estimates in all the sampled populations of the 1980s except 1980 Chile is $e^{.0989}$. For 1980 Chile, 1921 Canada, and the three relevant populations of the 1960s, the average is $e^{.0794}$: not so steep. One possibility is that under modern conditions age-specific mortality has been progressively converging upon some log-linear maximum in the vicinity of .1. If, on the other hand, all 11 roughly log-linear cases are included, the average is $e^{.0900}$ or 3 times the $e^{.03}$ that is so basic to all the trends discussed here. Further research is required to assess the significance, if any, of such approach to log-linearity for M_x in modern populations.[19]

Historically, however, any approximately log-linear pattern--even in the later 20th century--obviously misses bending of the data in semi-logarithmic graphing. E is an improvement, as Figures L.3a through L.3h illustrate. E', however, provides even tighter fits to the data.

What the curvature of E' does, first of all, is to capture better the higher levels of early adult mortality that any simple exponential line would miss (the error for which William Makeham tried to correct in 1867 CHECK). Then, the inclusion of second (or further) subsequent curves, which begin relatively slowly then accelerate anew, better portrays levels in late years of life, where the other type of shortcoming in the simple Gompertz model has been identified. Here, overestimation rather than underestimation appears. While the E pattern makes some of the needed corrections at both ends of the adult span, and in several cases of Table L.6 has to be restarted less often over the duration of the life cycle, E' curves most tightly address the shortcomings identified by various demographers in first the Gompertz and then the Makeham models.

A logistic solution to these problems, which some have proposed (reviewed in Bongaarts 2005, 24-29), while covering the entire adult age range more accurately than the modification by Makeham as well as the original of Gompertz, also requires 3 parameters:

$M_x = (ae^{bx}/(1 + ae^{bx})) + c.$[20]

On the face of it more cumbersome, E' says that

$M_x = ae^{(1+(-.03(t_0 - x)) - e^{(-.03(t_0 - x))})}$. Use NB 4

[$M_x = a(\exp(1+(-.03)(t_0\text{-}x))\text{-}\exp((-.03(t_0\text{-}x))))$] remove after CHECKING

This formula, though, has just 2 parameters, a and t_0 because b is replaced by the constant .03. Increase of this shape with age in M_x, however, frequently occurs more than once during adult stages of the life cycle, Table L.6 indicates. The choice becomes one of whether insisting upon a single curve for all adult mortality or recognizing the bends and sequences of bends as they actually take place is more insightful for understanding how mortality progresses with age and varies through time and from one population to another.

The new "shifting logistic" model proposed by Bongaarts (2005, 29-30) assumes that a pattern of increase in the "senescent" component (his b parameter) of the total force of mortality remains constant with age for a given population, though historically it can slide forward or back across the life cycle. This modification (ibid., 27) seems analogous to the way that, to employ a simple graphic illustration, the C pattern in T_x moved upward and to the right in several populations between the 19th or early 20th centuries and the 1980s in Figures L.1a, L.1b, and L.1c. Similar historical shifts in the E' pattern of M_x in Figures L.3a through L.3h, L.5a, and L.5b (and Tables L.6 and L.7), during both earlier and later stages of the life cycle, are more complex but evident.

The Bongaarts model (ibid.,29), however, allows a *different* fixed *b* for each population, or for men and for women within a population. For all available years from 1950 through 2000 in 14 countries this parameter for females 25 through 109 has an overall average of .114 with national averages ranging from .101 to .120 (ibid., 26). For males, the average is .105 overall, with a range among nations from .094 to .112.

In E' *b* is instead a universal constant, .03, evident in both East and West at least since the 16th or 17th century. It is not this slope parameter that varies in addition to the *a* value for level from population to population or from phase to phase of mortality increase within a given population. Instead, t_0--the timing that determines how fast the rate of increase in mortality is accelerating at subsequent or prior *x* points of time--is allowed to float. With these dates made a parameter, *c* or the third component of the shifting logistic model--for "background" mortality within total age-specific mortality--can be dispensed with. Instead, transitions from one E' trend in M_x to another seem to capture phenomena such as what have been called 'background' and 'senescent' impacts upon death rates. These patterns early and later within the adult life cycle pool results of the ways that different types of mortality bear upon various age groups within populations, which, as noted i Table 8, often themselves take the E' form--otherwise mostly its inverse G'.

How the E' trends found in M_x have shaped l_x and T_x, and therefore human experience in which demographic renewal plays a role, is the topic of Table L.9. It summarizes particulars from the 23 illustrations of Table L.6 in a simplified way and combines them with some additional estimates of other relevant patterns to demonstrate how these dimensions of the life table have evolved relative to each other between childhood and old age. The height at t_0 for the various fitted or estimated curves is ignored. The age at which the zero year for the relevant trend falls is emphasized in order to focus on connections among movements.

One link between variables to note is how the zero years for the C' curves in l_x during the later decades of survival always fall close to the t_0's for the C curve of T_x: for example, 30 and 30.5 for females in 1861 England and Wales, 26 and 31 in 1881 Italy, 43.1 and 36 in 1881 New Zealand, and 36.5 and 31 in Japan as of 1899. Both T_x and l_x are hypothetical extrapolations from the observed age-specific mortality rates. They have a special relationship. Though they are calculated from q_x (the probability of dying in the next *group* of years,--1, 5, 10, etc.), if they are viewed as *continuous* variables--with the age divisions made infinitely brief) T_x can be seen as the definite integral of l_x between age x and infinity: the sum of all l_x's in that range, or the area underneath the curve for l_x.[21] Since C is by definition the integral of its derivative C', a C' pattern in l_x implies a matching C pattern in T_x. Such simple connection, with comparable zero years for the paired curves, appears as expected in all 23 populations examined--at least from middle age into old age.

During the very last years of life, moreover, as T_x drops below its long-running C path, the new downward trend is generally estimated to take C' form. These curves are not plotted in Figures L.1a through L.1f; but it is clear there how the calculations typically fall below the C projection in later years. Approximate C' fits to account for these departures are estimated for 22 populations of Table L.9.[22] In this twilight phase, though, l_x now seems to follow a C" path--as suggested in Table L.9. C" is the second derivative of C, or in turn the first derivative of C', which preserves the relationship of l_x and T_x, as the zero years for these C" trends in l_x and for the closing C' patterns in T_x again mostly fall close together.

Earlier in the human life span life, however, whereas T_x starts to decline in C fashion during childhood, l_x does not take up its matching C' path until middle age or later. Before then, C--not C'--is the pattern of erosion in survivorship as well as in T_x. It is characteristically a flatter C, however, whose zero year falls much later than the one for T_x, recapitulates Table L.9 from Table L.6. Before its zero year, C' rises. Survivorship, however, cannot increase from a lesser age to a greater one. The members of the birth cohort have already died. Because T_x is the sum of l_x's from age x to infinity (85 is generally used in abridged life tables), however, it accumulates or compounds the shallower declines in l_x up through middle age to come down in appreciably steeper C fashion, and begins doing so by the end of childhood.

M_x shapes the trend of l_x only indirectly, through ${}_nq_x$ (the probability of dying between exact ages x and $x + n$) and then ${}_np_x$ (simply 1-${}_nq_x$ or the probability of surviving between exact ages x and $x + n$). The subtraction from 1 makes p_x curve quite differently from a simple opposite of M_x, as estimates in Table L.9 indicate.

To begin, p_x from about age 10 though age 50 is quite flat in all populations. Figure L.3a illustrates this phenomenon for females in England and Wales at 1861 and then 1985. Without Cameroon (about 14.0 percent), the decline in proportion surviving across successive 5-year spans during this large slice of life contracts only 4.5 percent on average from its level at year 10 for 22 populations.

Beginning about age 45 or 50, on the other hand, p_x seems to decline in a C' pattern that is quite stable across time and culture. The average zero year estimated for the 8 populations through 1921 in Table L.9 is 47.0. For the 7 populations of the 1980s, this age has extended only to 53.0, with the trends of the 1960s averaging 51.4. The estimated level at t_0 for the C' trends of these same two groups alters even less: by .928 for the early populations, .969 for the later ones, and .939 for the 1960s in between. Through this middle stage of life, moreover, p_x declines in C' fashion like l_x with zero points that on average follow those for survivorship by about 12 years among populations through 1921,[23] 8 years for the sample from the 1960s, and only 4 years for females of the 1980s.

Early movement accelerating in E' form for M_x clearly exists, but before middle age its level is so low as to barely affect p_x other than starting it slowly downward with age. Later in adult life, as loss rates become higher, the filtering of E' increase in M_x (sometimes two such increases) through grouping for q_x then subtraction from 1 for p_x makes p_x and l_x decline together in C' fashion. Only during the last years of life with their steep advances and high levels of age-specific mortality, Table L.9 shows, do C” decreases in survivorship and the C’ fall of T_x begin to resemble in timing reciprocal E” trends for M_x, most closely in populations before the 1980s.

HISTORICAL *HOMO SAPIENS* IN THE BROADER SETTING OF NATURE

The examples used so far to illustrate the permeation of life tables by G-related trends all involve societies with written histories and various degrees of early modern or quite recent socio-economic development.[24] If the phenomenon is, as suspected, rooted in the biological nature of mankind, however, it should also occur in much simpler human contexts. There is evidence that it does.

Figures L.6a and L.6b trend l_x for selected populations of hunter-gatherers, forager-agriculturalists, and acculturated hunter-gatherers. Gurven and Kaplan (2007, 328) describe these collectively as “the most complete set of preindustrial populations available” with adequate demographic particulars. Acculturated hunter-gatherers have “either recently started horticulture and/or have been exposed to medicines, markets, and other modern amenities” (323). Among the sufficiently documented hunter-gatherers, the Dobe !Kung live in the Kalahari desert of Botswana and Namibia, the Hazda in Tanzania, the Agta in the Philippines, the Ache in Paraguay, and the Hiwi in Venezuela. Of the forager-agriculturalists, the Tsimane reside in forest areas of the Bolivian lowlands, the Yanomamo Mucaj in the Parima highlands of Brazil, the Yanomamo in Venezuelan Amazonia, and the Gainj in the central highland forests of Papua New Guinea. Aborigines of Australia’s Northern Territories are included among acculturated hunter-gatherers along with later populations of the !Kung, Agta, Ache, and Hiwi. Further details on these peoples, assessments of the quality of the data available, and the periods and conditions in which their demography was recorded are given (ibid., 324, 354-59).

All 15 groups, except perhaps for the very last years of life for transitional Agta in Figure L.6b, display the same sequence of three distinctive trends found for modern and pre-modern historical populations in Figures L.3a through L.3h, Figures L.4a and L.4b, and Tables L.4 and L.5. A decelerating drop into mid- or later childhood is followed by a long span during which l_x takes C shape. Then through the later years of life survivorship erodes away faster, in C' fashion.

Table L.10 estimates the particulars of the second and third trends of this lifetime patterning and provides some comparisons with historical populations previously examined. The human groups from 1661 London downward in the table are ordered primarily by the base years for their C curves in survivorship, beginning there at 22.6 and flattening out to 120.7 for China in 1981.

For the 20th-century Yanomamo and the Hiwi, the zero year of the C trend falls between those for the general population of 17th-century London and elite Qing females of 17th-century Beijing. The t_0 for the Yanomamo Mocaj, on the other hand, resembles those for Qing males born between 1644 and 1739 and for Taiwanese women in 1920. All of these C trends end by about age 40 or 45. Their heights at the zero year range from 27.3 to 39.3 per 100 births, averaging 32.6, or typical of all the populations from 1661 London downwards in the table on into the 20th century (range 20.8 to 39.3, mean 30.7). In all, that is, for three centuries and from preindustrial conditions to quite modern ones, the base year for the C trend has pushed forward with little change in the proportion still surviving at that point.

In this historical process, for the Gainj and the !Kung and for the acculturated Hiwi after 1960, the timing of the C trends in survivorship were comparable in target year to those for Qing males born between 1740 and 1890, the population of Breslau in the 1690s, and women in 1909 Chile and 1966 Madagascar. The t_0's for C in l_x for most other preindustrial populations analyzed by Gurven and Kaplan, on the other hand, arrived about a decade later--in the 60s rather than the 50s--like those for Sweden in the middle of the 18th century or females in Peking around 1930 or in 1899 Japan; and, like them, now sometimes lasted close to 60. For the acculturated Aborigines of Australia's Northern Territories, finally, the C pattern targeted only age 84, even later than was the case in several western countries during the later 19th and early 20th centuries or in Indonesia as late as 1961--but sooner than in rural Taiwan in 1966, not to mention the populations of the 1980s characterized in Table L.4.[25] Yet the settled Ache and the acculturated !Kung after 1963 have estimated target years for their C's comparable to the populations of many developing or developed countries of the later 20th century.

Less variation is evident in the C' trends of Table L.10 in the age projected for t_0 but more in the height of the curve at that point. The latter depends upon the timing and therefore the slope of the preceding C trend. The Gainj, the !Kung, and the peasant Agta display the earliest zero years of all; but these come not so very much before those of 1661 Londoners or Qing males in three different eras. The other 11 detectable C' curves for the preindustrial populations of Gurven and Kaplan fall in a range of 25.9 to 51.9, a span that embraces the zero years for all of the developing populations illustrated. For the most part, the drop-off during later life in C' fashion, like the C trend preceding it, has not differed radically in modern societies from preindustrial populations, either historical or relatively contemporary.

Drawing upon Gage, Figure L.6c goes a step further in putting the G-related patterning of survivorship for historical *homo sapiens* into broader biological perspective. As Table L.10 summarizes, for a dozen samples of *prehistoric humans* (1998, 202; from O'Connor 1995) between ages 1 and 20 l_x declines in C fashion with t_0 approximately at 39 for age 29.[26] The level at the zero year falls within the range for all historical populations from 17th-century London downward in Table L.10. The age there is like that found for C in 1661 London, among the Yanomamo and the Hiwi, and in Qing females born from 1644 through 1739. The C' trend that follows from 30 through 60 for prehistoric humans, in contrast, implies over 110 "survivors" at something like 11 years before birth. It is an unusually steep drop. Was that fall-off after the late 20s inherent in the nature of prehistoric human life; or does it somehow originate from the way such data must be derived?

For three captive populations of *Pan troglodytes* (the common chimpanzee, Man's closest present neighbor on the evolutionary tree--Gage 202; from Dyke et al. 1995), the C phase of decline in survivorship runs almost twice as long through life, perhaps into the 40s, like the historical populations in the top half of Table L.10. The timing of the base year for the curve, meanwhile, once again resembles those for the Yanomamo and the Hiwi, and for Qing females born from 1644 through 1739--though with 43 survivors out of an original 100, the level at t_0 is a little higher than is typical for the historical populations in Table L.10 or L.4. Among captive chimpanzees, furthermore, the C' decline that follows from ages 25 through 50 is much like those among the Gainj and the !Kung both in base year and in level at that point. Assisted by human care, survivorship for *Pan* is very much like that in some historical human populations, though a final steep drop from 50 through 65 resembles in timing the C' path of l_x for prehistoric humans after age 30.[27]

Among *wild chimpanzees* (Gage 204; involving Gombe animals from Mode 1988), on the other hand, though the C trend runs through 35 or so and its level (about 36) is comparable to what is found throughout Tables L.10 and L.4, the zero year arrives noticeably earlier than for captive *Pan* and for prehistoric or historic humans: at about age 12. The C' trend that follows, on the other hand, is about average for *Pan* and prehistoric humans in its timing, and like the lower range of historical populations in its height at t_0.

In all, humans and chimpanzees--relatively close biological cousins--display similar C then C' patterns of l_x across their fairly comparable life spans. Survival with age for other primates is clearly more different, as Figure L.6c and Table L.10 indicate.

Gage's model for *old world monkeys* (1998, 202; from Gage and Dyke 1998 and 1993) blends life tables from several populations. Most are macaques (some rhesus, some Japanese), including one wild and two provisioned groups among six. The two others are mixed *Papio* ssp (mostly yellow baboons). Most notably, their lifespan is only about half of that enjoyed by *homo sapiens*. Still, the characteristic C then C' patterns appear, switching at about age 20. This transition comes only slightly earlier than for prehistoric humans. But the base year is as early as age 1. The C' trend, meanwhile, has its t_0 at -30 from a level of 273.

New world monkeys are represented in Figure L.6c and Table L.10 by a blend of life tables for four species of captives. These include the common marmoset, the golden lion tamarind, the saddleback tamarind, and the cotton-top tamarind (Gage 1998, 201; from Dyke et al. 1993). For this family of primates, the span of life hardly passes 20 years. Furthermore, no C trend in survivorship appears; and what seems a C' pattern running from ages 1 through 20 has extreme parameters: over 2,000 per 100 births at -63 years.

While for old world monkeys the typical succession of C then C' trends in survivorship has little resemblance in timing or in level to what is found among humans, and it simply fails to appear among new world monkeys, most of that distinction derives just from the very different lifespans of the organisms involved. Unlike a rough similarity with closely related chimpanzees, *homo sapiens* has characteristically lived approximately twice as long as the old world monkeys illustrated and almost four times as long as the new world primates. If the length of life is made more comparable, however, a rather different relevance of the C then C' sequence emerges for these two groups of monkeys--and also for much more diverse types of fauna.

Figure L.8 and Table L.11 crudely adjust the lifespans of several species to the 70-to-85 years experienced by humans from prehistoric to modern times. (The basic evidence comes from Figure L.6c and from Deevey 1977 [1947], 62-72). These plottings are very rough: over half are estimated from graphs; adjustment to fall within the range of a historically increasing human life span is approximated by simple multiples and the true natural lifespan of a species to which the multiple is applied is often difficult to identify. In the cases of the snowshoe rabbit, the herring gull, and the song sparrow the original data are given not as calendar units but as multiples of the mean length of life. Still the figure and Table L.11, which compares its results with some of the findings in Figure L.6c and Table L.10, should provide some useful insight and provoke further investigation as to what is common and what varies in the survivorship of fauna.

Framed hypothetically to have comparable lifespans, the indications are that:

1) Not just for humans, but for mammals more generally, the C-then-C' sequence of survival characterizes younger then older ages.

2) For chimpanzees, Man's closest relative, the .03 exponential coefficient of C and C' is shared since no adjustment of the lifespan is necessary. Furthermore, both the level and the timing of these two curves falls within the range for historic or prehistoric humans.

3) For the two other groups of primates, the lifespan must be doubled or more than tripled to resemble that for *homo sapiens*. Once such adjustments are made, nevertheless, only the timing of the C trend for new world monkeys stands out as being much different from human populations. Extending the length of life, however, means that in the natural populations--as opposed to the artificially long-lived ones--the .03 coefficient of curvature *multiplies* accordingly so as to increase the speed of decline. The other groups of primate species, in other words, each have their own larger, but likewise constant exponential coefficients for the life table. They do not share the .03 of humans and chimpanzees. But given these different fixed values, their survivorship also follows the equivalent of C-then-C' attrition with the appropriate exponential constant of that species (*c*) to replace .03 (making the curves C_c and C_c'*)*. The structure of the formulas remains the same, as in l_x = a*exp(1- exp(c*(t_0 - *t*))) for C_c. CHECK

4) For the mountain sheep, whales, and rabbits in Figure L.8 and Table L.11, the other mammals illustrated, distinctive exponential constants for the actual counterparts of C and C' trends also clearly apply, because length of life must be extended considerably to compare with that for humans. Each species, moreover, displays different timings and/or levels for these patterns when these are set artificially for longevity similar to that of Man--more divergence than is evident just among primates. Still, the equivalent of C_c-then-C_c' succession persists across these very different species. Is such trending universal for all mammals?

5) For birds and for invertebrates, it appears that it is not, summarizes Table L.11. Instead, survivorship from early in life onward erodes via a succession of C_c' movements without any C_c phase. The multiples for lifespan relative to humans for birds have to be about

three times greater than for primates other than chimpanzees and the other mammals illustrated. For the two invertebrates, the required adjustment for lifetime is much larger still. The exponential constant (*c*) for C' must increases accordingly; but the characteristic fixed curvature for each species is retained. Among the birds examined, the last C_c' stage for l_x seems quite comparable. In timing, furthermore, it resembles that for the mammals in Table L.11, though in height of the trend at t_0 it does not. Do warm-blooded creatures in general encounter similar acceleration of attrition in later years of their life cycle? Less similarity shows up in the first C_c' stage among birds, and resemblances to patterns for mammals--while they do occur for certain species--are more spotty. An implication is that from species to species how young are nurtured, trained, and make a successful transition into mature life varies more than how adults wear out. For invertebrates, in contrast, the heavily adjusted examples are very similar to each other during the first C_c' decline, less so thereafter.

SPACE

Even via these few crude artificial comparisons, such similarities and differences in survivorship patterns among mammals, birds and invertebrates may offer some fruitful insight for population biologists and geneticists. Earlier investigation relative to Volume I of this study (not published), furthermore, has suggested that species of fauna, and perhaps flora, like mankind also have G-type (G*) related patterns for *growth* with their own distinctive fixed exponential coefficients (* rather than .03) as well as for survivorship and other dimensions of the life table.[28]

The point for the present argument, however, is that humans are not the only creatures who have the types of G-connected trends for survival and related demographic experience that is identified as crucial in shaping many forms of demographic and other change through time. That this characteristic is shared with other organisms underscores its biological nature. Humans die off this way as a 'biological brake' embedding the -.03 exponential constant slows life to a stop. Because mortality repeatedly erodes life in this manner, the imprint of G-related change--

particularly accumulative survival or T_x, which simply takes C shape between childhood and quite old age--constantly shapes demographic replacement or renewal and imbedding G-related patterns in all human experience affected by it.

Notes

1. Made by graphing and template.

2. Starting more like 15 in 1899 Japan, 1920 Taiwan, 1965 Algeria, and 1964 West Cameroon; lasting up to 80 in 1970 St. Christopher and Nevis and 1965 Algeria, and all the way through 85 in 1963 Réunion and the Seychelles of 1960.

3. Though rather more tardily, in the ‘teens rather than by age 5 or 10, and rising briefly before looping back down to the C trend.

4. C then C’ succession in life expectancy, however, emerges for unmarried Yale graduates of the 18th century and Andover females born between 1730 and 1755, while Plymouth women of the 17th century seem to have lost years yet to live along a single C path from 25 through 85. In Breslau as early as 1693, too, life expectancy for the most part came down with age simply along one C path.

5. Even taking just the rural population at the later point.

6. Excepting 1964 West Cameroon and 1966 Algeria.

7. Though for some of these populations the C pattern began by age 5.

8. Estimating via log-linear interpolation from 36 percent loss by age 6 and 60 percent by age 16.

9. Data for Schenectady between the 1880s and 1930 take a parallel, somewhat higher C path, while evidence for the observed New York counties of 1850 to 1865 and certain Pennsylvania counterparts in the 1890s indicate a somewhat flatter decline earlier, with zero year in the early 1930s if the infrequently observed trends had C shape.

10. England and Wales, the United States, and New Zealand, finally, display C’ trends for chronological reduction in deaths by age 10 in the later 20th century, a pattern not developed elsewhere among these

seven examined populations by the 1980s.

11. For example, Keyfitz and Flieger 1990, 22-25, or Newell 1988, 67-78.

12. The abrupt slowing of decline in l_x in relatively modern populations tends to be over by about age 5. In the larger sampling of Table L.4, a comparable small number of exceptions are virtually finished by age 1 or persist to age 10.

13. Just one trend of this shape suffices for 1881 Italy, 1960 Tunisia, and 1966 Fiji; four such curves are appropriate for 1960 Mexico (Figure L.3g).

14. In 12 of 23 illustrations just one trend of this shape accounts approximately for change with age during most years of maturity; in the 11 other cases two E-shape segments are adequate.

15. And also for males, indicates the lighter accompanying but unfitted line.

16. Chile as of 1909 for some reasons displays two E’ patterns instead, while one such trend appears in middle age for 1964 Japan.

17. For some reason it increased in G’ fashion in 1920 Taiwan.

18. The exception was G’ gain in Japan after age 50. Did older Japanese women as of that date simply not drive?

19. Also, .03 x π = .09425.

20. Makeham’s model was: $M_x = ae^{bx}$ + c.

21. Integral formula for Tx from lx.

22. The missing phenomena is for 1920 Taiwan.

23. England and Wales as of 1861, 1881 Italy, 1909 Chile, and Taiwan in 1920 show lags of 15 years or more.

24. Ancient development in the case of Ulpian’s Rome of 225.

25. Their mean was rather higher, .37.

26. All trends from Gage are estimated from his graphs on pages 204 and 205 not the original data upon which he based these. The patterns offered are thus only rough approximations; but they should serve to illustrate parallels and discrepancies among humans and primates and perhaps inspire others to analyze

these and additional appropriate populations more precisely in comparable terms.

27. Here higher, however, or about 450 at hypothetical age -10).

28. For instance, in place of the logistic curves popularized early in the past century, as in Lotka's review of contemporary studies of expanding populations of fruit flies and bacteria, on the one hand, and the growth of individual sunflowers and rats, on the other (1925, 69-74).

Chapter M

How G-Related Patterns Keep Appearing in Demographic Change: Conceptual Explorations and Experiments

The way that the ingredients of the life table over and over again take G-related forms in turn serves to imprint such patterns upon the manner in which many dimensions of populations change through time. Notably, the curve of survivorship repeatedly shapes the properties of a population as it replaces itself. If l_x retains this C form across most of its span, the age structure will tend eventually to follow suit, smoothing out anomalies such as baby booms, baby busts, or mortality crises. The C-shape age structure in turn will shape the number and proportion of dependent, productive, fertile, and mortality-prone individuals in a population. Some of these dynamics have been effectively outlined in the development of stable population theory. Other results require further exploration.

Central to the evolution of population theory since Euler in the 18th century has been the tenet that fixed birth and death rates will eventually produce, on the one hand, constant age distributions and, on the other, log-linear change for the size of populations. However, the way that G-connected patterns--observed historically in fertility, mortality, and age structure alike--might channel any *approach* to such stability, perhaps over long periods of time, needs more attention. The conclusion of Ansley J. Coale four decades ago that "little attention has been given to the *process* of convergence from arbitrary initial circumstances to the stable form" seems still to apply (Coale 1972, 61). And extended simple exponential change in population size has in fact been shown in Volume I to be a rather rare historical phenomenon.

Such fresh analysis of the transitional effects of fixed vital rates is just the simplest case to be considered. Preceding chapters of this volume have demonstrated how both fertility and mortality in fact have *not* been constant, but instead have repeatedly altered through time via G-related trends--not log-linearly as modeled by Coale (ibid., Ch.'s 4 and 5). What happens when such change, either simultaneous for all or shifting across cohorts, is introduced into demographic regimes? Can historically observed G-based patterns for fertility, mortality, and population size be seen to result from arbitrary experimental shifts?

Finally, how are demographic shocks such as baby booms and mortality crises--or for that matter migrations in or out (as in Vol. II)--related to the longer-term G-connected trends of demographic change that are observed? Of interest is not only the form that such events take but their timing. Are populations that alter in G-related patterns particularly sensitive to shock or instability at certain stages or intervals, as through the waves or roots of fertility change explored by Coale? How are his and subsequent investigations of such disequilibrating phenomena affected by the fact that changes in both fertility and mortality have G-shaped forms imbedded in them?

SOME MATHEMATICAL CHARACTERISTICS OF G-RELATED MOVEMENTS

Along with the continual and pervasive, in origin biological, imprint of the C shape that is contained in survivorship upon many aspects of demographic change, certain properties of G-based curves as a class (including simply reoriented C, D, and E) should be noted: especially 1) the tendency over long periods for the bending or change in acceleration to resemble the curvature found in the cumulative normal pattern of transition; and 2) the nature of the roots and powers of G, which turn out to relate insightfully to the best fit of G to the normal distribution and to the roots of the renewal equation in stable population theory. These connections help steer many kinds of demographic movements into G-based paths, and hold them there, as populations digest lasting shifts or cope with temporary shocks.

Though if both curves are given the same zero year of inflection (t_0) and the same height or *y* range from 0 to 1, the arithmetically presented shapes can at first look quite different, across the heart of its total span G representing a proportion follows a trajectory very similar to that of a **cumulative normal** curve that has certain dimensions. The cumulative normal pattern is the integral of the normal ("bell") curve from minus infinity to year *x*, the way that G is the integral of rather differently rising then falling G'. True, the cumulative normal follows a path in which the segments of the 'S' pattern are symmetrical whereas for G the second or upper arm is considerably larger than the first or lower part of the 'S'. If, however, one allows the parameters of the cumulative normal to float in order to fit G with the best possible pattern of that type, for about 150 years the arithmetically expressed paths become very similar (Fig. 9.1, left panel; G is represented by hollow circles with an 'X' at t_0; the best cumulative normal follows the dashed line, pivoting at the solid square).

From roughly year -60 through year +100 the G curve is closely captured by a cumulative normal trajectory. The latter curve has a *z* of approximately 37 years; its range from bottom to top of just under 1.00 runs from about -.05 to .95 (rather than from 0 to 1); and the point of inflection lies in the vicinity of .475 some 8.4 years after t_0 for G (rather than at .500 for year 0). The residual error (G - CN) fluctuates around zero between about +.018 and -.016 with a frequency of approximately 90 years (the bottom plot in the figure magnifies it by 10).

In a function that constantly increases, however, *proportional* fitting of change weighs the error around low expected values equally with those at the high end of the trend rather than letting the latter dominate the whole comparison. In the right panel of Figure 9.1, the best G (a dashed line) is fitted logarithmically for -60.3 through 101.7 to a cumulative normal curve (-2.6 *z* to +4.4 *z*) in which *z* = 23.1 years (the hollow circles). There are obvious bulges of proportional error in this fitting: high around -40 and low in the vicinity of +20. However, in spite of these zones of visible difference G with a value of .479 at year -3.34 does tend to converge in waves toward the cumulative normal (.500 at 0) over a considerable span of time (bottom plot).

The cumulative normal curve is given a *z* value of 23.1 in the right panel of Figure 9.1 for a reason. The two curves most resemble each other through the middle years of transition. The early and late tails diverge from each other. The range from -2.0 *z* through +2.0 *z* covers 95 percent of the transition and 72 to 104 years of G for cumulative normal curves with *z* values of 18 through 26. Standardizing the curve segment being analyzed to always embrace this identical dominant proportion of total change without comparing the extreme tails of the two curves (where least change takes place), the best proportional or logarithmic fit in fact appears empirically when z equals about 23.1. Table 9.1 shows, for selected *z*'s from 18 through 26, how the overall norm for the G fit, the standard error for *x* (the year), and the standard error for *y* (the height of the curve, or value of G, at t_0) all attain a minimum when *z* is in the vicinity of 23 years, while x_0 moves closest to the cumulative normal's 0 year and y_0 best resembles the .500 height of the cumulative normal at that point. A slightly smaller norm (.219) for the fit and standard error of timing or *y* (.317) appear when *z* = 22.5 rather than 23.1, but at the cost of somewhat more error for the height of the curve (.00931) and poorer values for year and for G (+2.78 and .520). The best *z* span of 23.1 years is shorter than the 37.4 for the best arithmetic fit of the cumulative normal to G for the particular time range from -60 through +100 (the left panel of Fig. 9.1) because of the different method for assessing error that is employed in its proportional comparison.

As Figure 9.2 indicates, it is especially between about year -41.6 and year +27.7 (-1.8 *z* and +1.2 *z*, the curve with the stronger line in the graph) that G most closely follows the cumulative normal (for 3 *z* spans rather than the 4 enclosed by -46.2 through +46.2). In all, a change that takes G shape tends to converge with the cumulative normal about year -50.8 (briefly overshooting somewhat around -46.2, but adjusting back). During previous years, the ratio of G to the cumulative normal increases in what seems to be G' manner, targeting 1.629 at -24.5 years--or approximately $e^{1/2}$ (1.6487) at -*z* (-23.1049). Then from about -50.8 through +27.7, for almost 8 decades, the ratio holds very close to 1.0. Finally, after about year +27.7 G pulls away, its ratio to the cumulative normal gradually rising from here onward in G shape (pivoting on .512 at year -11.18, or roughly -*z*/2, headed toward a maximum of 1.3918 (roughly $e^{1/3}$, or 1.3956) as the latter effectively flattens out. In Figure 9.2 one sees not only where G most tightly follows the path of the cumulative normal but how it initially joins that pattern and with time eventually then pulls away from it.

In all, a budding tendency to change in G form soon converges on a cumulative normal ceiling, is thereafter along its G path closely compatible with normal transition for almost 80 years, but then has to push upwards independently in order to sustain its particular, higher trajectory as the cumulative normal decelerates faster. When $z = 23.1$, making the best fit between the two curves, first the convergence with the cumulative normal and then the departure from it occur in G-based patterns whose parameters, are roots of *e* and multiples of *z*. These close mathematical relationships to a normal pattern of transition would seem to affect how random disturbances to a population, certain to occur in historical phenomena, are channeled to support rather than disrupt change in G-connected fashion for long periods of time. For an extended and centrally significant portion of the total change, when $z = 23.1$ years any relationship between randomness and the aggregate path that is imbedded in the cumulative normal distribution works to support the trajectory of G . In contrast, systematic exogenous stimuli of G' then G shape are required to start a G-shaped change or, eventually, to sustain it above the normal past a certain point.

Empirical findings that G resembles the cumulative normal for about 46 years before and 46 years after t_0 (or from -2*z* to +2*z*), and most closely models that curve when *z* equals about 23 years connect insightfully with certain **mathematical properties of G** itself. Most simply, $e^{.03}$ (the rate of change in the pace of increase for G) has a doubling time of 23.1049 years (*ln* 2--or .69315--divided by .03). G^2, furthermore, equals *e* times the value of G with t_0 coming 23.1 years later, while $G^{1/2}$, or the square root of G, equals G x $(1/e)^{1/2}$ with t_0 23.1 years sooner. Figure 9.3 first of all plots these patterns for the square and the square root of G relative to the basic trend. It also displays the timing of the zero years of other powers and their values at t_0 relative to these particulars for G.

The bottom plot in Figure 9.3 shows how other powers and roots of G from $G^{1/6}$ through G^6 tend to trend in E (G^I or G inverse) form via multiples of 23.1 and powers of *e*. The hollow squares represent year relative to t_0 and height at that point of inflection relative to 1 (graphed as 1/1,000) for five powers and five roots of G as determined by multiplying G the requisite number of times by itself and fitting the G model to the results. The timing (*x*) and height (*y*) at the zero points for each of these curves, plus G itself (1.0 at year 0), appear in the first two columns of Table 9.2. The third column displays the E curve that this series approximates (the dashed line in Fig. 9.3), with a *y* value of 1.0016 at year -.05--or almost exactly the expected 1 at year 0. The 4th and 5th columns contain estimates of the years and values at t_0 for the various roots and powers of G as modeled by the power equation for *y* and the third spacing formula for *x* in part B of Table 9.3. Columns 6 and 7 express the fitted values of columns 1 and 2 as a multiple of the modeled estimates in columns 4 and 5 (i.e., indicate the proportional error of the dimensions of Model 3 at each point).

First, it should be noted that 23.1407 is the result of e^{π} (the natural logarithm, 2.71828, to the power of 3.14159), a rather basic and provocative value. This very closely resembles the 23.1049 years for the doubling time of $e^{.03}$ or the -23.1053 and +23.0955 year shifts of t_0 for the empirically fitted square and square root of G, and suggests that both *e* and π are fundamental in trying to construct formulas for the roots and powers of G.

The values at t_0 for empirically fitted powers (p) of G from 1 through 6 all equal almost exactly the value at this base point for G itself (G^1) times the (p-1)th power of e. For example, for G^3, the height of the curve at t_0 becomes 1 x $e^{(3-1)}$ or 7.3891 (1 x e^2), compared with 7.3908 for the empirically determined value (col. 5 vs. col. 2, Tab. 9.2). For roots (r) of G, quite effective approximation of the levels at t_0 is attained through the formula $G_r = (r\text{-}1)^{-.25}/e^{-.5}$, or the 4th root of r-1 divided by the square root of the natural logarithm, $e^{-.5}$ or $\sqrt{e}$ (Tab. 9.3, part A). For the cube root of G, G at $t_0 = (3\text{-}1)^{-.25}/1.6487$, or .5100 vs. the empirically fitted .5134. This modeling is very accurate from G through the cube root of G (Tab. 9.2, col. 7), but then errs progressively more through the 6th root (2.5, 4.8, and 7.2 percent). Nonetheless, from $G^{1/6}$ through G^6 the estimation in column 5 of Table 9.2, based upon powers of e, closely resembles the fitted values at successive t_0's and the E path that they follow (cols. 2 and 3). The model results are graphed as the X's along the bottom plot of Fig. 9.3.

More than a single method closely reconstructs how the *zero years* for the roots and powers of G are distributed. These estimations are shown in Table 9.3. One approach (Model 1) sums the steps from one power or root of G to the next, spacings that are based upon roots of π. The other (Model 2) multiplicatively compounds each successive timing via powers of the square root of $4/\pi$. This happens to be the ratio (1.27324) of the side of a square to the diameter of a circle that contains the same area. Model 3 modifies this approach slightly to obtain a better fit with the empirical evidence.

In all models, the **height** of G at year zero, y, is:

for powers (p), $y = G \times e^{p - 1}$;

for roots (r), $y = G \times (r - 1)^{1/4} / \sqrt{e}$ [the 4th root of r - 1 ÷ the square root of e].

Three methods approximate the **spacing** of zero years, x, for both roots (negative) and powers (positive) relative to t_0 for G:

In **Model 1**, the series $e^{\pi}/\sqrt{((p - 1)\pi)}$ for the spacing of t_0's accumulates additively for the intervals between powers 1 through n, so that for G^6, for example, t_0 is the sum of the lag between G (0) and G^2 (e^{π}) plus the intervals between all other pairs up to G^6.

In **Model 2**, to obtain t_0 for higher powers of G, e^{π} for G^2 is accumulatively *multiplied* by successive powers of the square root of $4/\pi$, beginning with the 4th, in which the square root of the last *power* applied to $\sqrt{(4/\pi)}$ becomes the next power in the series, for example from $(\sqrt{(4/\pi)})^4$ to $(\sqrt{(4/\pi)})^2$ [more simply, from $(4/\pi)^2$ to $4/\pi$] as the next term.

In **Model 3**, the same multiplicative series as for **Model 2** is employed, except that $e^{\pi}/1.03$ replaces e^{π} as the base.

Table 9.4 compares the zero years for roots and powers of G which are obtained from empirically fitting the curves that result from these mathematical operations with the estimates that the three models of timing generate, including ratios of the fitted values to the modeled ones. The average ratio, or timing relative to the empirical fits, for Model 1 is quite small, 0.80 percent too low. The average ratio for Model 2, on the other hand, is a substantial 2.62 percent too high. A reduction of Model 2 by .03 (the $e^{.03}$ or $e^{-.03}$ rate of acceleration or deceleration imbedded in the G, C, D, and E functions) to construct Model 3, however, best approximates in average ratio the empirical findings--only 0.04 percent high. Also, when fitted via E, the t_0 for this model comes nearest to the empirical finding of -.05. (that is, +.34 vs. -.72 for Model 1 and +2.24 for Model 2).

The .03 correction, however, reduces the t_0 for G^2 (and for $G^{1/2}$) to 22.4667, a rather shorter interval relative to G than the 23.1407 of e^{π} or the 23.1049 doubling time for $e^{.03}$. (The latter comes closest to the actual fitted values of 23.1053 and 23.0955.) This variation, though balanced by high values for $G^{1/5}$ and G^5 to average out closest to the fitted results, makes the mean squared error for Model 3 as a predictor of the empirical findings amount to .0171 compared with .0106 for Model 1 (but .0316 for Model 2). The underlying path for Model 3 resembles that for the empirical evidence more closely; but there is more offsetting fluctuation around it. The reduced base at 22.4667, nonetheless, is reminiscent of how the best proportional fit of G with the cumulative normal curve, judging by the norm for the overall fit (Tab. 9.1) is derived when z for the latter is somewhere in the vicinity of 22.5, slightly below 23.

The top plot in Figure 9.3, finally, shows how according to Model 1 (hollow circles) and Model 3 (plus signs) given the spacing in time that is indicated in each case the ratios of the zero years for successive roots and powers to the base t_0 for $G^{1/2}$ or G^2 increase in C or G fashion (with zero year at -34.71 or +34.68). There (denoted by the solid squares), these curves for relative timing have a value of about 1.50 times that at $G^{1/2}$ or $G^{2.}$ The timing of this inflection point in years, meanwhile, represents almost exactly 1.5 times the 23.1407 first interval between G and G^2 according to Model 1 or 1.03 × 1.5 times the alternative 22.4667 first gap for Model 3. It is also virtually equivalent to $e^{\pi\sqrt{(4/\pi)}}$ (34.6365). At the zero year, moreover, projections of these C and G curves call for a level of .24104 or almost precisely the natural logarithm of $4/\pi$ (.24156). The $4/\pi$ element is decidedly imbedded in the mathematics of G-based patterns.

In all, zero years for roots and powers of G as multiples of G are spaced according to combinations of e and π that work from a base of about 23 years or slightly less. This fundamental first interval, meanwhile, simultaneously represents the z score or standard deviation of the cumulative normal curve that best fits G-type change. On the one hand, the very basic and unusual mathematical relationships with normal accumulation and their connection to the roots and powers of G would seem to help change take G-related shape and hold it. On the other, does the approximate 23-year span upon which the spacing of roots is based make shocks or impulses upon G-type trends more consequential at this kind of interval than elsewhere in the course of their unfolding?

The mathematics of the G pattern seem related to several previous findings about stability and disruption in demographic change. In his pathbreaking exploration of stabilization and fluctuation in demographic properties (1972), for example, Coale observed that, internationally, the proportion of females cohabiting maximized between about age 23 in societies with early marriage and high rates of widowhood and 37 years where marriage came late and little widowhood and divorce took place (p. 6). While e^{π} = 23.14, about the lowest mode found, $e^{\pi} \times 4/\pi = 29.46$, or about the mean female generation or age of fertility for humans, while $4/\pi$ times 29.46 equals 37.51, or an apparent upper limit for the mode of female cohabitation. As observed, 23.1 years is the interval of time separating the inflection or zero points of both the square and the square root of G from that for G. The value $4/\pi$ (more exactly its square root), meanwhile, has been shown to be a fundamental element in the spacing of t_0's for the roots and powers of G (Tab. 9.3).

The ability to bear children normally runs from about 15 through 45 and the international average for mean fertility tends to focus a little under 30, its range extending from slightly less than 26 to a somewhat over 33 (Coale 1972, 5).[1] The practical limits for the range of mean female fertility among human populations, in other words, are approximately $23.1 \times 1.1284 = 26.06$ and $37.51/ 1.1284 = 33.24$, or those for the mode of cohabitation multiplied or divided by the square root of $4/\pi$ (1.1284). The full range of 7.18 years, meanwhile, is almost exactly half of the 14.37 year spread for the maximum proportion of women 'at risk' in cohabitation. It should be noted, generally, that to divide each end of a range by the square root of $4/\pi$ is to cut the full spread in half while $2 \div (4/\pi)^{1/2}$ reduces to $\sqrt{\pi}$ or 1.7725.

In analyzing how populations with arbitrary characteristics approach the stable condition when fertility and mortality remain constant over time, to determine the path of births one can either use conventional population projection or decompose the birth sequence beginning at $t = 0$ into the eventual exponential trajectory of the stable form plus a series of oscillatory terms: r_0 plus complex roots of the form $r = x + iy$, where x is the real part (which must always be less than r_0) and iy is the imaginary part (Coale 61-62, 64-65). Coale noted how for the lowest frequency oscillation, the first complex root, the period is the mean (μ) of the net fertility function or $\phi(a)$, typically about 30 years. The effect of the cosine component upon $\phi(a)$ is negative below $3/4\mu$ and above $5/4\mu$, making the bulk of fertility occur between 22.5 and 37.5

years for women in a universe of populations with mean age of fertility at 30 (Coale, 72; assuming symmetrical distribution, which is usually not the case).[2] The particulars of this critical span compare closely with the 23.1 to 37.5 limits around a mean of approximately 30 found for maximum cohabitation among international populations (Coale, 6). Fertility, like the proportion of the female population 'at risk' to bear children, has a mean of about 30 years and concentrates within a range of $\pm 4/\pi$ x around that mean, with a lower bound of some 23 years and a higher bound of about 37.5.

The maximum fertility rate for cohabiting females, furthermore, occurs between ages 20 and 25 (ibid.). This is the case whether no contraception takes place or the practice is widespread, though these extremes produce very different means and skews for the fertility schedule. In spite of such differences in the shape of distribution, generally 75 percent of total fertility in practice occurs within a span of about 16 years (ibid.), or only half the rough biological range of 15 to 45 (not necessarily at the center of this span because of the skew in most fertility schedules). In other words, maximum individual fertility (statistically speaking), occurs at the beginning age for the 23-to-37.5 range for a symmetrical concentration of aggregate fertility in a population between 3/4 and 5/4 times the mean age.

The relationships of age structures also display values observed in these basics of human fertility but also in the nature of G-shaped change. When the age structures of two stable populations are compared, if they share the same mortality but one has higher fertility, from the beginning of life into the 80s the proportions at each successive age for the one with higher fertility start out greater than those for the compared population and decline comparatively in linear fashion, becoming lower (< 1.0) around age 30, the average female generation or the mean age of fertility (Coale 1972, 38).

If the second population has the same fertility but lower mortality than the first one, then the ratio at successive ages declines in linear fashion only between about age 5 and age 55 or 60 (ibid.). This persistently linear reduction in spite of an alteration in the mortality schedule, again passing through a ratio of 1.0 about age 30, reflects how from later childhood to around 55 or 60 survivorship very generally erodes in C form in population after population (Ch. 8). Both life tables will behave in that C manner for this particular segment of the life cycle, and thus will relate to each other linearly. Lower mortality especially entails less loss of babies and young children. That has the counter-intuitive effect of relatively enlarging later portions of the population (Coale 39-40). Reducing early mortality, in the Swedish example provided by Coale, makes the proportion just after birth in fact about 1.12 or approximately $(4/\pi)^{1/2}$ lower than in the base population (roughly 1.11/.99). After about age 60, meanwhile, lower mortality progressively increases the proportions of older individuals in the altered population. By age 85 the ratio reaches about .92/.82 or roughly $(4/\pi)^{1/2}$ as much.

The proportions of particular populations found at successive ages themselves erode in accelerating C fashion from about age 10 or less into the 40s or later (compare Coale 1972, 42, if the graph is re-scaled logarithmically--with the findings of Ch. 8). In Coale's examples, the distributions for two stable populations increasing at the same rate (r = .010), one with lower mortality and another with higher fertility cross each other about age 28. There, the example with higher fertility falls below its competitor. Both distributions, however, drop considerably earlier--around age 23--through the stable age structure for a population that does not grow (r = 0) but has fertility comparable to the one and mortality comparable to the other (ibid.).

Age-specific mortality rates, on the other hand, tend to have much the same "U" shape whether life expectancy is high or low (Coale 1972, 10). The difference between two age-specific mortality schedules, however--"West" model for females with life expectancy of 20 at birth minus the same type of life table with 50-year expectancy in Coale's example (1972, 154)--rises in decelerating manner from age 12.5 through 47.5 via G', or through the most active span of life, to about .019 around age 48 (or, perhaps, via G based near age 23 at a level of .012 for the same ages). A second, surge through later life, however, from 32.5 through 72.5 takes accelerating E shape upward from about .020 around 44.

Indeed, the effect of declining mortality (in Coale's example, equivalent to a 0.01 percent annual rise in fertility) is to lower the proportions of population to be found at young ages relative to the stable population and raise the fractions of older people. The comparison passes through equality about age 30 after a few years of development (15, for example) but more like age 35 once a generation or more has lapsed (1972, 162). Early on, after just 15 years, from age 22.5 though 62.5 the difference rises via G based upon a back-projected ratio of about .44 in the vicinity of -18 years. But by the time 45 years have elapsed, from age 12.5 to 62.5 or a little later the age distribution with declining mortality increases relative to the stable one in accelerating E fashion targeting a ratio of about 2.3 about age 87 according to the formulas of Coale and 2.4 near age 99 by conventional projection methods. In between, after 30 years, a short G trend is followed by a short trend in E form as the eventual effect of the transition begins to show itself.

Evident here, significantly, is a way that not only the ubiquitous G but the E shape can enter population change. Modern 'demographic transition' in the 18th, 19th, and 20th centuries, for instance, has typically begun with reduction in mortality, and many populations at this stage (Harris 2001)--and their births (Tabs. 2.3a, 2.3b)--have expanded in E fashion.

??In calculating the first complex root of a net fertility function--$\phi(a)$--for the Swedish population of 1946-50, Coale began by normalizing by 1/1.1372 to make $\int_0^\beta \phi(a)da = 1$. That is, in this population the sum of fertility through the highest age of fertility was 1.1372 times the norm.(77-78)??? Peculiar to this population or more general?

Assuming symmetry and zero alteration via the real root (x) of the underlying exponential path, the lowest frequency oscillation (y_1) in the way that fertility converges on a stable trajectory must satisfy both a cosine integral equation equal to 1 and a sine integral equation equal to 0. It has a period of μ_1. At this frequency sin y_1a is negative at ages below μ_1 and positive above it. The sine minimizes at about age 23 and maximizes about age 38. Cos y_1a, meanwhile, attains 1 at μ_1--empirically on average just under 30, as opposed to about 32 years in Cole's illustration--and is negative only below $3\mu_1/4$ and above $5\mu_1/4$, or about 23.1 and 37.5

years if (assuming symmetry) the cosine equation reaches maximum at μ_1 (Coale 1972, 71-72). Once again 23.1 years and multiples of it by $4/\pi$ structure demographic change.

The less the concentration of fertility around the mean age,, however, the greater the decrement of the lowest frequency oscillatory term. That is, the greater the damping (difference of amplitude between r_0 and the real component or x of the first complex root) becomes. Outside the range from $3\mu/4$ through $5\mu/4$ the effect of the cosine element upon net fertility is *negative* (ibid., 73). The more dispersal in an actual net fertility schedule, in other words, the weaker the wave effect of the first complex root becomes.

In 47 mostly European populations studied by Coale, F--the proportion of net fertility or $\phi(a)$ occurring between $3\mu/4$ and $5\mu/4$--varied from .599 to .791 (1/1.2642 to 1/1.6695). That is, approximately $1/(4/\pi)^2$ to $1/(4/\pi)$ (1.2732 to 1.6211). Assuming symmetry, the implied mean and median for F would be about .695 (1/1.4472). [or 1.0233 times the square root of 2?] Assuming symmetry, concentrations of fertility between $3\mu/4$ and $5\mu/4$ in the first complex root of stabilization, in other words, are structured internationally relative to an observed group mean by $4/\pi$ or its square root, like modes for cohabitation, the mean age of fertility schedules, and net fertility schedules or $\phi(a)$'s (Coale 1972, 74; 6; 19; 72, 74).

Fertility schedules, however, rather than being symmetrical, are at least somewhat skewed. V, the ratio of the median age of the net fertility function to its mean, ranges from .956 to .995 in the 47 populations studied by Coale (74). From one approximate empirical extreme to the other, that is, the ratio changes by a multiple of 1.0408. This is almost exactly the cube root of $(4/\pi)^{1/2}$ (1.0411) or $(4/\pi)^{1/6}$. The formula for skewness is SK = $\sum x^3/N\sigma^3$ (Harshbarger 1971, 100). The range of imbalance for median relative to mean for at least 47 populations is likewise framed by a third power, in this case the cube *root* of the now familiar value $(4/\pi)^{1/2}$.

The next, or fourth, root of $(4/\pi)^{1/2}$ also plays a central part in demographic change. Its value is 1.0307 or $e^{.0302}$ or almost exactly the rate of change in the rate of change for the G, D, C, and E functions. While Coale's models (1972) assume log-linear developments in fertility, mortality, and growth, previous chapters have instead demonstrated trends that *decelerate* or *accelerate* proportionally. As this tendency is added to Coale's framework of analysis, as it must be (by someone with much more mathematics than this author), one can expect that further shaping based upon the roots of $4/\pi$ will appear.

According to the Swedish example of 1946-50, the initial phase of the first damped oscillatory component of the birth sequence that results from a population element at age *a*, $\theta_1(a)$, from ages 10 through 45 rises in G' shape toward a crest of about 6.3 in the vicinity of 45 (Coale 1972, 93). Perhaps relevantly, 6.2842 = 2π, while 46.28 = $2e^{\pi}$. The equivalent phase for the 6th oscillatory component increases to age 23, then levels out around 21, never breaching 7π (21.991). In each case the limit is about $\pi(i + 1)$ for $\theta_i(a)$. How general are these characteristics for other case of convergence upon a stable population?

Once again for the Swedish example of 1946-50, $M_2(a)$, one of the key elements in calculating the 2nd complex root of the fertility integral, is negative around age 23 and again around age 43, reaching maximum about age 33 (above the international average for Coale's sample of populations). $N_2(a)$, another basic component, hugs 0 until just under age 20, bottoms out at about 29, peaks around 38, and returns to 0 at approximately 46 (Coale 1972, 65-66, 95). A composite of the two waves together would pass through zero around 22 and then around 46.

In contrasting fast and slow convergence of fertility upon stability with examples, respectively, from Sweden 1891-1900 and Yugoslavia 1960, Coale (1972, 98-99; by projection) found initial drops that bottomed out around 13 and 10 years. The ensuing upswings peak about 32 and 26. In other words, on average the opening decline maximizes around 11.5 years or approximately $e^{\pi}/2$ while the first upward fluctuation on average crests around 29, the global average female generation or approximately $e^{\pi} \times 4/\pi$ (or 29.46). The adjustments toward stabilization, in other words, start close together from a common human demographic structure. The differences expand with time. As evidenced by the highs and lows of the first two waves, however, years for the slower Swedish convergence at each turning point run roughly $4/\pi$ times those for the faster-converging Yugoslav example: approximately 13:10 L; 32:25 H; 47:36 L; 63:52 H, for an average ratio from these four comparisons of about 1.274 vs. the 1.273 for $4/\pi$. If these two examples were the extreme cases encountered by Coale, the range for rate of convergence to stable conditions for human populations seems to entail a spread of about the familiar $4/\pi$.

Coale compared projected births for four populations, all given the net Swedish fertility function of 1946-50 (1972, 100). (1) When with the stable age distribution for 1946-50 fertility is made to decline 2 percent annually, there is very little departure from the log-linear path plotted by the real root for births. The projection just rises above this trajectory slightly between about years 8 and 23,with a maximum variation from the log-linear base in the vicinity of 16, and falls below even less markedly between about 23 and 36, with a relative low about 30. Further crossings occur about 38 and 58. (2) If the base population under the age of 2 in the stable age distribution is reduced by 50 percent, appreciably more fluctuation about the log-linear appears. The first wave rises to a relative high in about 12 years before falling to a low around 23; the second peaks about 40 before dipping to something like 57. The fluctuations cross the underlying trajectory in the vicinity of years 4, 19, 33, 50, and 60. (3) Projecting the actual Swedish population conditions of 1946-50 without modification, in contrast the fluctuations reverse those of example 2. Lows occur around 11 and 42, highs about 28 and 58. The waves traverse the baseline around years 5, 20, 36, 50, and something like 63. (4) The strongest wave movement appears, however, when the stable population has its cohorts under 5 reduced as in Germany during World War I, "one of the largest short-term reductions of fertility on record." These fluctuations resemble those where the population under 2 is cut in half, but are stronger. The highs arrive about 11 and 40, the lows appear in the vicinity of 21 and 53. The crossing points for the fluctuations come around 3, 17, 30, 47, and 58.

These are just rough visual approximations from movement's in Coale's Figure 3.9. But, as Table 9.4 indicates, they allow some general comparison of the effects of three different kinds of manipulation of fertility upon an actual population: Two ways of reducing the very young in the initial age structure (Coale 102-03), examples 2 and 4, generate much the same waves around the trajectory of the real exponential root though the amplitude is somewhat greater and the period a little shorter using the age reduction under 5 based upon German experience in World War I (example 4) rather than just cutting the population under 2 by half (example 2). Both these experimental alterations, however, roughly turn the waves of the original Swedish population (example 3) upside down. This happens because in the initial age structure as of 1946-50 the 'baby bust' of the Great Depression imprinted a sharp drop for proportions of females who were roughly age 10 through 25, in contrast to the reductions under age 5 in examples 2 and 4. Upside down, however, the spacing of how a shock to the age structure makes waves remains much the same. If fertility is reduced 2 percent per year (example 1) rather than containing a 'cut' that passes through the system, the age structure smoothly and consistently becomes younger than the stable distribution for 1946-50, the amplitude of the fluctuations are made very small, and the early high and low points and crossings over the underlying trend are stretched out most of all. The waves, nonetheless, are lengthened versions of those found in examples 2 and 4, other ways to reduce fertility, and are again inverse to the projection of the original Depression-generated population conditions. A cut in the age distribution focused around 15 rather than 2 flips over the wave pattern for birth projections but largely retains the period. Gradual, persistent reduction tends to suppress the amplitude of fluctuations while shock early in the life cycle does not.

Coale illustrated how population elements at different ages combine to produce aggregate fluctuations that diverge from the wave patterns of each component (1972, 107). From the fertility schedule of Swedish females 1890-1900, with a life expectancy of 70 at birth, he chose those at 0 and 16.7 years (about half a generation). The waves for those 16.7 years old at the start crested after about 15 years, dipped to about 31, and then peaked again after about 48 years of projection. The offspring of those only just born at the start maximized after approximately 30 years, and bottomed out after about 47, roughly opposite to births from the 16.7-year element. In a population where the 16.7-year element was 1.4363 times the size of the newly born, combined projected annual births would crest after about 23 years, fall to a low after about 30, peak again near 39 years, then minimize after about 46. The period amounts to 16 years or about half a generation. The first and strongest peak comes at about 23 years, but at twice that time a low rather than a high occurs as the period of the wave is 16 years rather than 23.

The age distribution of a population with the current fertility and mortality of 1946-50 Swedish females but with a history of fertility declining constantly at 2 percent (Coale 1972, 112) from age 0 through 40 follows the findings of Chapter 8 in that it takes C shape (with zero year at about 12). Its net fertility schedule, $\phi(a)$ maximizes (has its mode) at about age 26 for at least the first 25 years of projection (Coale 1972, 113). Its low frequency oscillation crests about 14 and 45 years around a bottom of approximately 29, crossing the underlying exponential birth sequence in the vicinity of 7, 15, 22, and 38 (ibid., 114).

When fertility declines at a constant rate, the ratio of births to those in a comparable population with constant fertility shows signs of stabilizing through fluctuations of successively lesser amplitude over 120 years but in periods repeatedly close to 33 years, all around a level of approximately 1.03 (Coale 1972, 139). Coale's estimate for the ultimate greater flow of births that would result from a history of declining fertility is $e^{-kT/10.5}$ (140). Eventually, he calculated with $e^{kT/10.67}$ for years greater than $3T/4$, where T is the female generation or beginning just under 24 years. This results in a ratio of about .9715 or 1/1.0293, the underlying level of the ratio after a century or so of fluctuations (139), whereas to employ the originally estimated 10.5 rather than 10.67 would produce a level of more like 1.0312.

After 50 years of development, the ratio of the age distribution of a population with steady 1 percent decline in fertility at ages under 45 exceeds that of a comparable population with constant fertility. Above 45 the ratios fall increasingly short of 1.0 (Coale 1972, 146). The curve for this ratio from age 15 through 80 takes C shape with a target around .47 near age 86. If the divergence were to continue “forever,” the C trend is virtually identical, while under 50 years the shorter the period of change, the flatter the comparison, especially at older ages (147). Conversely, when fertility *stops* declining, the longer that it as ceased, the flatter the ratio becomes for the formerly altering age structure relative to the stable one (148).

Coale also addressed the possibility of demographic changes when fertility fluctuated rather than altering at a constant rate. He argued, however, that empirically such waves have been observed only for very short seasonal movements, too brief to shape significant developments in births and age structure.

He analyzed 45 net fertility schedules for the amplitude and phase of birth cycles produced by fertility cycles with a wide range of frequencies (1972, 171-73). For U.S. females as of 1960 (with NRR set to 1.0), as the duration of the fertility cycle approaches about 16, amplification (amplitude of birth cycle/amplitude of fertility cycle) falls somewhat below 1.0 (about .86 = 1/ 1.1628, approximately $1/((4/\pi)^{1/2} \times e^{.03})$ or 1/1.1627 . Between there and a fertility cycle of some 25 years (or the median of the net fertility function,[3] the amplitude ratio surges to 1.56. This value closely resembles $(4/\pi)^2 \div e^{.03}$ or 1.5732. The ratio then dives to a two-century minimum at a frequency of roughly 60 years (“twice the mean age of the net fertility function, or about one cycle every two generations,” p.173, though the generation was actually 26.37 years in 1960, Keyfitz and Flieger 1985, 81). This minimum level is about .55, or the maximum of 1.56 minus 1.0. Simultaneously, it for some reason almost exactly resembles $1/(4/\pi)^{2.5}$ or $1/((4/\pi)^{1/2})^5$ = .5467. Thereafter, frequencies in fertility through the next 140 years produce amplification that increases arithmetically roughly .006 a year, for a multiple of 2.2727. For the long term, this generates a net proportional result of $e^{.01623}$, about e to $.03000/(4/\pi)^{2.5}$ or $e^{.01640}$, in other words $e^{.03 \times \min}$.

For about the same span, the phase of birth cycles lags behind fertility cycles about .257 years more every additional year of duration for the fertility cycle. When fertility cycles last between about 23 and 53 years birth cycles lead rate than follow them, pulling farthest ahead for fertility frequencies in the vicinity of 32 years. When the duration of fluctuation in fertility is less than 23, the birth cycles are generally coterminous with them (Coale 1972, 172-73). Something of an early crest appears of lags when the duration of the fertility cycle is about 20 years compared with the much stronger peak for amplification about 25.

The components c_f and s_f are cosine and sine elements that help determine the frequency response of a net fertility function (Coale 1972, 170). For U.S. females 1960 with NRR set to 1.0, their joint positive effect, $(c_f^2 + s_f^2)^{1/2}$, begins about 1.0 at one very long cycle every 500 years , then progressively falls to 0 as cycles shorten to about 6 years (ibid., 176). Viewed from the perspective of *length* of fertility cycle (not frequency per century as graphed by Coale), as the fluctuation lengthens from about 12.5 to 50 years $(c_f^2 + s_f^2)^{1/2}$ rises in G' fashion toward about .80 in the vicinity of a 60-year frequency. Two generations are considerably less than 60 years for this population (more like 53); but 23.1 × e = 62.9 years ($e^{\pi} \times e$, or $e^{\pi+1}$).

Fluctuations of both c_f and s_f contract significantly with length of cycle. Crests of s_f attain about .95 when the cycle is around 111 years, approximately .25 for a cycle in the vicinity of 19 years, and roughly .10 for cycles close to 9.5 years. The interval between these peaks, meanwhile, narrows from some 90 years to more like 9. The troughs arrive for frequencies around 36, 13, and 8 years, reaching about -.42, -.16, and 0 at these points. For c_f, meanwhile, the highs come about 1.0 at an ultra-long frequency of over 500 years, approximately .33 around 25 years, then roughly .10 near 9.5 years. The lows appear around frequencies of 57 (-.78), 15 (-.20), and 8.5 (-.02) years. Collectively, the troughs for s_f and c_f together tend to flatten (lose amplitude) for cycles at least between 57 and 13 years in C fashion based about .50 around 42 years. For peaks, between frequencies of at least 111 and 19 years the path seems to be C with .37 at a t_0 of approximately 30.[4] For frequencies within these ranges, meanwhile, the zero years of the trends and the levels at t_0 seem to maintain a ratio of highs to lows for s_f and c_f combined of about 1.375 (actually 1.4 for frequency, 1.35 for level). Given the rough approximations from Coale's graph from which these patterns are estimated, that ratio could easily be $\sqrt{2}/1.03$

(1.4142/1.03 = 1.373). These fluctuations of s_f and c_f, however, through their different timing offset each other so as to produce an interacting cumulative trend, $(c_f^2 + s_f^2)^{1/2}$, that from frequencies of about 50 through 12 years declines very smoothly via C with .80 at a base cycle of approximately 60 years.

The phase difference between the current periodic fluctuation of births, h_1, and the weighted average for the fluctuation of births one generation before, z_1, with fertility concentrated at the mean age of the stable population increases in multiples of π along with the frequency of cycles per century (Coale 1972, 175, 177-78). It therefore *decreases* with the length of these fluctuations in *years* as shown in Table 9.5 (cols. 1, 2, and 3). This makes the difference in phasing rise from frequencies of 26.3 through 7.5 again in an E' path based upon a level of about 3.6 in the vicinity of a frequency of some 56 years (Fig, 9.4). For the female population of the United States as of 1960, the E' curve again appears for cycles of roughly 24.3 through 5.6, but based with a level of more like 4.0 at a frequency of some 52 years. This similarity exists in spite of the manner in which, expressed as cycles per century rather than in years, the two trends diverge as graphed by Coale (177).

Table 9.5 indicates how close, for the actual 1960 U.S. population, the timing at which successive multiples of π arrive is to the successive *intervals*, in years, between zero points for the fitted powers or roots of G (spans between entries in Tab. 9.2, col. 1). On average, the 5 new estimates are 1.1026 higher (col. 4). A multiple of $(4/\pi)^{1/2}$ (1.12838) would run about 1.0233 times more than that. This extra difference amounts to approximately $e^{.03/(4/\pi)}$ or $e^{.0236}$ = 1.0238. Meanwhile, the ratio of frequencies for a population with its fertility concentrated at the mean age to those of the actual United States females of 1960 (Tab. 9.5, col. 1/col 2.) generally increases from one value of π to the next in E fashion (across the middle of Fig. 9.4) toward a target level of about 2.5 in the vicinity of projected year -23--or into cycles of infinitely small frequencies in years and large repetitions per century.

The *frequencies* for Coale's illustrative 1960 U.S. population at successive multiples of π, furthermore, decline closely parallel with the *intervals* between successive zero years for the fitted powers and roots of the G function (cols. 2 and 3 in Tab. 9.5; the spans for col. 3 come from the spacing of entries in col. 1 of Tab. 9.2 plotted as the E trend in Fig. 9.3). The bottom plots of Fig. 9.4 compare the mid-points between powers or roots from 1 through 6, whose x values are in fact multiples of e in powers/roots of G (Tab. 9.3), with frequencies at successive multiples of π for Coale's phase differences. For graphing, both e and π are given a width of 10 arbitrary units. On this scale, the approximate frequency in years for each multiple of π in the phase lag of h_1 and $z_1$declines from π through 7π in D shape based on a frequency (vertical) of about 10 years at a zero point (horizontal) around 4.4π (or 13.82). The intervals between the t_0's for the powers of G, in multiples of e, meanwhile, contract also via D but with a y of more like 8.4 in the vicinity of 4e or 10.87. The estimated horizontal unit value, 13.82, for the zero point in the phase lag is 1.271 times that for the power/root interval for G or 10.87. That ratio almost exactly represents the 1.273 of $4/\pi$. The ratio of 10 to 8.4, the approximate y values in years for the two series, meanwhile, comes to 1.1905. This result very closely resembles π/e, the ratio of the base units for the two sequences compared (1.1557), times 1.0304 or $e^{.03}$, the underlying accelerator (positive or negative) of the G function and its family of curves--in all, 1.1909.

?? In short, the imaginary components (iy's) of the successive roots or powers of G are simply and systematically related to the phase differences between h_1 and z_1 in at least one illustrative population. This indicates........

Given the fertility of U.S. females in 1960, amplification of fertility cycles in birth cycles rose from a low of about .58 for cycles in the vicinity of 70 years to 1.0 around 3.1 (approximately π) cycles per century or a frequency of some 32 years (Coale 1972, 180). It continued increasing, however, to maximize at a frequency of about 26 years (the female generation at that time) at a level of 1.56 or $(4/\pi)^2/e^{.03}$. The ratio of where the maximum was reached to where the trend transcended 1.0 amounted roughly to 32/26 or 1.2308, which approximates $4/\pi \div e^{.03}$ or 1.2357. The phase differences, meanwhile, declined from 90° through 0° linearly, mostly like those for phase differences with fertility concentrated at the mean--to turn increasingly negative until reaching a minimum of about -30°, also around π cycles or about a frequency of 32 years before heading back to 0 at roughly 4.1 cycles per century or around 24 years (close to $23.1 \times e^{.03}$ or 23.8 years).

The ratio of the amplitude of birth fluctuations to the amplitude of fertility fluctuations based on Swedish women 1891-1900, itself fluctuates strongly at low frequencies, reaching a minimum of under .6 in the vicinity of 1.5 cycles per century (some 67 years) and a high of over 1.6 for approximately 3.0 cycles or 33.3 years. As of about 4.3 cycles or 23.3 years, however, further movements in the ratio become minor and it tends to hover around 1.0. Likewise, some comparative narrowing in swings of amplication for comparatively greater amplitudes of fertility (g = 0.5) disappear. The amplification resulting from harmonics at $2f$ and $3f$, meanwhile, become negligible (around 0.15 and 0.02) already by cycles of 100 years and are virtually absent for cycles shorter than 23 years (Coale 1972, 186).

{Please note that Harris indicated possible additions here. I could not find those in his notes. MSW 31 July 2015}

{Please note that there seems to be a transition missing. Also, pages 24 and 25 are drafted but not fully developed notes and thoughts. MSW 31 July 2015}

[Approximately 23.1 years is not just an arbitrary choice for *z* in comparing the cumulative normal curve with G. It is indicated empirically. Through the middle of its distribution the best arithmetic fit of the cumulative normal to G indeed tends to have a standard deviation for the time variable of about 23 years. For the range from -30 to +30 years in G the standard deviation for the cumulative normal is 21.60 years. For -30 to +40 it is 24.50 years. The average for these spans is 23.05 (for an implied range of about -30 to +35). This fitting, due to the options for *Tablecurve*, is done with the arithmetic rather than the logarithmic version of the data. For an increasing trend such as G or the cumulative normal, absolute error in later years has a disproportionate weight (unlike the use of *proportional* error for most G-related fits in this study). That effect shifts the best-fitting range between the two curves forward in time from roughly -46 to +23 (Fig. 9.x [8GF]) to more like -30 to +35.

Figure 9.c illustrates the excessive amount of arithmetic error after about +14 years in G relative to the cumulative normal as fitted proportionally for the range of -32.3 through +13.9 in Figure 9.GF. After fluctuating around an average of merely .00135 for seven decades, this soars more than 200-fold in a G' path through about year +60.1. Here, or a few years sooner, further increase shifts into more gradual G shape.

The *proportional* difference between the two curves, however, is less than 2 percent from -27.7 through +18.5 and virtually level (av. = .997) from -9.2 through +13.9. It then gradually accelerates in E fashion to about +41.6, where it swings over into a decelerating G trajectory to reach 1.37 in the late 70s. It requires an absolute stimulus in G' shape to push the G curve relatively above the normal via E. To hold it in proportional further gain via G a G trend in the arithmetic difference suffices, though this G must be markedly stronger--with a base year about

50 years later than the G for relative difference. At the early end of Figure 9.GF, on the other hand, the G curve converges upward to the cumulative by about year -20 through gaining proportionally for some 40 years in G' manner. Very little absolute difference as both curves low, but swings around cumulative normal - + -, picking up its path..

If a population, for example, begins to grow via G or a fertility reduction spreads within it in G fashion, by about 35 years before t_0 the trajectory will converge from below on the cumulative normal distribution. For over half a century random variations in the process will then add up in G form and support a G trend for demographic change. To continue thereafter, the G trend will have to exceed random accumulation by-------]

Consequences for G growth and other G (or D) change.

C as in lx or E

What might be the significance of these findings for changes that curve in G or G-transposed shapes (C, D, or E)? Discussion of roots and waves.

Another is the way that through about 50 years around its zero point G (or C in reverse) converges with the cumulative normal distribution. This convergence, finally, is most evident if the standard deviation of the normal curve is about 23 years, the imaginary component of the second root for the G function.

??The convergence of C on the reverse of the cumulative normal curve through the 'active' middle years of the human life cycle will assist in reducing random variations in attrition to the underlying curve. A similar smoothing process will be facilitated by the resemblance to the normal distribution in other trends that bend like G.

The consequences of the root. Fluctuations there most effective (cf. Coale)? Tie between secular trend and fluctuation.??

IMPRINTS OF G-RELATED TRENDS IN THE LIFE TABLE UPON AGE STRUCTURE

Though short-term baby booms and mortality crises can significantly affect the age distribution of populations, much about age structure is determined by the nature of the current mortality schedule or life table. Figure M.1 begins by illustrating consequences of this influence that take simply C followed by C' shape. Figures M.2a, M.2b, M.3a, and M.3b then provide examples of more complex mixes of trends, including partial log-linearity and the progression of temporary bulges or depressions through age distributions. Table M.1 enlarges this set of examples with visually estimated patterns for 22 additional historical instances by time and place to provide a total of 43 cases.

Figure M.1 shows a simple succession of C then C' contractions with age in six populations: Swedish males and females together in 1750 and females alone in 1800 France, 1960 Tunisia, 1964 Argentina, the Philippines in 1960, and Ceylon (later Sri Lanka) as of 1967. A similar two-stage pattern in C then C' form has been identified in survivorship (l_x) for all 51 modern populations surveyed in Table L.4 and also some earlier groups illustrated in Table L.5. In each of the four populations of the 1960s in Table M.1, for which both l_x and age distribution are known at the same date or a closely comparable one, a C phase of contraction followed by a C' stage characterized each type of tapering off. The steepness of the decline with age (the base timing of the two curves) and the points at which transition occurred were very different, however. On the one hand, the C trends for survivorship were much flatter, with target years more around 100 than the 30 average for the four age structures. Meanwhile, with average zero years around 46 rather than 25, the C' trends for l_x were also slower to decline.

Please note that Table M.1, which exists only in draft form, is not reproduced here. Other M-labeled Figures and Tables referenced in chapter M are not interleafed in the chapter but appear at the end of the text (notes).Other letter-labeled Figures and Tables (excepting "P" are missing since they were not included as print-outs in Harris's notes. MSW 31 July 2015}

This phenomenon reflects the vigorous rate of growth in the populations of the 1960s. When the trends of survivorship in Breslau at 1693 are compared with age structures in England at 1656, 1686, and 1726 and for France and Sweden as of 1750--much more slowly increasing peoples of the 17th and 18th centuries--the timing of the C path for survival is age 52, which compares with an identical average of 52 for age distributions in the five early national populations examined. Likewise, the subsequent C' trends both for l_x in Breslau and for the average among the age structures of roughly contemporary European populations are based at 29 (Table L.5 and Table M.1). For the moderately expanding population of England at 1861,[5] the gap in timing begins to be imbalanced in the direction of rapidly growing modern populations, but is not nearly so extreme.

In short, the C-then-C' sequence in survivorship imprints comparable patterns upon the tapering of age structures. As is well known, in growing populations (with births significantly exceeding deaths) the overall sloping of the age distribution, steepens with the rate of increase. The C-to-C' combination is apparently universal in survivorship for a wide variety of human populations--and for some other primates (Tables L.4, L.5, L.6, and L.10). In age structures, however, while there is an overwhelming tendency toward the same succession of patterns, two variations upon this patterning appear.

As Figures M.2a and M.2b illustrate, for *parts* of the life cycle the age distribution can taper in *exponential* fashion. This pattern is apparently never characteristic for *all* ages; it is most familiar early in life, and changes by mid-life to C or C'. Sometimes the exponential decline with age substitutes for any C stage, as in 1821 England or 1964 West Cameroon. Sometimes it precedes a late-starting phase of that shape, as in 1816 England, Mexico at 1966 or Madagascar and Cameroon in 1985.

For Mexican women in 1983, a vestige of such an e^{-x} decline from the 2-to-27 pattern of 1966 lingers in the female age structure between 32 and 47. This introduces the next point: exponential tapering is a *temporary* phenomenon. In a context of continuous historical demographic change, it is soon replaced with C-shape contraction, as totally in England between 1821 and 1841, and partially in Mexico between 1966 and 1983 or Cameroon between 1964 and 1985 (Figures M.2a and M.2b). In Cameroon, C curvature invades the latter part of the preceding exponential range; in Mexico, it intrudes upon the early years of life. The females of Madagascar, on the other hand, provide an example of exponential tapering arriving on the scene, between 1966 and 1985, as does the population of both sexes in England between 1726 and 1816.

The appearance or presence of an exponential slope in age structure for 7 of 8 of the examples with such a trend that are examined, Table M.1 indicates, is connected with substantial E-shape, exponentially accelerating, growth in the relevant population. In early 19th-century England the two cases of 1816 and 1821 follow an era of E-type population increase from 1726 through 1806 (which was followed by an H trend from 1816 to 1861). For Costa Rica in 1966, an E movement from1920 through 1963 had likewise just ended (transitioning to a G for 1963 to 1990), while in Cameroon each example, for 1964 then for 1985, sits in the midst of successive E patterns of demographic expansion. The illustration of Madagascar as of 1985 follows an E trend of post-World-War-II population growth that lasted into the 1970s, succeeded by F-type expansion. In Mexico at 1966, E-form demographic increase penetrated to about 1960, overlapping with F expansion from the 1940s to 1990. In the one exceptional case of partially log-linear age structure without accompanying E-type growth, Mexico at 1985, the log-linear form of tapering in age structure had, as Figure M.2a indicates, largely disappeared.

In all, for these several historical illustrations at least, it can be said that an exponentially *increasing* pace of demographic growth, not constant log-linear expansion in numbers, laid the foundation for any exponential tapering in age structure that appeared. In stable theory, it should be remembered, log-linearly tapering age structure is not expected with exponential growth, just any constant shape (Smith and Keyfitz 1977, 9-10). Looking at the reverse relationship, on the other hand, in the one observed case where E growth occurred but log-linearly tapering age structure did not, France in the early 1800s, the E movement of expansion in the population was short and very flat--just from 1792 through 1827, with a target year only at 1876.

Figures M.3a and M.3b illustrate a second embellishment upon the general tendency of age structures to take C then C' form: relatively short-term swings whose effects pass from age to age with time. Since World War II, 'baby booms' and their impact upon education, health services, commerce, politics, and other aspects of collective life have worked their way from professional population studies into popular consciousness. Historical demographers, on the other hand, have frequently encountered 'mortality crises' and their consequences in various international settings.

Without trying to fit all movements of this sort in Figures M.3a and M.3b,[6] let it be said that these swings take roughly C" shape, the second derivative of C. The approximate age at maximum is employed in Table M.1 to compare timing of such bulges rather than the zero age for the C" curve, which lies about 32 years before that crest.

All but one of the examples of roughly C" movements in Table M.1 appear in 20th-century populations. This suggests, given the well-known 'baby booms' of the era, that *fertility* shocks produce the trend rather than mortality crises, though the former often tend to occur in the wake of the latter. An implication of this generalization is that the C" surge in 1561 England, the one early exception noted in the examples of Table M.1, with its crest around age 10 reflects a 'baby boom' that peaked in the vicinity of 1551. Considerable support for this interpretation comes from the observed rise then fall of births, the percentage of the population younger than 5 and the gross reproduction rate from 1541 through 1561or later (Wrigley and Schofield 1981, 498, 528; Wrigley et al. 1997, 614-15). In politico-economic historical setting, this would have been a surge of fertility that built up during the last years of Henry VIII (which, beginning in 1536, included a major redistribution of property in England with the confiscation of monastic lands and their transfer to private ownership), culminated during the brief reign of Edward VII and his radical mentors (1547-1553), and faded under Mary (1553-1558).

In comparison, the most familiar ‘baby booms’ of the 20th century reflected the passing of the Great Depression and World War II. In Table M.1 examples appear for Norway (cresting in the vicinity of 1952, judging from age structure at 1967 and 1985), France (1955), the U.S.A. (1958), and the U.S.S.R. (1961). In Japan, the surge was more pointed than C” form and more immediately followed the war, spiking about 1947. The rather later bulge in the age structure of Taiwan around 1964 was shaped by the flight of old regime supporters from the mainland at the end of the 1940s. Postwar ‘baby booms’ are also indicated for Algeria (1963) and Mauritius (1961). The age structures of Norway and Japan display second bulges after World War II (around 1965 and 1973).

The age distributions of Norway and the U.S.A., on the other hand, appear to reflect C” crests in births also soon after World War I (in the vicinity of 1921 and 1925). A more delayed response in age structure, presumably because of more demographic disruption from which to recover,[7] is implied for France and the U.S.S.R., both maximizing about 1933. In the French colonies of Mauritius and Algeria similar movements appear, the former peaking along with the one in France, the latter not until about 1941. Greece shows something like a C” swelling among age groups born around 1901 as well as 1933. Conflict with Turkey in the early 1920s forced relocation of Greeks living east of the Aegean Sea, somewhat analogous to the flight to Taiwan after World War II. Balkan shifts and a new national political structure may have influenced the earlier surge of Greek births to about 1900 that then passed through the age structure.

Besides usefully, if tentatively, connecting bulges in age distribution with the historical events or circumstances that apparently produced them by means of surges in births, rough identification of the C” movements involved helps understand how one ‘boom’ in a population relates to others. Such sequences are evident in France, the U.S.S.R., the U.S.A., and Norway at two dates in Table M.1, and at one point in time for Greece, Japan, Algeria, and Mauritius. Excepting the extra bulge in the youngest ages for Norway in 1985, the average spacing for a dozen estimated pairs of C” crests is 28.3 years, ranging from about 23 years in Algeria and France to more like 32 years in Norway, the U.S.A., and Greece.

For the populations in Table M.1 that have possible C" patterns in age structure, the length of *generation* ranges between 26.2 and 28.5 years (Keyfitz and Flieger 1971 and 1990, same pages as cited in Table M.1). As has been widely discussed--in the United States, for instance--the indication is that the later C" surges in age structure are 'echoes' of their predecessors, not the results of new historical shocks. The weakest cases for this interpretation among the sampled populations are for the United States (with an average generation of 26.3 but a mean C" lag of 32.5 for the age structures of 1966 and 1985) and for 1965 Algeria (reversely imbalanced at 28.5 and an estimated 22.0).

Figure M.3a, finally, shows what is perhaps the most important point about these bulges: over time, their impact upon age structure--and therefore in turn its impact upon other demographic tendencies--effectively washes out. To illustrate the stability of overall patterns in age structures as bulges come and go, averages are taken for age distributions at different times. These averages are transformed in level to fit visibly on the graph. For the United States, such averages of age proportions at 1966 and 1985, which separately fluctuate in offsetting ways, from age 2 (perhaps better 7) through 52 taper smoothly in C fashion toward a target at 64. From 62 through 87, the averages then almost as closely follow a C' path based at
39. These patterns place U.S. age structure in with those for other developed societies in the second half of the 20th century, where one would expect it to be. For France, meanwhile, averaging distributions at 1967 and 1985 produces a C pattern from 2 through 52 with t_0 at 72, followed by a C' decline for ages 57 through 87 based on the age of 43. There is somewhat more variation around the underlying average tendencies for France; but the conclusion is the same. Long-term consequences for the demographic system will reflect these forms in spite of temporarily significant impacts from bulges in the age structure.

In sum, the nature of human mortality stamps C and C' forms upon survivorship (Chapter L) which then imprints these images upon age structure. Age distribution, in turn, has long been recognized as a principal factor in the shaping of demographic systems.

MOMENTUM IN DEMOGRAPHIC CHANGE: THE LONG RUN VS. LONG APPROACHES TO IT

A special instance of the interaction among demographic components is where in closed populations patterns of fertility and mortality remain fixed over time. The properties and consequences of such a regime form the focus of stable population theory. Though a useful tool for several types of demographic work, especially exploiting incomplete data, this approach has severe limitations when applied to the historical experience of real populations. On the one hand, many are by no means closed systems, but instead have significant net migration--with changes within the demographic regime contributing, along with exogenous socioeconomic forces, to pushing people out or pulling them in. On the other, Chapters 1 through 6 have shown that, historically, both fertility and mortality have usually not remained fixed for long. It is nonetheless useful to begin examination of how the observed G-related patterns keep recurring by reassessing how stable populations might eventually emerge as expected from actual historical starting points--to reevaluate stable assumptions on their home field, so to speak.

Leonard Euler (1760) was the first to point out how

> a closed population experiencing the same mortality risks for many years, and births that change in number in a geometric progression (i.e., change at a constant proportional rate) from year to year....has an unvarying age distribution, increases at a constant rate, and has constant birth and death rates (Coale and Demeny 1966, 9).

Alfred J. Lotka, apparently independently, rediscovered these relationships and Euler's formula in 1907, and with F. R. Sharpe offered in 1911 mathematical proof "that the continuation of a specified fertility and mortality schedule would lead to an unchanging or 'stable' age distribution" (ibid., 9-10).

Figures M.4a and M.4b illustrate how one feature of this system of stable relationships--constant rates of change in numbers (involving either growth or decline)--comes about when the fertility and mortality schedules of several actual populations are held constant for 100 years, or three to four generations, forward from the date of observation. Data for the base years come from the international compendia of Keyfitz and Flieger (1971 and 1990). The trends that result on the one hand reaffirm the value of Euler's insight. On the other, though--and most importantly--they demonstrate how in real historical populations with varying age structures much change can take place *before stability is achieved*. The paths of approach to stability in growth, moreover, repeatedly follow G-connected shapes.

Algeria in 1965 (Figure M.4a) had one of several national populations studied that as of the year examined was in virtually stable condition. Without change in rates of birth or death, and absent significant net migration, the country's female population would have grown at an exponential rate of .0330. The catch, of course--as for all instances of projected Eulerian expansion--lies in these assumptions of stable conditions. In 1965 Algeria, for both sexes, had a birth rate of 43.6 and a death rate of 10.0, yielding a growth rate per 1,000 of 33.6 or .0336. By 1985, however, these rates had dropped to 40.2, 9.1, and 31.1 respectively (Keyfitz and Flieger 1971, 308; 1990, 64). While from 1970 through 1990 the observed population of Algeria might be said to have increased in F form ($e^{.0300}$; Harris 2001, 280), changes were beginning to take place within it that would curb growth well below this pace in the future (in rapidly decelerating G shape from 1975 through 2004, indicate the 1990 observations of Keyfitz and Flieger and the U.N. *Demographic Yearbook* for 2004).

When the female demographic rates of Madagascar as of 1966 are projected forward, on the other hand, one way in which populations not already expanding this way, like that of Algeria, can *initiate* a period of growth in approximately F form is revealed. Simultaneously shown is how 'exploding' or accelerating increase in E shape comes to an end. Continuing the observed conditions of 1966 through 1985 produces E-type expansion with target year at 1990.

That is where a .03 rate of multiplication would be reached. This movement is followed by log-linear growth of .0271 for the remainder of the century of projection. The E phase is a temporary result of the age structure and vital rates for Madagascar that were inherited by the 1966 population. But Euler's dynamic soon brings this acceleration to an end. In the observed population of both sexes, meanwhile, from 1950 through 1970 growth has been estimated to take E shape with zero year at 1969, which was followed by F-type ($e^{.03}$) increase through 1990 (Harris 2001, 280).[8] While the log-linear projection for Algerian females at .0330 was slightly higher than the .0300 of the F trend estimated for actual growth for both sexes together after about 1970, the .0271 for females in Madagascar was slightly lower. From Algeria, considerable migration to Europe is known. For both populations, it should be remembered, the F estimates of Volume I were based upon only the 20 years from 1970 through 1990. The departure in each case of about .0030, or 10 percent, from the F rate is not large.

For 1981 China, too, existing vital rates and age structure (Keyfitz and Flieger 1990, 350) push up the size of the female population in E fashion during the first 20 years of projection. What follows, however, is 35 years of growth in H form. In all, it would be some two generations before Euler's dynamic took over (with a very modest .0056 exponential trajectory). Even then, the log-linear path would depart very little from a continuation of the H trend, as Figure M.4a indicates. Further, it would fall somewhat below it. The total population of China, male and female together, is in fact estimated to have grown in H fashion from 1950 through 1990 from a t_0 at 1923 (Harris 2001, 243, 251; with U.N. data this trend can be extended through 2004) compared with the 1913 of the H for females calculated in the figure. Given the long-curving path of the H curve, a decade in timing represents very little difference in slope.

For the females of West Cameroon in 1964, projection produces an H trend immediately, without the E-shape prelude observed in China. After about 40 years, stabilization of growth appears--with instantaneous increase at the rate of .0153 compared with the .0056 of China. Left open is the question of whether during the 21st century death rates will continue to fall while birth rates remain high and generally level, which were the trends between 1950 and 1985 (Keyfitz and Flieger 1990, 66). Is Cameroon instead continuing the 'demographic transition,' with falling birth rates beginning to catch up with declines in mortality--as, for instance, Keyfitz and Flieger anticipated in 1990 (121)? In contrast to these female projections from 1964 conditions, estimated actual population growth in Cameroon for both sexes together between 1950 and 1990 accelerated upward in E fashion.[9]

The demographic particulars of East Germany in 1967 (Figure M.4b) presaged gradual but slowly accelerating population increase in E shape through 2027, followed--beginning only over a half-century after the base date for projection--by stable exponential advance at the relatively flat rate of .0029. Such a growth trajectory never was realized because young people had, especially before "the Wall," emigrated to form their families in the West and, along with the consequent aging of the population, living conditions in the GDR became more and more depressing, lowering the birth rate while raising the death rate somewhat (Keyfitz and Flieger 1990, 92). Between 1946 and 1990 the population in fact contracted somewhat in D manner (ibid.; Harris 2001, 148).

The demographic conditions in Norway were typical of many European populations in the 1960s. Extrapolated into the future, they would have produced population decline in C shape for 80 years before contraction stabilized at a rate of -.0213. Actually, though, between 1948 and 1990 the Norwegian population *expanded* somewhat in G form (Harris 2001, 149, 152). Net immigration, about which so many western European countries have become so uneasy, offset the effects of death rates that rose somewhat and birth rates that fell by a third during the second half of the 20th century (Keyfitz and Flieger 1990, 96).

Projections from female population in Japan at 1966 also produce an era of C-shape decline. This appears, however, only after a quarter-century of growth in G fashion. With its base year at 1922 this curve of increase between 1966 and 1991 is somewhat flatter than estimated gains for both sexes together from 1965 through 2004. Having t_0 at 1939,[10] this pattern was steeper than what actual data extended into the early 2000s reveal (base year at 1925). Between 1965 and 1985, the birth rate fell by more than a third (from 18.6 to 11.4) while the death rate only dipped slightly before regaining its 1965 level (Keyfitz and Flieger 1990, 84). Only after 75 years of momentum following 1966 would the size of the female population in Japan finally decline at the exponential rate of -.0096.

Creating a hypothetical demographic future for female population in the U.S.A. as of 1985, finally, first of all produces G-type growth through the first quarter of the 21st century. Though a little flatter without the earlier data, this movement essentially continues the trend of the observed female population from 1945 through 1966, as Figure M.1 indicates. From 1985 through 2025 the projected female growth splices onto the actual from 1945 to 1965 to yield a G trend with base year at 1937 before, after 40 years of projection, C decline gives way to stable exponential contraction at the rate of -.0041.. The total population of the United States, meanwhile, can be said to have increased between 1950 and 1990 in G shape with base year of 1938. From 1940 through 1997 (now, evidently 2004 or later), however, more of an H pattern appears. This more slowly slowing trajectory appeared in Bureau of the Census projections of 1997 for the next half century (Harris 2001, 27). Their estimations melded movements in fertility, mortality, and migration. Since crude vital rates had relatively stabilized as of 1975 following demographic transition and the postwar ‘baby boom’ (Figures 2.1f and 2.2h in this volume; Keyfitz and Flieger 1990, 80), it was immigration that made the difference between G-shape projection from momentum and H-type reality.

The currently bitterly-debated flow of young adults, legal or illegal, into what has historically been a “nation of immigrants,” in other words, has over the past several decades kept the population of the United States on an H path of increase rather than the flat later stages of a G trajectory, like the peoples of international developing challengers and its own history since 1850.[11] H trends in China, India, and Brazil are currently steeper, with base years at 1923, 1947, and 1948 rather than 1888 or so; but the United States, thanks to immigration, is still following the shape of demographic path found in developing countries rather than the kind of faster flattening out in G form now evident throughout Europe, in spite of widespread H increase there in the past, between the later 18th century and World War II (Harris 2001, ch. 5). Like the classic, energy-devouring industrialization with which both Europe and North America developed economically, H-type demographic expansion may be environmentally unaffordable in the future (though that is what humanity as a whole will probably have been experiencing from 1950 through 2025 or so, shows Harris 2001, 385). The question becomes how, without the old partnership of H-type demographic growth and economic development, first encountered in the Dutch province of Holland, in England, and in Sweden during the 16th century (Harris 2001, 200, 148-151), societies can achieve and sustain high standards of living under global competition without the more robust and enduring input of new people. Is the experience of Japan and several countries of western Europe in the 21st century, for example, going to resemble the stagnation of the Netherlands following the Golden Age of the 16th and 17th centuries,[12] or will ways be found to maintain a widely distributed high quality of life without more robust and persistent H-type demographic expansion to feed the machinery of growth with new producers and consumers? For instance, can one country exploit another's population to expand its economy in H form without actually incorporating its people and experiencing H-form demographic increase?

In all, Figures M.4a and M.4b serve to illustrate three fundamental points about the behavior of demographic systems: 1) Actual regimes usually are not stable for any length of time. 2) Even when fertility and mortality schedules are held constant, because of varying actual initial age structures other aspects of the systems approach stability only with time. 3) The paths that changes take during this stage of transition repeatedly take G-related shapes. As in the economic reasoning of Keynes, most of what matters demographically in fact happens before the theorized 'long-term' arrives. And G-based curvature governs these movements.

SPACE

Table M.2 adds projections of growth for 21 more populations including 9 other countries and calculations from second base dates for the United States, Norway, and Japan to the 8 examples graphed in Figures M.4a and M4.b (which are denoted '*' in the table). The remaining patterns are estimated by eye with template (except for 2/3 examples fitted for Figures M.5a though/and M.5x, marked '**')

Some populations were, like Algeria, in stable growth in the 1960s, though projections for Mexico and Venezuela illustrate how already by the 1980s expansion was falling below this pace as birth rates declined more than death rates. The later forward iterations, from current conditions in the 1980s, call for H-type, slowly decelerating growth, the kind of transition from F-shape log-linear multiplication that occurred in the United States in the 1850s.[13]

Another group of populations in the 1960s (Peninsular or Western Malaysia, and Fiji) can be seen, like Madagascar in Figure M.4a, to accelerate upward in size to reach approximate F-type increase. By the 1980s, however, projected growth that holds constant current vital rates progressively flattens out in Peninsular Malaysia and Fiji to H paths, as in Mexico and Venezuela.

It is important to note how for the eight e^x patterns projected in the first two groups in Table M.2 (excluding those coming into being only following some decades of decelerating H-shape approach) the average log-linear slope is .0303 or only about 1 percent away from the .0300 of the F trend model. As first encountered in the British colonies of North America from the 1670s forward to the 1850s (Harris 2001, ch.1), this $e^{.03}$ trajectory is the path of growth that characterizes relatively uninhibited human demographic increase. Other trends, like the E projections of group 'B' in Table M.2 or the actual initial G of the early Thirteen Colonies (ibid.) do not exceed that pace by much or for long. The F trajectory, its contexts of historical occurrence indicate, takes special conditions to sustain. The continuing role of young, fertile migrant adults and their families in "frontier" societies with expanding opportunities is highlighted as a dynamic by the way F trends of demographic increase found in Volume I were distributed by space and time and socioeconomic conditions. In relatively recent populations, the F form is observed mostly in Africa and in Iraq and possibly Iran: places in which war, disease, genocide, starvation, and emigration have been notable since the 1980s, where the observations of Volume I end (Harris 2001, 280-81, 250).[14] These depressing forces are likely by now to have steered such potentially constant .03 log-linear population growths into deceleration, the experience of many countries previously, Volume I has shown.

As in West Cameroon, the female age structure and vital rates of Ceylon (now Sri Lanka, both in the ‘C’ group of Table M.2) in the mid-1960s would have already been generating future H-type slowly slowing expansion, though both national populations were actually approximating E-type increase at that point (ibid., 250, 281). The age structure and vital rates for the females of Chile at 1967, on the other hand, forecast pressure for future growth in the E form that the population as a whole had been taking in the preceding years, not the decelerating expansion that actually followed. By 1980 the vital rates and age structure for Chilean females were more in line with the shape of growth in fact experienced: a G trend was previously estimated for the whole population through 1990 (ibid, 116); but including recent U.N. data through 2004 an H path is indicated. In China as of 1981, finally, the demographic internals for the time being project growth in E fashion. By 2001, however, the trajectory would have become very much the kind of H trend that actually has been identified between 1950 and 1990 (ibid., 243). Indeed, Figure M.4a has shown how projections from the particulars of 1981, regardless of fine distinctions in E, H, then $e^{.0056}$ shape, on past the middle of the 21st century very closely would follow the kind of H path observed between 1950 and 1990. The closed nature of the Chinese population contributes significantly to this adherence.

In France, the United States of America, and Japan, vital rates and age structures as of the 1960s first forecast continuing G-type demographic expansion, which decelerates more rapidly than the H trends of the ‘C’ group of populations above them. The projections of the 1980s extend these patterns further into the future. Where the trendings sometimes include calculations for actual female numbers during earlier years the starting date is in italics. The same kind of G path appears in projection for Yugoslavia as of 1966 and 1985--and for Taiwan at 1985, though as of 1966 E-type increase would have been expected there. Forecasting from 1985, Norway likewise displays such a pattern by 1985. While Norwegian particulars at 1967 call for some increase through 1972, the shape of this movement is unclear.

The observed total population of Norway in fact swelled slowly in G fashion from 1948 through 1990 very much like the momentum calculated from the vital rates and age structure of 1985 (Harris 2001, 149). For Norway as of 1967, anticipated C-type decline (though not observed this early in real demographic expansion) intruded back into the 1970s. In France, Japan, Yugoslavia, and Taiwan the G-shape projections from the 1960s and the 1980s both closely resemble the trajectory of increase for the actual total population (ibid., 148, 251; Keyfitz and Flieger 1990, 261). In the United States, however, as has been shown in Figure M.4b, actual population growth through the later 20th century took a considerably more robust H path instead of the type of G trajectory suggested by the female projections with fixed vital rates from both 1966 and 1985. The congruence of these two estimates of female momentum, from the 1960s then the 1980s, furthermore, suggests that for the U.S.A. net migration, not significant further post-demographic-transition changes in rates of births or deaths, made the difference between projection and reality. Is not always welcomed immigration comparably sustaining G growth in current European populations and preventing them from entering upon the type of C-shape decline that is projected from their fertility, mortality, and age structure of the later 20th century? Alternatively, will socioeconomic opportunities encourage increased fertility with the same result in societies like Japan, where significant immigration is unlikely?

Finally, by 1985 the fertility and mortality regimes and the age structure of Taiwan joined most populations of group ‘D’ in projecting decline in C form. These several C projections from the 1980s all had target years between 2076 and 2125. Those trends of accelerating contraction then transformed into gradual log-linear declines from between 2030 and 2050 forward with rates between -.0015 and -.0079. Lastly, as noted in discussion of Figure M.4b, 1967 projections for East Germany rise in slowly accelerating E fashion whereas the actual population was contracting via D ever since World War II because, while it was still possible, young adults left the country in large numbers, leaving an aging people behind.

In all the illustrations of Table M.2, from the 1960s and from the 1980s, projections for future population growth that employ fixed schedules of age-specific fertility and mortality predict patterns of increase in G-related forms. Before eventual log-linear expansion is reached, sheer consequences of the initial age structure in the base year for projection shape future growth this way for substantial periods of time. In this fashion, the universal C-then-C' shape of survivorship observed in Chapter L imprints G-based patterns on demographic change

COMPARABLE MOMENTUM-GENERATED AND ACTUAL G-RELATED MOVEMENTS IN SEVERAL DIMENSIONS OF DEMOGRAPHIC SYSTEMS

In real populations, as opposed to the arbitrarily projected ones of Table M.2, which assume fixed patterns of fertility and mortality, vital rates do not remain constant for long. Table M.2 already has listed significant shifts between the 1960s and the 1980s that appear for most of its populations; and preceding chapters have outlined many comparable changes for birth and death rates, and also age structure, during epochs before the later 20th century. It has just been seen that constant vital rates, based upon initial demographic conditions the 1960s or the 1980s, of themselves generate substantial G-related curving in population growth before 'stable' e^x expansion occurs. Actual increases of the past half-century have followed comparably G-connected paths. These trajectories are usually not the same as the projections of momentum from the 1960s or the 1980s, however, because vital rates generally have not remained fixed.

Age structures and rates of birth and death are affected in G-based fashion along with patterns of growth. Some of this shaping, it can be shown, comes from nothing but the impact of initial age structures upon the consequences of fixed vital rates. In addition, though, exogenous forces such as alterations in the natural environment, economic changes, or shifts in social values raise or lower levels of mortality and fertility (and thereby affect age distributions) in ways that are themselves digested through cohort structure in G-connected shape by populations.

Table M.3 addresses the first of these two sources of G-related change: endogenous consequences from the workings of demographic regimes even when schedules of fertility and mortality are not being altered by the natural or man-made environments in which populations live. It summarizes from about 1950 into the early 21st century for the sample populations of Table M.2 (without East Germany) the kinds of G-based patterning in some components of the demographic regime that have been encountered in previous chapters for past national populations, and also for local ones. The first two columns present estimated trends for population, crude birth rate, percentage of the population under 15, and percentage age 65 or older for projections with fixed schedules of fertility and mortality. The two right-hand columns, on the other hand, display observed or independently estimated (Keyfitz and Flieger 1990) actual trends in these properties of populations--and also in crude death rates and rates of natural increase and gross reproduction--across the second half of the 20th century and into the early years of the 21st. Figures M.5a and M.5b, (M.5c?) for Mexico and for xxxxxx, illustrate visually how projected movements from momentum in the 1960s and the 1980s compare with each other and with actual trends that have unfolded as far as the early 2000s and show how these involve G-related patterns in several demographic characteristics before stabilizing.

The populations in Table M.3 tend to form three groups. In section A are those that several decades ago seemed to be undergoing exponential growth in approximately the F ($e^{.03}$) form--with Fiji, Western Malaysia, and Taiwan entering this path somewhat later, following a period of accelerating E-shape increase. A second or ‘B’ group is composed of populations in developed countries that experienced G growth through the second half of the 20th century even though their momentum as of the 1980s, and sometimes as early as the 1960s, foreshadowed actual decline in size. In the third, ‘C’, portion of the table are some populations observed at other stages of ‘demographic transition.’ Through the later 20th century, the peoples of Madagascar and Cameroon were surging toward peak rates of growth near .03. Demographic conditions in China and Chile, on the other hand, as of the 1980s were forecasting the actual H growth that is evident through 2004. The female population of the United States of America in the 1960s and 1980s continued to project G-type expansion, perhaps even soon C-shape accelerating contraction, but the actual path of demographic increase through 2004 took H form. Conversely, while the momentum of Sri Lanka in the 1960s suggested H-type increase ahead, between 1955 and 1985 actual expansion followed more rapidly decelerating G shape.

Part A of Table M.3 shows how the population of Mexico, which in the 1960s looked as if it were expanding in F fashion, by the 1980s had slipped below such an $e^{.03}$ trajectory, though it still retained the potential of H growth. In fact, however, according to later observations through 2004 this increase seems to have further decelerated into just G form.[15] Similar slowings in trajectory of growth from F to G have occurred with time in Fiji and Taiwan (which was already foreshadowing a G pattern by 1985), and--though the table provides no projections from the 1980s--for actual demographic increase in Algeria and El Salvador by the 1970s. In Western (Peninsular) Malaysia and Venezuela the F momentum from the 1960s yielded to an H by the 1980s, a type of expansion followed by actual population numbers through 2004.

In all of these ‘A’ cases of slowing growth and curbed momentum, fertility as measured by the gross rate of reproduction fell from about the 1960s forward, sometimes in concave D fashion or alternatively in convex C’ movement that reached a crest mostly in that decade. (In 1990, Keyfitz and Flieger expected the patterns often to continue into the 21st century.)[16] These fertility trends imprinted D shape on actual patterns of crude birth rate except in Algeria and El Salvador, where the C’ of the GRR is reproduced instead. By the 1980s, current schedules of fertility and mortality and existing age structure together projected D trends for future birth rates that much resemble what actually unfolded into the early 2000s. Simply digesting the impact of crests of ‘demographic transition’ that were already passing through the age structure shaped the paths of CBR in these G-related ways during the second half of the 20th century. In contrast, demographic particulars of the 1960s, which in this group of populations are mostly taken at the height of ‘demographic transition,’ generally projected the kinds of flat or level birth rates through time that theory expects for stable populations expanding at constant exponential rates, such as the projected paths close to $e^{.03}$ in the first column of Table M.3.

Like the crude birth rate, the percentage under the age of 15 in these populations was forecast by conditions of the 1960s to remain generally flat. By the 1980s, however, projections with fixed current schedules of fertility and mortality uniformly call for contraction in D form. The observed proportion under 15 during the second half of the 20th century, on the other hand, tended to rise and fall in G’ fashion, cresting between 1947 and 1973.[17] The origin of this humped aggregated impact of elevated fertility lies in the behavior of the GRR. Whereas postwar trending for Algeria, El Salvador, and Taiwan reflect the up-and-down movement that eventually shapes the percentage of the population who were young (if in slightly different C’ rather than G’ form), any rise in GRR before about 1960 is not captured in Table M.3 for Mexico, Fiji, Western Malaysia, and Venezuela. The question remains open as to whether with later data the declines of GRR in Algeria, El Salvador, and Taiwan then turn into concave D shape following their C’ peaking.

The demographic particulars of the 1960s for these group ‘A’ populations promised increase for a while in proportions age 65 or older, mostly in G form but sometimes rising then falling via G’ (in Venezuela giving way to a concave D trajectory). Conditions of the 1980s also projected a higher proportion of older people. By then, however, E-type acceleration in accumulative aging became the most common pattern. In actual numbers of the later 1900s, and also in 1990 projections by Keyfitz and Flieger for the near future, this predominance of E trends was sustained in the increasing representation of the elderly.

The most common tendency of the crude death rate, which chiefly reflects improved care for the young, was to fall in D' fashion. This pattern is G' upside down. For these 'A' populations such a sag to a bottom between about 1986 and 2006 was universal except in Algeria. In Venezuela, Western Malaysia, and Taiwan it was preceded by decline in C form, the widely observed tendency of the CDR during 'demographic transition' (Chapter 2) and the trend for Algeria through 1997.

These declines in the death rate interacted with mid-century crests in the birth rate (captured in Table M.3 for Algeria and El Salvador, and probably preceding D-type declines noted elsewhere) to produce mostly C' surges of natural increase that peaked between 1954 and 1978 (though G' in Venezuela). This C' pattern in natural increase, Chapter 3 has shown, results when reduction of the death rate in C form precedes contraction of the birth rate in similar shape, the typical dynamics of 'demographic transition.'

Populations of part B of Table M.3 represent developed societies whose birth and death rates had been substantially reduced by the middle of the 20th century. Their actual growth across the later 1900s took parallel G form. Probably a second such pattern of increase appeared in Norway after about 1990. As noted, C-type demographic declines predicated by the age structures and vital rates of the 1960s and 1980s had not come into effect by 2004 (or the break-up of Yugoslavia).

Paths of anticipated momentum for the crude birth rate and the percentage of the population under 15 as of the 1980s closely resembled the D patterns found in group 'A' of Table M.3. Earlier--from the 1960s--however, rather more frequent D-shape decline in proportion young was expected, especially from the demographic particulars of Norway, Yugoslavia, and Japan. The actual weight of the young in the four populations of part 'B' generally rose than fell in C' fashion as in Mexico, though earlier, not the G' patterns mostly found in group 'A.' More often, a G' surge in the birth rate appears in these examples before the trend changes into the D shared with those 'A' populaations. Underlying these more frequent up and down movements in fertility and youthful populations, the gross reproduction rate in France and Norway experienced quite focused 'baby booms' that tended to be shaped like the *second* derivative of C, C" rather than C'. These sharper surges with C" form then pass on to natural increase, making such imprints of 'baby booms' (and sometimes also their generational echoes), in France Norway, and Japan as the death rate (except in Norway) dipped in D' fashion like in the populations of part 'A' of Table M.3--only bottoming out noticeably earlier. In essence, the C" form seems to distinguish the archetypical 'baby boom' bulge in demographic systems from the C' shape of surge that is generated by 'demographic transition.'

Part C of Table M.3 includes examples of populations experiencing other stages of transformation during the later 20th century. In Madagascar and Cameroon, where numbers were rising toward the F path or were in it, GRR was not declining until about 1980. This held the crude birth rate, through two successive G' surges, almost level as far as 1998. Combined with the fall of death rates, that elevated natural increase in both populations through the 1990s in C' form, signaling typical tipping points of modern 'demographic transition' that arrived two to four decades after even the actively transforming populations of part 'A' of Table M.3. The proportion of persons in these two countries under the age of 15 rose through the 1980s and probably to the turn of the century (Keyfitz and Flieger 1990). The small percentages of inhabitants who were 65 or older bulged in both populations in G' fashion, cresting in the vicinity of 1980, as death rates fell via D--persistently, if less sharply than the D' path found so often elsewhere. Projections of momentum from age structure and vital rates of the 1960s in Madagascar and Cameroon foreshadow what actual demographic trends would be for the remainder of the 1900s considerably more frequently than is the case for the populations of parts 'A' and 'B' of Tables M.3, though hardly in all respects.

In China and Chile, where H growth indicated by conditions of the 1980s was actually realized (if sooner in China than sheer momentum would indicate), crude birth rates actually declined in successive parallel C' steps (contrary to the concave D paths projected from the

1980s). Similar movements in GRR for the two countries did most to shape these patterns, though for Chile the postwar surge phase that in each case preceded D-type reduction was more focused in time, taking C” shape rather than C’. The result in both countries was a bulge of young people in C’ form that crested in the early 1960s, not--or not yet--taking the D trends indicated by age structure and vital rates in the 1980s. While death rates in both countries fell in C then D’ trajectories, the C” pattern in the gross rate of reproduction for Chile in the third quarter of the 20th century left its imprint upon natural increase there, instead of the broader C’-type pattern found in China.

Sri Lanka and the United States of America, like Chile, experienced during the second half of the 1900s the kind of C” bulging in rate of natural increase seen for France, Norway, and Japan in part B of Table M.3. Underlying these movements, GRR in the U.S.A. displays first a C” ‘baby boom’ between 1953 and 1973 (a phenomenon also appearing in France, Norway, and Chile) then relatively flat D-type decline, perhaps into the 2020s (comparable to trends in Yugoslavia and Japan). In Sri Lanka the 1953-1973 pattern for GRR is more of a broader C’ ‘transition’ high than a sharp C” ‘baby boom,’ and the following D trend is a steeper one, more like the behavior of GRR in China. Crude birth rates for both countries fell in mostly parallel D forms, a pattern anticipated by the age structure and vital rates of the 1960s and 1980s in the United States but not in Sri Lanka.

In response to these movements in fertility (and to evolving schedules of mortality), the proportions of people in Sri Lanka and the United States who were under 15 shrank in C’ fashion from the 1950s to the 1980s--as in China and Chile (and France and Norway)--then probably tapered off further via D, as in Yugoslavia. The momentum of the U.S. population at 1985 foreshadowed this latter movement. Demographic conditions for both countries in the 1960s instead indicated no change to speak of. The proportion of the Sri Lankan population 65 or older, meanwhile, swelled in E fashion along with developments in China and Chile and several countries in groups ‘A’ and ‘B’ of Table M.3. Particulars of the U.S. population in 1985, on the other hand, forecast the actual G-shape accumulation of older people there, a pattern found in Norway and Fiji. Finally, the crude death rate in Sri Lanka exhibits the D' type of drop observed in China and Chile and most populations of parts 'A' and 'B' of Tables M.3, while the CDR in the U.S.A. atrophied much more slowly in successive C trends as its population aged (and infant mortality stopped improving as seen in Chapter 2).

SPACE

Besides providing further insight as to demographic experiences that various populations did or did not have in common, and how these similarities or contrasts appeared, Table M.3 has shown the way demographic momentum with fixed schedules of age-specific fertility and mortality not only produces substantial periods of population growth (or decline) in G-related forms before log-linear, 'stable' increase is attained. It illustrates how imprints of this type are also made upon birth rates and age structures before the theoretically expected stabilization can occur. The way initial patterns of age structure are digested by demographic systems *by itself* tends to produce G-based movements over time in several key properties of populations.

In some cases such projections from sheer momentum forecast quite well actual trends in populations size, composition by age, and vital measures (as illustrated by the birth rate). The demographic particulars of the 1980s prove to be somewhat better at this than the unusual conditions of 'baby booms' in developed countries and turning points of 'demographic transition' for developing ones that clustered in the third quarter of the 20th century. Table M.3 also shows, however, that the actual trends that unfolded in these demographic variables through the early 2000s often looked rather different. This was because patterns of fertility and mortality did not remain fixed. They altered in ways above and beyond the mere digestion of initial conditions over time. Who had how many children when in their lives, or died at various ages, also shifted contributing--in some cases substantially--to make actual trends different even from what projections of quite recent momentum would be expected to generate.

Over a long and diverse historical context, previous chapters (and also findings on migration in Volume II) have identified certain recurrent types of exogenous impulses beyond the endogenous dynamics of momentum to which demographic systems must respond. These include abrupt mortality crises (as from famines or epidemics) and long-lasting shifts in death rates (as upward with the arrival of plague in medieval Europe or lasting economic collapse, or downward with improvements in health care or conditions of living); short fertility impacts of wars and other crises, but also long-term shifts such as curtailment of child-bearing (progressing from older women to younger ones in much of the history of family limitation, but sometimes from younger upward in postponement of marriage whether for economic necessity or opportunity); and the impact of focused migration by young adults forming or about to form their families. Did the effects of these familiar historical phenomena, not just during the second half of the 20th century addressed by Table M.3 but backwards in time, likewise repeatedly imprint G-related forms upon the various dimensions of demographic change?

THE CONSEQUENCES OF CERTAIN TYPES OF HISTORICALLY OBSERVED CHANGE IN VITAL RATES FOR DEMOGRAPHIC SYSTEMS

"Experiments" can be done to demonstrate the impact of frequently appearing G-related forms of change in birth rates and death rates upon demographic systems. The first step in this process is to select representative populations upon which to impose such alterations in vital rates.

Choosing Typical Historical Populations to Manipulate

Most of the historical peoples examined in this study can be considered as cases of one of four general types: 1) pre-modern, pre-'transition' populations with high birth and death rates and very little growth; 2) populations entering transition, with death rates that have begun to lessen but whose birth rates have declined relatively little so far, and therefore are expanding at a significant rate; 3) populations at or near the peak of modern 'transition'--with death rates already well down, but birth rates hardly reduced as yet--which are therefore growing very rapidly (near the $e^{.03}$ pace of F); and 4) populations that have gone through 'transition,' whose birth and death rates are now both low, and which exhibit very little increase, or from their internal characteristics even bode some decline in the near future.

Looking backwards across this sequence of demographic development, the particulars of Italy at 1980 serve to represent the several recent, later-20th-century populations of type 4 that have been observed. With a CBR for females at 10.68 and a CDR of 8.98 there is a current crude rate of natural increase at just 1.70, while extrapolating projection with fixed schedules of fertility and mortality indicates (absent net migration) some actual contraction by about 2000. The age structure tapers via C from 7 through 57, with target year around 90, then via C' from 57 through 82 with t_0 estimated in the vicinity of 40--not unlike the long-term patterns that underlie age distributions in the 1980s for France, Norway, and the U.S.S.R. in Table M.1, cutting through 'baby boom' bulges that more markedly appear in those populations. One reason for choosing 1980 Italy among several comparable possibilities is indeed that the age structure displays less sign of a postwar 'baby boom' than is often the case (though for ages 57 through 87 some such concentration exists for those born between 1893 and 1923--years of massive emigration from population pressure, reiterates Harris 2003, 28). Survivorship tapers from 1 through 60 in C form, targeting about 118, then from 50 through 75 via C' with base year around 52--much like females in the U.S.S.R. at 1979, the U.S.A. at 1985, Chile and Cyprus at 1980, New Zealand at 1985, and Japan or China about 1980 (Table L.4).

Mexico in 1966 serves to represent populations in category 3. With a birth rate of 42.5 but a death rate already all the way down to 9.0, the number of females is projected to expand at 33.5 per thousand (.0335, or somewhat above the F pace). Historically, from 1953 into the 1980s natural increase peaked around 1964 in C’ fashion (Table M.3), the pattern Chapter 3 has shown for growth when decline of fertility in C shape lags behind decrease of mortality in comparable form. The mid-1960s was when the crude birth rate and gross reproduction finally began to atrophy and slow growth down. As of 1966, from 2 through 27 the age distribution for females declined log-linearly, about .037 in pace. Tapering via C through age 47 followed, with zero year around 34, then further contraction in C’ fashion based about 27 (Table M.1). Meanwhile l_x fell from 10 through 55 with t_0 around 96 followed by C’ type tapering from 45 though 75 based about age 43, much like patterns for several rapidly growing Latin American, Caribbean, African, and Asian populations in the 1960s (Table L.4).

Particulars for the females of Madagascar in 1966 resemble characteristics of group 2 populations, in which prototypical ‘demographic transition’ has begun with some substantial decline in crude death rates but birth rates have still remained high. These characteristics make it possible to simulate change in populations as the phenomenon of ‘demographic transition’ began to appear in the 19th century. Part A of Table M.4 presents some comparisons with the peoples of England and Sweden (both sexes). Whereas survivorship can be patterned for England at 1861 and Sweden in the 1750s, l_x is not known for other dates. Survivorship patterns for Breslau in 1693 provide another, and somewhat closer, pair of comparisons with that for Madagascar’s females in 1966. In all, though crude birth rates in early modern Sweden and also in England by 1861 had come down rather more, the particulars for Madagascar females in 1966 were not unlike those for the other five much earlier European populations in Part A of Table M.4.

Females in 1966 Madagascar, if their death rates are magnified, can also serve as the basis for experimenting with the impact of demographic change upon pre-‘transition’ populations, those in which fertility and mortality were both high. Drawing upon examples of the 16th, 17th, and 18th centuries, Part B of Table M.4 makes French comparisons at two points in time and English ones at four dates with a doubled-mortality modification of the 1966 demographic conditions for Madagascar’s females. The dates chosen approximate transitions from one trend of growth to another in the French and English populations (as do those for England and Sweden in part A of the table).

The closest match with the Madagascar population once its age-specific mortality rates are doubled to make increase insignificant[18] is with the French population at 1750 (assuming that something like the 1693 pattern of survivorship for Breslau applied). At this juncture, the French people had been multiplying slowly in ever flatter G fashion for half a century and was about to commence four decades of new, but only slightly steeper G-type growth (Harris 2001, 148, 152). In the other early European populations of part B of Table M.1 CBR and CDR were also closely comparable, but at a somewhat lower level: in the 30s--except for England as of 1656, where the population was about to decline a little for three decades in D form. Chapters 2 and 5 have discussed how the French reduced fertility along with lessening mortality prior to 1800 while Chapter 1 has set forth demographic changes during successive H, D, H, E, and H trends in population size for England between 1561 and the first years of the 20th century. In this country, birth and death rates declined but also rose during that era. While the modified particulars for Madagascar’s 1966 females do not exactly match those for any of the six early European examples, the model does provide a population with high fertility and high mortality, very little growth, and at least comparable age structure and survivorship upon which to experiment.

Consequences of Increasing Mortality in Some Historically Familiar Ways

What patterns, what forms of demographic trends, result when changes in death or birth are imposed upon these four types of populations that are so frequently encountered in historical research? To begin, Figures M.6a and M.6b illustrate what happens to population numbers when mortality is arbitrarily increased in forms that have been observed in this historical survey.

Table M.5 summarizes these consequences. The first column presents how demographic growth or decline among females would unfold over 100 years given the properties of the original or base populations observed (or, in the case of the pre-transition model, an adaptation from Madagascar 1966 by making death rates more even with birth rates). The second column increases age-specific death rates by the given multiple just at the 20th year of iteration in the development of each population, returning by year 25 to the original mortality schedule. The third column expands these rates at year 20 as described, but lets them taper off in G' fashion (converging toward an $e^{-.03}$ path) until the original levels are reached. The final column triples age-specific mortality rates in G' form, beginning before that maximum where they first exceed the original levels and ending when they return to them. This way, mortality grows worse for a while (about 40 years) before it becomes progressively better. A lower multiple than 3 would shorten the periods of both increase and return to original level; a higher multiple would increase these spans of adjustment.

A mortality shock in just one 5-year period for the four typical populations as summarized in Table M.5, mimics (via a variety of temporary multiples) a frequently encountered phenomenon for historical populations, particularly pre-modern ones. Famines, floods, epidemics, and wars have tended to strike populations in this manner, often time and time again--with some shocks much greater than others (for example, Livi-Bacci 1992, 107-08; 2000, 82; Dupâquier 1997, 448). In each of the four populations experimented upon this way, the first two columns of Table M.5 show how, with a return to original age-specific mortality rates, recovery in numbers takes G shape back to emulate the paths of growth or decline imbedded in the original regime.[19] Thus, one way that the G form of population increase appears over and over again in so many historical populations in Volume I is via the impact through time upon size of the mortality crises that are so frequent before the modern era--and can return, as Malthus pointed out, wherever and whenever demographic expansion exceeds the combination of human ingenuity and natural resources.

Examples in Volume I of such sudden brief decline with increase in mortality then G-type rebound include shocks of the Thirty Years War for the village of Lambsheim in the Pfalz during the 1620s (367), for the Schwabian commercial hub of Augsburg in the 1630s (304), and for the Belgian town of Mechelen in the 1640s (308). Evergem and Eeklo, also of the Spanish Netherlands, experienced similar abrupt losses of population followed very quickly by a G-shape recovery during later Low Country conflict in the 1670s (308, 347). Einbeck, in Hanover, and Neckershausen, southward in Württemburg, suffered similar blows during the Seven Years War in the vicinity of 1760 but rebounded comparably along G paths (347-48, 367). In much more modern times, as other regions continued to add residents several parts of Japan lost population around 1920 only to recover with new G growth (270), while under the bombing of the mid-1940s Tokyo and Osaka sharply lost population but then regained it in G fashion (319).

Also scattered across several centuries and many parts of the globe are cases where population was cut back more by famine or disease without war (which could bring on both): for example, the community of Halesowen around 1320 during a period of "Malthusian" agricultural crisis that preceded the Black Death in parts of England (360-61); the Tuscan town of Montalcino in the vicinity of 1480 (354); the Kamimichi district of Bizen province in Tokugawa Japan around 1730 (357); the Calabrian commune of Borgia near 1860 (370); or Sikiana about 1840 and Nukuria about 1890 as the populations of these Pacific islands were abruptly devastated by contact with the outside world (375). Comparable sudden drops in demographic numbers followed by recovery in G form probably occurred in other populations surveyed in Volume I, but cannot be distinguished from more accumulative and sustained contractions because dates before and after the fall are just spaced too far apart.

Such more sustained losses of population are much more frequently documented in the same chapters of Volume I. They take D shape. The third and fourth columns of Table M.5 show two different ways that demographic contractions of this persistent sort can be generated.

In the first type of change for the four illustrative populations, age-specific mortality once again increases suddenly by some multiple between the 15th and the 20th years of projection. Instead of returning to the original rates by year 25, however, it tapers off only gradually. The model employed for this hypothetical improvement is the G' curve following year 0. This keeps the rates relatively high for a few quinqennia, but then lets them recede in what becomes more and more of an $e^{-.03}$ path until they return to original levels. As a result, the population contracts rapidly, then more and more gradually--in all, in D fashion--as the threat is adjusted to across successive generations. Think of a new disease or a deterioration in resources that arrives suddenly but whose negative effects gradually peter out. One example of such change in mortality, behaving this way long-term though peppered with repeated shocks of less and less magnitude as mortality reapproached its initial level, is available from the plague-era pattern of deaths at the Dominican monastery in Sienna between the 1340s and the 1450s (Pinto and Sonnino 1997, 491).

Volume I is permeated with instances of the resulting D-type decline in populations: from the spread of the Black Death in 14th-century Europe across communities, regions, and nations and the recurrence of plague in the 1600s; from the 15th-century decay of Ming China and several of its provinces (243, 266); from the decimation of native peoples in the Americas when confronted with biological and military-economic invasion during the 1500s and 1600s (ch. 4); from lingering impacts of European warfare in the 17th and 18th centuries; from regional and local atrophy for a variety of reasons in southern Italy, China, and Japan during the 18th and 19th centuries (370-71, 375); from occupations of the islands of Oceania in the 1800s (130-36); from decline for native Canadians, some West Indian sugar islands, and U.S. states of the Great Plains (66, 123, 53) during the first half of the 20th century and the decay of many core cities of America from socioeconomic change later in the 1900s (297, 299). Similar contraction, it is hypothesized, is developing from the losses of several global peoples hit heavily by AIDS during very recent years.

Table M.5 first shows how for projections of populations in which birth and death rates are relatively equal (and growth or decline is slight)--both high in the pre-transition model created from Madagascar, both low in post-transition 1980 Italy--a tapering off of age-specific mortality rates in G' fashion after sudden increase generates contraction in D form for several decades before reapproaching paths of change expected from the initial demographic systems. Most populations of the past were pre-transition in nature; and most of the future will have post-transition conditions.

An historically important minority of observed peoples, however, were experiencing elevated rates of growth as they went through transition, with CDR's preceding CBR's in reduction--a moderate divergence in the case of 1966 Madagascar, an approximately maximum difference for Mexico as of that year. In these circumstances, population size enlarged for some time in E fashion, rather than contracting via D, before picking up again the log-linear path of growth imbedded in the initial regime. Examination of Figure M.6b, though, reveals that in effect the E path that is followed represents D-shape departure from the exponential trajectory inherent in the base population. In short, whether a population is relatively stable in size or is expanding substantially, D-form reduction from the original trend occurs, whether that path was level or exponentially sloping. Since, so far historically, population loss has been most evident in pre-modern populations, most D trends in size of Volume I are observed for that era of fairly closely balanced birth and death rates. While E-type increase might result from this kind of mortality increase in transitioning populations, that form of growth is more likely to be driven by mortality *decline*, since during transition death rates fall rather than rise relative to lagging birth rates.

It is easy to identify historical instances of the sudden advent of disease that then works its way through a population, the arrival of hostilities whose effects devastate health and making a living but are gradually overcome, or the consequences of abrupt collapse in an industry or economic sector. While one might model the tapering off of mortality after the initial shock in ways other than the G' path, any step-by-step reduction after sudden increase should have a generally comparable impact upon population size through the years.

It is also possible that mortality might rise in stages for a while before falling away. That, for example, may prove to be a better model for recent devastation from AIDS. It does appear to be the case for surges of early modern endemic disease. Losses from smallpox, for example, built to a crest this way in Geneva before and after a maximum around 1600 and in London in the vicinity of 1765 (Perrenoud 1997, 314). Overall population deficiency in London, created by excesses of deaths over births, swelled then shrank in G' manner between the early 1600s and the early 1700s, topping out in the vicinity of 1660. About a century earlier, contracting deficits from 1562 through 1612 suggest a previous crest in the vicinity of 1560 (Harris 2003, 187). That was about the time of "Jack Fisher's 'flu" (cite ch. 1) and the hump in the crude death rates for all of England as indicated by Figure 1.1 in ch. 1 of this volume from 1541 through 1581.[20] For England as a whole, additionally, an up-and-down G' pattern in mortality (rather than just an abrupt increase to a maximum followed by G' tapering) appears for children from 1 to 4 and for all under 15 three times from the later 1600s into the early 1800. Such a series of G' surges is also evident in loss rates for adults from 25 through 50--though with a slightly different timing, which keeps the overall crude death rate from displaying such patterns (Figures 1.9a, 1.9d, and 1.10 vs. Figure 1.1). Local G' bulges in deaths of infants and/or children have similarly been found in several communities and regions of Germany in the 18th and 19th centuries (Table 5.9, Figure 5.11).

In the Atlantic slave trade, meanwhile, death rates also frequently swelled in G' fashion, whether from the dissemination of disease that accompanied extensions of intercontinental contact or because of crowding and poor provisioning during periods of particularly inept or greedy slaving practices. G' bulges of mortality crested in Dutch and British (and perhaps the French) shipments in the middle 1600s, then again in the vicinity of 1730. Later death surges in G' form appear in French, Portuguese, and Cuban operations--peaking in the vicinity of 1790, 1825, 1835, and 1860 (Harris 2003, 396). Death rates for slaves while 'seasoning' after arrival in America, meanwhile, crested around 1700 (ibid., 394).

In short, G’ rises and declines in mortality are another frequently identified historical phenomenon. What tends to be their impact upon the size of populations with time?

Where birth rates and death rates are relatively comparable, as in typical pre- and post-transition circumstances, the first or upward stage of G’ movement for age-specific mortalities makes the size of the population begin to decline in C form, drastically heading toward extinction where initial mortality was high, contracting gradually where the base level being multiplied is relatively low. This study has identified few C-shape declines in historically recorded populations (Harris 2001). None have experienced severe accelerating (i.e., C-type) crashes, though pre-history may include such examples (for instance, the Anazazi of the U.S. Southwest). Some milder C-type contractions have been found--especially in the West Indies (ibid., 123, 70-71), associated with problems and competitiveness in the global sugar industry. Aging, on the other hand, has recently elevated death rates in several long-developed societies in such a way as to push numbers down in C fashion should immigration be curtailed (for instance, France, Norway, Yugoslavia, Japan, and the U.S.A. in Table M.3 as well as Italy in Figure M.6a). Once the peak of the imposed G’ surge in mortality has been reached in this form of intervention, however, the same kind of D path for decline in population size appears as when losses are multiplied all at once and allowed to taper off through only the downward phase of G’.

Where a population is growing, under this type of G’ manipulation of mortality rates numbers can increase--briefly via G’ in 1966 Madagascar, where the momentum for growth is moderately strong, much longer and via H in 1966 Mexico, where exponential expansion projects at a rate over .03 (Figure M.6b). Relative to these e^x base projections, however, numbers fall away in the same C fashion that is found for populations with more balanced birth and death rates. Compared with the base projections, furthermore--rotating the exponential gain to make it the horizontal axis--both the E then e^x trends in Mexico and the D then e^x trends in Madagascar serve as parts of longer departures that take D shape. As in the other two experiments of Figure M.6b, this is the same form of movement relative to base projection as for sudden G’ manipulation.

Crude birth rates and age structure also alter in response to the mortality changes experimentally imposed upon the four model populations in Table M.5. While these movements are less distinctively G-related in shape and less commonly shared across the different types of initial conditions, some are worth noting. In all manipulations, it should be remembered, age-specific fertility is held constant while mortality rates are altered.

Following a short spike in mortality, in the post-transition case of 1980 Italy and the peak-transition example of 1966 Mexico because of resulting changes in age structure the crude birth rate falls back for several decades in D form. The proportion of the population age 65 and older rises via G. Elsewhere, just a D pattern for 1980 Italy appears in the percentage under 15, and no clear G-related pattern in either birth rate or age structure for the pre-transition model or for 1966 Madagascar.

In response to abrupt mortality increase followed by tapering off in G' fashion, the second kind of manipulation in Table M.5, the crude birth rate and the proportion under 15 remain relatively flat or alter slightly in no clear pattern for the growing populations of 1966 Madagascar and Mexico. For the Italian population of 1980, however, C-type decline appears in both. In the pre-transition simulation, the CBR contracts via D while the percentage of the population under 15 rebounds gradually in G fashion. The proportion of persons 65 or older, in contrast, in all four experiments sags then recovers in D' fashion (via the first derivative of the D curve). Starting with the more balanced vital rates of the pre-transition model and 1980 Italy, this movement is eventually followed by increased aging in G form.

If age-specific mortality rates are made to first rise then fall in G' pattern, the third type of manipulation in Figures M.6a and M.6b and Table M.5, following some increase of various forms during the first years of simulation, the crude birth rate declines in D fashion in the pre-transition model, 1966 Madagascar, and 1966 Mexico-- but more like C in 1980 Italy. While nothing much in the way of G-related patterns appears for the proportion under the age of 15, in all four populations the percentage over 65 and older first contracts via C then expands--except in the pre-transition instance in G form.

In all, three different ways of experimentally increasing age-specific mortality while holding other properties of populations constant produce G-related movements in age structure and the crude birth rate, though not as clearly, simply, and consistently as for total demographic numbers. Not surprisingly, given the effect of multiplying mortality for mature people who have higher initial rates, such patterns are most evident in the proportion of populations in older age groups.

Infants and young children are particularly susceptible to inroads from disease, scarce food, and inadequate shelter. Employing the example of pre-transition conditions with high birth rates and high death rates, Figure M.6c first of all displays in its top half what happens to the size and composition of populations when, beginning with the 20th year of projection, a lasting doubling of mortality mostly affects infants and children under 5. Arrival of a disease that hits the very young but does not much affect mortality later in life--perhaps the diphtheria of New England during the first half of the 18th-century or certain kinds of famine are cases in point--might leave such an imprint.

With such a shock, the proportion of the female population under the age of 15 falls in D form for about 50 years before leveling out. The percentage 65 or older first rises in offsetting G fashion, than surges in G' shape before being cut back around the 80th year of projection as the first reduced cohorts of the very young reach old age. The CBR surges somewhat (perhaps in C" or G" fashion) as the number of births rises to a maximum with increase in the number of women age 20 through 39 from 26 to 39 percent between year 0 and year 30 of the projection, then drops back to level out. The size of the female population, meanwhile, contracts in C shape from year 20 through year 60 before declining along a log-linear slope of $e^{-.0246}$.

A second scenario, in the bottom half of Figure M.6c, doubles age-specific mortality rates cohort by cohort from those under 5 to those in their 80s. This experiment, beginning with the 5th year of projection, is designed to represent plausible cases where poor conditions in childhood subsequently also weaken older age groups who had began life in the new circumstances. The population again erodes via C then $-e^x$ paths, but appreciably more steeply than above in the figure, where just the very young are affected. The proportion of the elderly soars in E then more abrupt E' manner before crashing in C' form as doubled mortality rates finally reach those age 65 and over. The percentage of females under 15 dips as the first three age groups are accumulatively affected by the mortality increase introduced, then again as these women come of child-bearing age about three decades later. Eventually, during the third quarter of a century of projection, the proportion levels out--possibly in G fashion. The crude birth rate, meanwhile, first surges in G" or C" shape, then climbs for a generation before it, too, levels out in G form. This type of experience has probably been more common than child-only losses, since malnutrition and much disease tends to have a cumulative impact upon populations as affected cohorts mature.

Generally speaking, G-based patterns repeatedly appear in most aspects of the age structure of populations and in their crude birth rates as well as their numbers when mortality is increased in several ways that are familiar historically. Interested readers can experiment with the impact of still other types of mortality increase. The crude death rate in England, for example, rose in E fashion between the 1560s and the 1680s; but this change amounted to only about 40 percent increase over 120 years. E-type advances of comparable extent for infant and early childhood mortality occurred in parts of Germany during the first half of the 19th century--and to a lesser degree for the CDR's of Cyprus and perhaps Jamaica in the early 20th century (Figures 1.1 and 1.2; Figures C.8 and 5.11a; Figures 2.1g and 2.1i). On the other hand, some worsening of death rates in relatively flat G form appears in Japan, Costa Rica, and Chile in the late 19th century, in Lombardy during the late 18th, in some German communities in between, and in many global populations during the decades following World War II--probably related to aging (Figures 2.1a through 2.1h and C.9). Advances of mortality in this G fashion have tended to be even smaller in result than those of E shape.

Some Results from Reducing Mortality

Historically, in contrast, the transition to modern demographic regimes began with *improving* death rates. Previous chapters have displayed repeated declines of mortality in C shape--from some European nations, regions, and communities beginning in the second half of the 18th century to recently developing countries of several continents in the second half of the 20th. Still earlier contraction of mortality in this form occurred among English infants and young children in the years around 1600 and perhaps also among most English adults under 60 during the century after 1650 (Figures 1.9a and 10; Tables 1.4 and 1.5). Back in the later middle ages, in recovery from the Black Death, the estimates of R. D. Lee suggest improvement for the crude death rate of England in C fashion between 1374 and 1475 (Lee 1973; fitted in Harris 1997, Figure 12.2).

Figure M.7a demonstrates what happens to population size (for females) when schedules of age-specific mortality are reduced in C form following the 15th year of extrapolation. The C path is adjusted to reduce numbers by half between there and the 55th year of projection, then the level is held at 0.5 through the 100th year. That patterning approximates how C trends have often followed each other historically within populations, the first years of the new movement being very flat (for example, Figures 2.1a and 2.1b).

Where the projection begins with a relatively high death rate--as in the pre-transition model and, to a lesser extent, 1966 Madagascar--numbers clearly swell in accelerating E form for a few decades before growth settles into a new, elevated exponential path. In 1966 Mexico, whose population was already expanding thanks to robust birth rates and well-reduced death rates, the change in eventual exponential rate is slight, from .0321 to .0344, and E-shape transitional movement between the 20th and 40th years of projection is barely perceptible. In the contracting conditions of 1980 Italy, on the other hand, the effect of the C-shape modification of age-specific death rates is just to extend the C pattern of demographic decline another two decades or so before log-linear attrition is resumed.

Population increase in E form as modern demographic transition began (with birth rates still high but death rates already declining) is first observed in England and Ireland (and perhaps the Belgian provinces of Antwerp and Brabant, Dutch Friesland, and the Rhineland principality of Mark) about the 1720s; Denmark, Scotland, the Netherlands, and Iceland (also Württemberg and possibly East Flanders) within the next few decades; and, briefly, in France between 1792 and 1827, lasting longer in certain departments (Harris 2001, 148-49, 198-99, 208, 337; "Figure 6.2" for Belgium). Subsequently, in the middle of the 19th century it appears in Germany, Austria, Spain, Portugal, and Romania--and rather later (between 1880 and 1910) in Switzerland, Bohemia and Moravia, and Hungary (Harris 2001, 148-49). Certain regions of Russia also display this E pattern of population growth in the 19th century (ibid., 220-22), though the underlying movements of birth and death rates are not known.

In Latin America (Harris 2001, 114), in a few islands of the Caribbean (122-23), in Asia (250-51, 258-59; noticeable soonest in Japan, some regions of China, and Hong Kong), and in Africa (280-81; first in Algeria) E-type population increase can be linked to reduction in death rates before birth rates also contracted, the familiar 20th-century phenomenon of 'population explosion.' Earliest of all, E-shape growth may have taken place in certain provinces of China between 1491 and 1578 (Harris 2001, 266), though the role of relative changes in birth and death rates for this era is unknown. E-form expansions of the populations of some parts of Mexico from the later 17th century into the 18th, however, are indeed likely to reflect improvement in mortality accompanying relatively steady fertility as adjustment to the biological and economic consequences of Spanish invasion worked itself out (105, 109)--a recovery phenomenon also observed for several island populations of the Pacific in the 1900s (133). In all, E-type expansion resulting from C-form decline in death rates without matching decrease in birth rates (which the French population, for example, was more often able to achieve) has been a very common historical phenomenon, as projected by the experimental manipulations of Figure M.7a.

Figure M.7b, on the other hand, illustrates the consequences of reducing mortality in some other ways while retaining initial fertility schedules. The most significant changes appear for populations in which the death rate is still high, unlike Italy at 1980 or Mexico in 1966 (where the CDR had fallen to modern levels even though the CBR had not). Generally the most sensitive population of the four being manipulated is the pre-transition model, with fully pre-modern death rates. Madagascar at 1966 represents an intermediate case, with already partially reduced CDR, that displays less distinctive changes.

If mortality in the pre-transition model is cut in half for just one five-year segment of the century-long projection, at year 20, the size of the population jumps somewhat at that point but thereafter increases via two flat successive E movements that closely resemble overall the $e^{.003}$ path anticipated from the characteristics of the initial population (Figure M.6a). If, on the other hand, such a reduction of age-specific mortality rates is kept in force from year 20 forward, then demographic increase takes G shape through age 40 before climbing via $e^{.0217}$, the pace for 1966 Madagascar, whose mortality schedule was doubled to create the pre-transition model in the first place. There seems, however, to be little historical evidence for mortality reduction in either of these forms. Improvement in death rates appears usually to have been more gradual.

While not so common as decline in C shape, temporary but protracted historical reductions of CDR in D’ (1/G’) pattern have occurred fairly often in two kinds of historical settings. Preceding modern demographic transition in various countries, and also during recent decades as death rates have bottomed out, the D’ form has not infrequently appeared. In England between 1681 and 1731, then again between 1731 and 1761, CDR dipped in D’fashion (Figure 1.1). Comparable movements occurred in Sweden between 1693 and 1743, Finland, Norway, and Denmark slightly later, local and regional German populations between 1755 and 1795, and Bohemia and Moravia at the end of the 18th century (Figures 2.1a through 2.1d). In recent years, D’ movement has also characterized the ending of mortality declines in countries like Mexico, Venezuela, El Salvador, Chile, Fiji, Taiwan, Malaysia, China, Japan, and Sri Lanka, but also

France and Yugoslavia, as the impact of further health improvements has slowed and populations have aged along with declining fertility (Table M.3).

The third and fourth plots in Figure M.7b represent results when after the 15th year age-specific mortality is reduced in D' fashion by just under a third, .312, bottoming around the 40th year of projection and returning to the original level at year 75. This experiment captures the typical depth and duration of D' movements observed in several populations of northern and central early Europe during the early modern era. In the projection of Figure M.7b, for the pre-transition model (designed, as Table M.4 indicates, to mimic conditions like those in France under the *ancient régime*) population size first multiplies in accelerating E manner through year 40, then increases to year 80 or so in G fashion before reacquiring the $e^{.003}$ log-linear slope that is inherent in the base population that is used for projection. The females of Madagascar as of 1966, on the other hand, have a CDR that more closely represents levels found in pre-1825 England and Sweden--and France around 1800--where D' patterns in the crude death rate are at times well documented. For these Madagascar females, whose properties collectively resemble those of a population that has begun to enter transition, some continuation of inherent upwardly accelerating E-type growth from year 15 on to year 35 is followed by expansion in H form to year 80 before the $e^{.022}$ path of the base population is rejoined.

In fact, as Figure M.7b predicts, H-type growth has been associated with mortality reduction of D' form which occurred in certain early modern populations that were on the threshold of demographic transition. Most neatly, in England between 1681 and 1731, a D' dip in CDR that bottomed out at 1704 contributed to H-shape population increase between 1681 and 1726. Earlier furthermore, beginning around 1561, the people of England began to multiply in H fashion as their crude death rate sagged in D' form for about four or five decades starting in the 1540s. The GIP procedure of the Cambridge group shows this later conjunction more clearly than the method of the *Population History* (Figures 1.1 and 1.2; Harris 2001, 150). In Norway, too, what seems to be a shallow D' dip in CDR between 1743 and 1773 (Figure 2.1a) helped set off H-type population increase that unfolded between 1748 and 1818.

Elsewhere, D' sagging of CDR in Sweden from 1693 through 1743 can be documented overlapping only the end of a long era of H-type population growth from 1570 through 1720. For earlier years, however, the crude death rate there is simply unknown. D' dips in CDR for some locales in Germany and for the Czech lands of Bohemia and Moravia, meanwhile--between the 1750s and the 1790s and the 1780s and the 1810s, respectively--significantly precede documentable H trends of demographic expansion--but because information on the latter only begins in the 19th century, not due to any contrary evidence.

D' sags of CDR in England from 1726 through 1761 and in Denmark from 1737 or earlier through 1762, on the other hand, definitely appeared as population growth in E, not H, shape unfolded (1726 to 1806 and 1735 to 1801), and while in Finland from 1723 or sooner D' movement of the crude death rate is evident, parallel to that in Sweden, the population expanded along successive G paths, not via H. Though G-type demographic expansion with D' sagging in CDR is expected from totally pre-transition demographic regimes, in Finland the death rate was already well under 30 by the 1720s, clearly more like 1966 Madagascar than the pre-transition model. H growth that did occur in England from 1816 to 1861 and from 1861 to 1939, and in Denmark from 1801 through 1845, from 1850 to 1890, and between 1890 and 1845, furthermore, was not accompanied by D' dipping of the CDR (Harris 2001, 148; Figures 2.1a , 2.1c, 2.1d). D' sagging in the CDR, in other words, has been neither necessary nor sufficient to produce H-type population increase; but it has been one way that the H pattern can appear historically, evident especially for populations on the threshold of modern demographic transition.

Still another type of experiment in the consequences of reducing mortality is presented in the bottom plot of Figure M.7b. Here, beginning at the 5th year (the first interval of projection following the zero base) death rates for infants and for children under the age of 5 are cut by half. Then, at every subsequent interval the next older group is also affected by the reduction until at year 85 of projection females of all ages benefit from halved age-specific mortality relative to the base population at year 0. With this kind of manipulation, population size swells in accelerating E fashion through the 45th year. By this point, females of up through age 49 have reduced mortality. That is, the reduction has advanced through the fertile portion of the life cycle. From this point in the experiment forward, the population expands at an exponential rate of $e^{.0226}$, or about the rate for Madagascar females as of 1966, whose mortality was doubled to mimic pre-transition conditions of high fertility plus high mortality.

As for increasing mortality, reducing it in various ways--some historically familiar, some arbitrary--not only shapes population size in G-related forms. It also leaves imprints of this type upon crude birth rates and age structure.

The least effect appears for the percentage of the female population under 15. For all practical purposes, in the pre-transition, 1966 Madagascar, and 1966 Mexico cases this remains level when mortality is reduced in C shape, when it dips in D’ fashion, and when it is pared back progressively starting with the young. A relatively constant proportion in this age bracket has also been found in the base populations for these experiments. The exception is D-type contraction for 1980 Italy with each of the three kinds of modification lowering mortality. In the case of Italy, however, D’ atrophy also is inherent in the original population being manipulated. The shape comes from there, not from various ways of reducing mortality.

The trends in birth rates for experiments on 1980 Italy also reflect the D shape characteristic of projection from the original, unaltered population. Similarly, when mortality for the female population of Mexico in 1966 is halved over time via C, the level movement of the base population is replicated. What 1980 Italy and 1966 Mexico share is low modern death rates. In the case of 1966 Madagascar, which had partially reduced death rates, slight G-shape increase over time in the CBR with the original projection disappears both when mortality rates are lowered in C form and when they are made to sag via D’. Both trends become virtually level. Whereas temporary reduction of mortality in D’ fashion retains the flat trend of the CDR, to cut death rates via C from their high starting point in this population pushes down the birth rate in D manner between the 15th and 60th years of projection as older females constitute more and more of the population. A similar effect appears if mortality is reduced first among the young, then diffused up the age scale.

The percentage of females 65 or older, a relatively small part of populations, alters most of all with reduction of age-specific mortality rates. Even in comparatively imperturbable 1980 Italy, while the sagging D' pattern does not change the G trend for the elderly found in the original, aging population, to cut back death rates in C form turns G-type accumulation into accelerating E expansion. A similar replacement occurs for 1966 Mexico. In 1966 Madagascar, meanwhile, though a G' surge for four decades of projection in the base population is retained with mortality reduction in C form, C-shape decrease in the percentage of females 65 and over occurs instead for a long while when age-specific death rates are made to dip in D' manner. In the pre-transition model population, on the other hand, original G' movement for the share of the elderly in projection becomes C-shape decline when mortality is sagged in D' form or expanded from the very young on up through older age groups, while, if cut back via C, makes the percentage of females 65 and over rise increasingly in E manner.

In all, both raising and lowering mortality schedules tends to shape trends of population size, age distributions, and even birth rates in familiar G-based forms. Holding age-specific fertility constant, simply grinding arbitrary or historically observed alterations in mortality through the internal interactions of demographic systems that constantly include the underlying C and C' distributions in age structure and survivorship identified in Chapter L over and over again produces very simply connected G-related forms of change in populations.

Consequences of Reducing Fertility

Raising or lowering levels of age-specific fertility while holding death rates constant also makes imprints of G-connected form upon age structure and even crude birth rates. Certain historically familiar or imaginable ways of reducing reproduction, first of all, generate such patterns. Using the same four illustrative populations, Table M.7 summarizes the impact upon numbers of females resulting from different ways in which fertility has declined or can be expected sometimes to do so. Figures M.8a and M.8b fit certain of these trends, others--denoted by “*”--are estimated by template.

For the historically recorded populations, mostly beginning as pre-transition peoples with almost equally high birth and death rates, the most frequently observed pattern for fertility decline has been of C shape--starting downwards slowly but progressively accelerating until some lower threshold is reached. This is the typical way that fertility has contracted as ‘demographic transition’ diffused across human societies. Many examples have been observed across the 19th and 20th centuries: for crude birth rates and for overall, marital, and extramarital fertility (Chapters 2 and 4); and several local, regional, or national instances reach back into the 18th century (Chapter 5). In England, indeed, C-shape declines in crude birth rate and gross rate of reproduction appear as early as between 1556 and 1661 (Figures 1.1 and 1.2), long before reemerging there with modern transition after 1850. Figure M.8a and Table M.7 show, first of all, how for a pre-transition population, which projects slow inherent growth (“base”) because of near balance in births and deaths, to cut births in half, step by step, between the 15th year of projection and the 55th in C fashion produces contraction in C form for over five decades before Euler’s log-linear expectations are fulfilled starting with the 75th year.

In the example of post-transition 1980 Italy, where some shortfall of births relative to deaths already promises a little C-shape contraction from the base population, the effect of C-type reduction in age-specific birth rates for 40 years is to steepen the C-form decline in female numbers, moving the zero year for the curve from 106 to 86 before exponential shrinkage takes over about year 80. In the early transitional 1966 population of Madagascar, in whose base births exceeded deaths sufficiently to produce projected growth at a pace of $e^{.0216}$, reducing fertility by half via C over 40 years drags increase down from this exponential pace into G form before virtually flat log-linear movement appears around the 80th year. For 1966 Mexico, meanwhile, where a typical maximum domination of births over deaths--historically typical of the peak of transition--exists, comparable C-shape decline in fertility pushes increase in population from its $e^{.0321}$, or approximate F, pattern into H-form expansion instead as far as the 80th year of projection, where relatively slow exponential growth replaces it.

Each of these last two cases of shift into decelerating expansion has many examples among the international populations described in Volume I. Typically the change has occurred as birth rates began to fall only considerably after death rates during modern transition, contraction of fertility that--as noted--demonstrably took C form. If death rates, on the other hand, did not decline before birth rates, the pre-transition model in Figure M.8a indicates, such populations would have declined. That in effect happened to the English population in the 17th century, as between 1556 and 1661 the CBR shrank via C while the CDR rose somewhat via E rather than falling. This combination pushed the rate of natural increase into C-shape decline until it went negative between 1666 and 1681, when a dip in death rates provided relief. Population size, however, actually contracted via D rather than via C thanks to a collapse of that shape after about 1660 in what had been substantial net emigration (Figures 1.1, 1.2, 1.3).

Less frequently, certain other types of trends in reducing reproduction have been observed. D-shape movement has occurred for crude birth rates in late 20th-century Austria, Ireland, and Fiji (Figures 2.2f, 2.2c, 2.2j). Previously, decline in this form appeared in the Paris basin for marital fertility from 1790 through 1880 (Figure 5.1a) and for the crude birth rate and gross reproduction in England during the first half of the 19th century (Figures 1.1 and 1.2). Dipping in D’ form, meanwhile, shows up for birth rates in Denmark and Sri Lanka in the late 1900s, and for marital and overall fertility in England across the second quarter of the 19th century. Reduction of fertility beginning with older women and spreading to young ones, on the other hand, has been seen from the later 17th century to the present. It is conceivable, in contrast, that younger women might curb fertility first in a change of sexual norms, spreading the practice to older cohorts as they matured. The results of two other hypothetical manipulations are also reported in Table M.7: reducing age-specific fertility by half all at once, leaving it at this lower level, and cutting it this much just at the 20th year of projection as might happen as the result of a war or a depression.[21]

The main point about these different ways of reducing fertility, which Table M.7 shows, is that the variations in procedure make little difference. For several decades, all methods produce for 1980 Italy C-shape declines in numbers that are to varying degrees somewhat steeper (having earlier target years) than the trend of this shape that is inherent in the original population. The almost level log-linear projection of the pre-transition model is with one exception transformed also into C shape declines. That is for 35 years in the one-time shock modification, where a very flat G segment appears instead. For early-transitional 1966 Madagascar, all projections of numbers commence with G trends rather than the fairly strong exponential growth expected from the base population, while in peak-transitional 1966 Mexico H-type increases taper off below the original F path.

As demonstrated by Euler, when fertility eventually stabilizes at a new level, exponential growth or decline takes over. One exception, the C for 1966 Madagascar if fertility is suddenly and permanently halved at year 20, is so flat that it might well in fact involve slight exponential contraction. The other three cases all result from D’ sags which over time re-elevate fertility rates after lowering them. D-type population decline approaches zero growth in the pre-transition model (Figure M.8a). Beginning with larger surpluses of births over deaths, the 1966 populations of Madagascar and Mexico instead display E-type expansion during the second half-century of projection (Figure M.8b). Once again, however--as with mortality increases in Figures 6.a and 6.b--these E patterns represent paths along which population growth drops below the original exponential trend in D-like manner to assume eventually parallel, if lower, log-linear paths.

It should be remembered that change in age-specific fertility rates does not automatically entail comparable trends in crude birth rates. Table D.1 in Appendix D presents estimated movements in CDR that result from altering age-specific fertility in various ways for the four illustrative populations.

Excepting only 2 of 24 experiments, after a few decades of projection the CDR approaches a new level along a D path. In the case of a permanent down-shift for the pre-transition population at the 20th year a slight G' rise leads directly into new level movement. In 1980 Italy, on the other hand, the increase in age-specific fertility as the D' sag wears out suffices to increase the CBR after its decline, making the trend take E' rather than D form across the second half of a century of projection.

The C pattern of decline in CBR has been observed as a very common feature of modern 'demographic transition' (Chapter 2, for instance); and limitation of offspring starting with older females has played a characteristic role in this reduction Chapters 1, 5, and 6). During the earlier decades of manipulation, halving fertility rates beginning with older women then moving step by step across younger child-bearing ages produces C-shape decline in CBR for all four types of populations. So does this sort of modification if reversed from young to old in the cases where fertility in the base population for projection is still high, the pre-transition model and 1966 Madagascar. In 1966 Mexico and 1980 Italy, in contrast--where fertility is already down to modern levels--D trends result instead. The arbitrary, and rather exaggerated, diffusion of cuts in fertility in age sequence, especially from older to younger females at risk, of itself produces the kind of C-type contraction in CBR that has been so historically significant. Cuts passing from young to old might be expected to result from abandonment of traditional family norms by certain cohorts who then took their reproductive changes along with them as they aged. Perhaps because the base population already has low birth and death rates and is inherently declining via C, a sudden shift downward in age-specific fertilities for 1980 Italy likewise reduces the CBR over some time in C fashion--as does D' curtailment.

In contrast, to cut back age-specific fertilities simultaneously via C, except in Italy, in fact *increases* CBR in E manner before it eventually falls in typical D mode as the changes pass through growing populations. The E pattern also appears with D and D' reductions where the gap between births and deaths is substantial at the start of projection, as in Madagascar and

Mexico, and with the D form of manipulation in the pre-transition model. G-type increase in CBR, meanwhile, occurs only with D' alteration in the pre-transition population, or temporary relief. A simple, lasting downward shift in the level of age-specific fertilities, however, generates G' swelling in the CBR in all populations but post-transition Italy.

FILL IN why certain forms historically important.

SUMMARY: In all, the shape of the trend

in spite of historical changes in this distribution, a concentration of the bulk of childbearing among women in their 20s and 30s subordinates effects

2 sections on changing fertility

{Please note that, obviously, the conclusion of Chapter M was conceptualized but was not fully developed (I could not find anything in Harris's notes). MSW 31 July 2015}

Notes

1. In 47 fertility schedules with which Coale worked closely, the mean age of $\phi(a)$, the net fertility schedule or $p(a)m(a)$, ranged from 25.8 to 32.2 years (1972, 74).

2. Coale's illustration is in fact for a female population with a mean net fertility function of about 32 years.

3. The mean being about 26 (ibid. 22; Keyfitz and Flieger 1985, 81).

4. For a much shorter span (from 25 through 9.5 years), the combined highs seem to follow a C trajectory anchored near .82 in the vicinity of 48 years.

5. England and Wales for survivorship in Table L.4.

6. They are just estimated by template.

7. In Russia, prolonged by years of civil war.

8. Data from the U.N. *Demographic Yearbook* indicates continuation of this F trend through 2004.

9. In one such movement to 1985 according to Keyfitz and Flieger (1990, 66); perhaps through 1998 in two successive surges before and after 1970 (Harris 2001, 281; U.N. *Demographic Yearbook* 2004).

10. Following a previous G of 1945 to 1965 with zero year at 1931.

11. Racist, social Darwinist complaints were of course a feature also of the late 19th century.

12. As presented by xxx Israel or Jan de Vries and Aud van der Woude.

13. These trends include, as appropriate, observations of actual population size for some years before the date of projection in the 1980s. Where this is the case, the starting date is given in italics in Table M.2.

14. Exceptions may exist in the Dominican Republic (Harris 2001, 122) and French Polynesia (131), while the deep, pre-Andean interior Acre region of Brazil has been more of an old-fashioned geographical frontier (129).

15. The H and G curves hold quite close to each other, and also to the F line, through years near t_0. It requires several years of data before or after this point, particularly when observations or estimates are spaced apart (as in the censuses employed to pattern Mexican growth in Volume I), to differentiate

confidently between such related possible paths.

16. An asterisk marks where their estimates extend patterns beyond the last actual observation of GRR (and certain other variables).

17. As noted, the reversed C' pattern (rising somewhat more flatly and falling more steeply) probably better suits the case of Mexico. But it maximizes in the same years.

18. The 1966 patterns for age structure among Madagascar females appear in part A of Table M.4. The somewhat steeper alternative tapering presented in part B appears when the modified birth and death rates are allowed to work on the initial population for several decades. Eventually such iteration also raises initial CBR and CDR slightly, to about 49, as from the 25th year forward the modified population stabilizes to have growth at the modest rate of just $e^{.003}$ or a CRNI of 0.3.

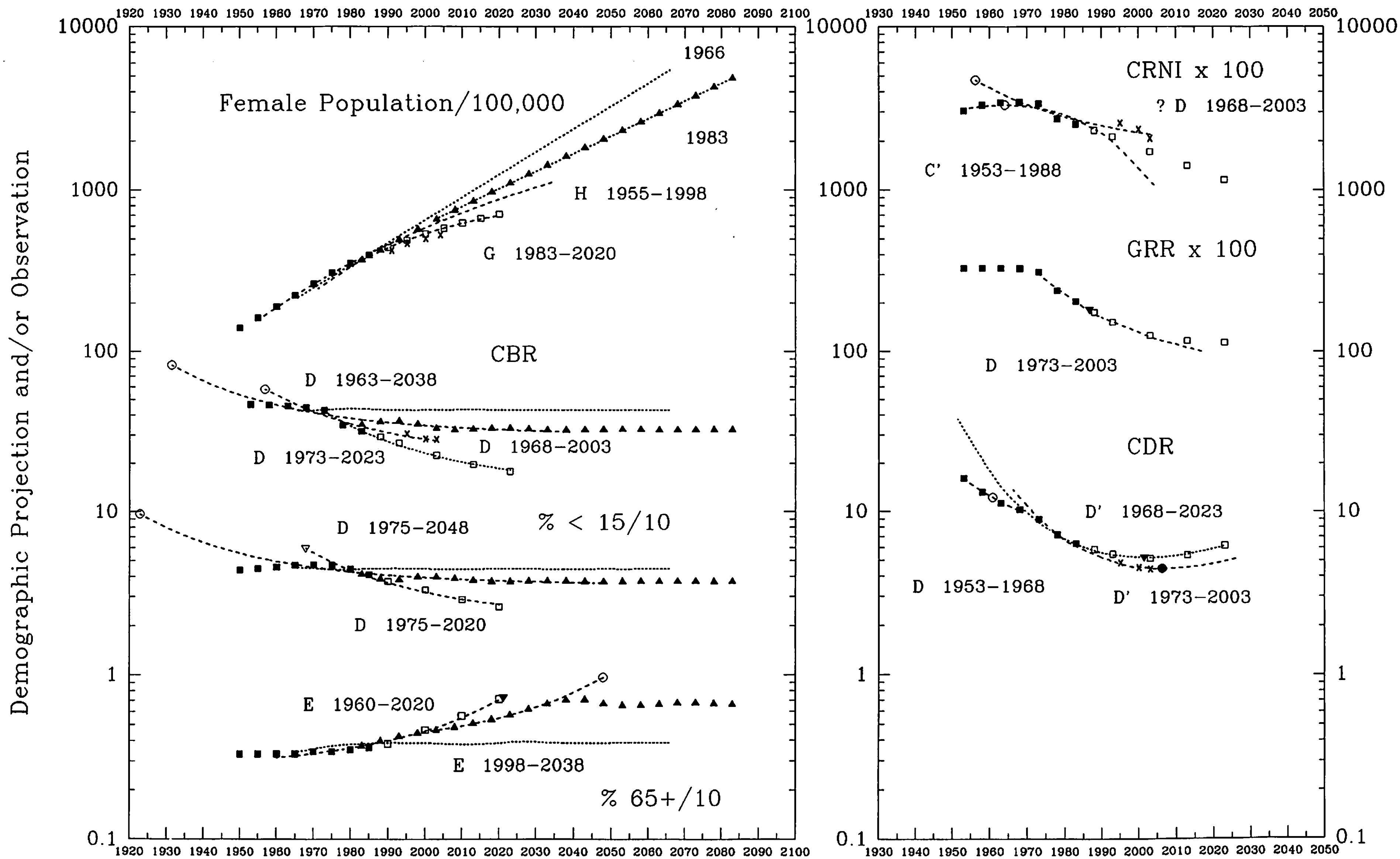
19. In the pre-transition model this trend follows 25 years of G' growth that could for its first two decades be said to have taken the form of an earlier G.

20. Though a G' curve is not fitted there.

21. All experiments commence following the 15th year. To move from old to young, age-specific fertility for those 40 to 44 is halved at year 20. Similar reduction is also made for those 35 to 40 at year 25, and so forth, until all females of child-bearing age are affected. Moving from young to old, conversely, starts with those 15 to 19 and moves up the life cycle. Births under 15 and over 45 are sufficiently infrequent to be ignored. These procedures in fact exaggerate the effect of movement across age cohorts, where the record more typically shows successively lagged C patterns of decline in fertility (for example, Figures 5.7, 5.8, and C.7; Table 5.6v ADD?), which sum into total contraction taking that shape.

Figure M.5a

Demographic Projections vs. Observed Trends: Mexico



Sources: Keyfitz and Flieger 1971, 344; 1990, 314, 189; UN Demographic Yearbook, 2004..

Table M.2

Momentum in Size from Initial Age Structure and Vital Rates

(selected female populations assuming no net migration)

	Date	CBR	CDR	NI[a]	Projected Trends in Size of Population							
A. Stable at Approximately F (.03)												
Mexico**	1966	42.5	9.0	33.5	1966-2066	$e^{.0328}$						
	1983	34.8	4.8	30.0	*1955*-1998	H	1974				2003-2083	$e^{.0248}$
Venezuela	1965	43.3	6.7	36.7	1965-2065	$e^{.0344}$						
	1985	28.7	4.0	24.7	*1965*-2025	H	1976				2025-2085	$e^{.0175}$
El Salvador	1961	47.9	10.3	37.5	1961-2061	$e^{.0328}$						
Algeria*	1965*	43.0	9.2	33.8	1965-2065	$e^{.0330}$						
B. Entering F Stability												
Madagascar*	1966	43.7	24.6	19.1	1966-1986	E	1990	1986-2066	$e^{.0271}$			
Pen. Malaysia	1966	35.8	6.6	29.3	*1960*-1991	E	1980	1991-2066	$e^{.0304}$			
	1985	30.0	5.4	24.6	1985-2025	H	1971				2015-2085	$e^{.0192}$
Fiji	1966	34.7	4.4	29.3	1966-1986	E	1979	1991-2066	$e^{.0258}$			
	1980	29.3	5.4	24.0	1980-2020	H	1961				2025-2080	$e^{.0149}$
Taiwan	1966	32.4	4.9	27.5	1966-1996	E	1977	1996-2066	$e^{.0264}$			
	1985	18.0	3.9	14.1	*1956*-2040	G	1961	2030-2065	C	2110	2040-2085	$e^{-.0038}$

C. In or Entering H Growth												
Ceylon-Sri Lanka	1967	32.4	7.0	25.4	1967-2007	H	1968				2007-2067	$e^{.0230}$
West Cameroon	1964*	44.6	23.5	21.1	1964-2004	H	1937				2004-2064	$e^{.0153}$
China	1981*	20.7	6.2	14.5	1981-2001	E	2015	2001-2036	H	1913	2036-2081	$e^{.0056}$
Chile	1967	27.6	8.4	19.1	1967-1987	E	1992				1987-2067	$e^{.0163}$
	1980	24.2	7.8	16.4	*1950*-2025	H	1925				2025-2080	$e^{.0049}$
D. G Growth Then C Decline												
France	1967	16.1	10.3	5.8	1977-2002	G	1942				2002-2067	$e^{.0077}$
	1985	13.2	9.4	3.9	*1946*-2010	G	1929	2010-2050	C	2097	2045-2085	$e^{-.0045}$
U.S.A.	1966	17.6	8.1	9.5	*1945*-1986	G	1935				1986-2066	$e^{.0054}$
	1985*	15.0	8.1	6.9	*1945*-2025	G	1937	2025-2050	C	2107	2040-2085	$e^{-.0041}$
Norway	1967*	17.1	8.7	8.4				1972-2052	C	2052	2037-2067	$e^{-.0213}$
	1985	11.8	9.8	2.0	*1951*-2000	G	1921	2000-2050	C	2087	2050-2085	$e^{-.0075}$
Japan	1966*	13.0	6.1	6.9	1966-1991	G	1922	1991-2041	C	2069	2041-2066	$e^{-.0096}$
	1980	12.9	5.6	7.3	1980-2010	G	1935	2010-2040	C	2076	2030-2080	$e^{-.0059}$
Yugoslavia	1966	19.2	7.7	11.4	1966-1991	G	1942				1996-2066	$e^{.0057}$
	1985	17.3	8.2	9.1	*1980*-2015	G	1937	2020-2060	C	2125	2060-2085	$e^{-.0015}$
E. Other												
East Germany	1967*	13.3	12.8	0.5	1967-2027	E	2093				2017-2067	$e^{.0029}$

* Fitted in Figure M.4a or M.4b; ** fitted in Figures M.5a through M.5x.
Italics denote starting date where trend reaches back before base year of projection.
[a] May differ from CBR - CDR by rounding.

Sources: Keyfitz and Flieger 1971 and 1990.

Table M.3

G-Related Momentum Changes in Population Size, Age Structure, and Vital Rates

A. Populations Slowing from F-Type ($e^{.03}$) Growth

	Momentum:		*Actual:*	
Population	1960s	1980s		Natural Increase
Mexico	1966-2066 $e^{.033}$	1955-1998 H 1974	1960-2004 G 1970	1953-1988 C' 1964*
Fiji	1966-1986 E 1979 1991-2066 $e^{.026}$	1980-2020 H 1961	1950-1997 G 1959	1968-1998 C' 1976
W. Malaysia	1960-1991 E 1980 1991-2066 $e^{.030}$	1985-2025 H 1971	2060-2004 H 1966	1978-2004 C' 1978
Venezuela	1965-2065 $e^{.034}$	1965-2025 H 1976	1965-2004 H 1973	1953-2000 G' 1955
Algeria	1965-2065 $e^{.033}$	-	1953-1975 E 1975 1975-2004 G 1984	1953-1983 C' 1975 1983-2001 D? 2001
El Salvador	1961-2061 $e^{.033}$	-	1950-1970 E 1961 1960-1990 G 1966	1963-1983 C' 1965
Taiwan	1966-1996 E 1977 1996-2066 $e^{.026}$	1956-2040 G 1961	1956-1985 G 1961	1956-1975 C 1959 1970-1985 C' 1954
Crude Birth Rate				Gross Reprod. Rate
Mexico	1966-2066 flat	1963-2038 D 1931	1968-2003 D 1957	1973-2003 D 1987*
Fiji	1953-2026 D 1922 2026-2066 flat	1985-2010 D 1950	1958-1998 D 1950	1958-2013 D 1970*
W. Malaysia	1976-2066 flat	1958-2045 D 1938	1963-2000 D 1952	1963-1988 D 1967*
Venezuela	1965-2065 flat	1975-2045 D 1948	1963-1988 D 1947*	1963-2023 D 1967*
Algeria	1965-2065 flat	-	1953-2002 C' 1962	1958-2003 C' 1969*
El Salvador	1966-2061 flat	-	1953-1978 C' 1959	1953-1983 C' 1963
Taiwan	1966-2066 flat?	1960-2060 D 1970	1960-1980 D 1967	1956-1975 C' 1936 1975-1985 C' 1950

	Momentum:		*Actual:*	
<u>Percent under 15</u>				
Mexico	1950-1975 G 1895 1975-2066 flat	1975-2048 D 1923	1950-2003 C' 1967	
Fiji	1976-2066 flat	1965-2045 D 1945	1950-1985 G' 1952	
W. Malaysia	1976-2066 flat	1958-2045 D 1937	1950-1985 G' 1962	
Venezuela	1965-2065 flat	1975-2045 D 1947	1950-1985 G' 1961	
Algeria	1965-2065 flat	-	1955-2000 G' 1973*	
El Salvador	1971-2061 flat	-	1950-1975 G' 1962	
Taiwan	1971-2066 flat	1963-2050 D 1969	1950-1985 G' 1947	
<u>Percent 65 or Older</u>				<u>Crude Death Rate</u>
Mexico	1966-1986 G 1928 1986-2026 flat	1950-1998 E 2025 1998-2038 E 2048	1960-2020 E 2021*	1953-1968 D 1961 1973-2003 D' 2006
Fiji	1966-2036 G 1960	1970-2000 G 1974 2000-2025 E 2027 2025-2055 G' 2039	1970-1990 G 1974*	1953-1998 D' 1991
W. Malaysia	1981-2016 flat	1985-2000 E 2025 1995-2030 E 2040	1965-2010 E 2024*	1953-1968 C 1950 1968-2004 D' 2005
Venezuela	1970-2000 G' 1987 1995-2020 D 1954	1980-2010 G 1977 2005-2030 E 2036	1950-1990 G 1947*	1953-1973 C 1963 1963-2013 D' 1993*
Algeria	1965-1995 G' 1979 1995-2065 flat	-	unclear	1953-1997 C 1975
El Salvador	1961-1996 G 1928 1996-2061 flat	-	1965-1985 E 2005	1958-1983 D' 1986
Taiwan	1966-2021 G 1952	1980-2015 G 1992 2015-2061 G' 2047	1965-1990 E 1982*	1956-1970 C 1948 1956-1985 D' 1990

Table M.3 (cont.)

G-Related Momentum Changes in Population Size, Age Structure, and Vital Rates

B. Post-'Transition' Populations Projecting Contraction

	Momentum:		*Actual:*	
Population	1960s	1980s		Natural Increase
France	1977-2002 G 1942 2002-2067 $e^{.008}$	1946-2010 G 1933 2010-2050 C 2097	1945-2004 G 1925	1946-1978 C" 1959 1995-2004 C" 2007?
Norway	1972-2052 C 2052	1951-2000 G 1921 2000-2050 C 2087	1951-1990 G 1925 1990-2004 G 1946	1951-1983 C" 1964 1983-2004 C" 1999
Yugoslavia	1966-2001 G 1942 1996-2066 $e^{.006}$	1980-2015 G 1937 2020-2060 C 2125	1950-1985 G 1930	1953-1978 D 1951
Japan	1966-1991 G 1922 1991-2041 C 2069	1980-2010 G 1935 2010-2040 C 2076	1965-2004 G 1925	1958-2004 C" 1966
Crude Birth Rate				Gross Reprod. Rate
France	1977-2067 flat	1968-2085 D 1949	1936-1985 G' 1951 1968-2004 D 1934	1936-1958 C" 1951 1958-1978 C" 1962
Norway	1987-2042 D 1978	1967-2075 D 1955	1950-1983 G' 1947 1960-2004 D 1936	1951-1978 C" 1960
Yugoslavia	1986-2066 flat	1953-2015 D 1950	1953-1983 D 1950	1963-2003 D 1943*
Japan	1976-2026 D 1961	1980-2050 D 1950	1953-1983 G' 1944 1973-2004 D 1983	1953-1988 D 1930*
Percent under 15				
France	1967-2067 flat	1975-2055 D 1952	1946-1985 C' 1968	
Norway	1972-2042 D 1974	1975-2050 D 1955	1951-1983 C' 1963	
Yugoslavia	1966-2026 D 1926	1965-2030 D 1946	1951-1975 C' 1957 1965-1985 D 1944	
Japan	1966-2066 D 1948	1980-2030 D 1960	1940-1965 C' 1938 1950-1980 D 1942	

Percent 65 or Older				Crude Death Rate
France	1955-1997 G' 1977 1987-2067 flat	1985-2030 E 2050	1950-1980 E 2009	1953-1983 D' 1970 1983-2004 D' 2015?
Norway	1972-2007 C' 1997 2007-2037 G 2012	1985-2005 C' 1994 2010-2055 C' 2046	1951-1985 G 1941	1957-2004 C' 1985
Yugoslavia	1966-2026 G 1955	1985-2035 G 1977	1950-1980 E 1989	1953-1993 D' 1978
Japan	1966-1991 G 1975 1991-2021 G 1990	1980-2020 G 1991	1950-1985 E 1985	1953-2004 D' 1977

Table M.3 (concl.)

G-Related Changes in Population Size, Age Structure, and Vital Rates

C. Some Other Combinations of Movements

	Momentum		*Actual*	
Population	1960s	1980s		Natural Increase
Madagascar	1966-1986 E 1990 1991-2026 $e^{.027}$	-	1950-1965 E 1966 1965-1985 E 1984 1985-2004 F	1953-1998 G 1924 1973-2020 C' 1996*
Cameroon	1964-2004 H 1937	-	1950-1975 E 1978 1970-1998 E 1992	1963-2020 C' 1996*

China	-	1981-2001 E 2015 2001-2036 H 1913	1950-2004 H 1924	1978-2004 C' 1966
Chile	1967-1987 E 1992 1987-2067 $e^{.016}$	1950-2025 H 1925	1950-2004 H 1933	1953-1973 C" 1970 1958-1983 D 1949

Sri Lanka	1967-2007 H 1968	-	1955-1985 G 1958	1953-1968 C" 1958 1973-1988 C" 1977*
U.S.A.	1945-1986 G 1935 1986-2066 $e^{.005}$	1945-2025 G 1937 2025-2050 C 2107	1940-2004 H 1899	1953-1973 C" 1952 1983-2004 D 1949
Crude Birth Rate				Gross Reprod. Rate
Madagascar	1966-2006 G 1926 2006-2066 flat	-	1953-1973 G' 1957 1978-1998 G' 1982	1953-1983 flat 1983-2023 C' 1992*
Cameroon	1964-1989 G' 1974 1989-2064 flat	-	1953-1968 G' 1952 1968-1998 G' 1976	1953-1968 flat 1968-1993 C' 1982*

China	-	1981-2071 D 1957	1953-1983 C' 1947 1983-2004 C' 1976	1953-1983 C' 1948 1978-2013 D 1968*
Chile	1967-1997 G' 1979 1997-2067 flat	1980-2005 G' 1980 1990-2020 D 1958	1953-1978 C' 1949 1978-2004 C' 1975	1953-1978 C" 1959 1963-1983 D 1971

Sri Lanka	1967-1997 G' 1980 1997-2067 flat	-	1953-1978 D 1932 1978-2003 D 1980*	1953-1973 C' 1939 1968-2003 D 1976*
U.S.A.	1966-1986 C" 1948 1976-2066 D 1932	1985-2035 D 1959	1950-2004 D 1941	1953-1973 C" 1955 1973-2023 D 1931*

	Momentum		*Actual*	
Percent under 15	1960s	1980s		
Madagascar	1966-2066 G 1916	-	1965-1985 G 1924	
Cameroon	1964-1979 D 1936 1979-2064 flat	-	1950-1985 G 1908	
....				
China	-	1981-2051 D 1951	1965-1990 C' 1962*	
Chile	1977-2067 flat	1980-2080 D 1953	1965-1985 C' 1965	
....				
Sri Lanka	1977-2067 flat	-	1959-1980 C' 1964 1970-1990 D 1959*	
U.S.A.	1966-2066 flat	1965-2040 D 1953	1955-1980 C' 1956 1965-1995 D 1949*	
Percent 65 or Older				Crude Death Rate
Madagascar	1971-2011 G' 1975	-	1965-1990 G' 1977*	1953-1998 D 1946
Cameroon	1964-1999 G' 2003 2004-2039 G' 2024	-	1965-2000 G' 1983*	1950-1998 D 1943
....				
China	-	1986-2011 G 1964 1991-2036 E 2037 2016-2046 G' 2043	1970-1990 E 2009*	1953-1973 C 1940 1973-2004 D' 1996
Chile	1972-2012 G 1956 2012-2042 G' 2028	1980-1995 E 2011 1995-2030 E 2036 2015-2055 G' 2040	1950-1980 E 2004 1980-2000 E 2033*	1953-1983 C 1985 1973-2004 D' 2002
....				
Sri Lanka	1977-2012 G 1954 2012-2042 G' 2025	-	1960-2000 E 2008*	1953-1973 D' 1981 1973-2003 D' 1997*
U.S.A.	1966-2006 G' 1989 2011-2046 G' 2032	1985-2010 G 1946 2010-2050 G' 2037	1925-1966 G 1919 1966-2010 G 1941*	1920-1953 C 1979 1953-1983 C 2023 1983-2004 C 2052

* Keyfitz and Flieger 1990 estimations employed to extend trend.

Sources: Keyfitz and Flieger 1971, 1990; U.N. *Demographic Yearbook*, 1995, 2000, 2004.

Three Kinds of Conclusions:

Recurrent Patterns of Change, Their Origins, and Their Implications

A reexamination of the history of England since the 1500s (Ch. 1), reveals that many aspects of demographic change followed G-based patterns previously identified in population growth or decline (Vol. I), and in migration--along with the urbanization and economic development accompanying it (Vol. II). These forms of change have likewise appeared internationally in basic birth and death rates since records for countries begin (Ch. 2). Such patterns cast new light upon the meaning of familiar phenomena like ‘demographic transition’ and ‘population explosion’ that result from the interaction of these vital rates to produce natural increase (Ch. 3). The rich, varied, and long-accumulating histories of fertility and childhood mortality in countries, regions, and locales of Europe (Ch.’s 4 and 5), of ‘offshoot’ societies of northern Europe overseas (Ch. 6), and of Latin America, Asia, and Africa (Ch. 7) can be better delineated, compared, and understood through the ways in which they share or do not share particular G-based changes, contemporaneously or in succession.

The origin of repeated, pervasive G-connected types of movement in populations lies in the nature of adult mortality during the active years between childhood and quite old age (Ch. 8). Rates of death by age for particular causes, which themselves mostly take E’ form, compound to generate trends for overall age-specific mortality that are even more consistently of E' type. These movements in the total 'force of mortality' produce patterns of C then C' shape in survivorship. These in turn imprint that C-to-C' succession of paths upon age structure. Most importantly, the C form constantly emerges for the long portion of the life cycle between puberty and old age during which family formation, reproduction, education, and work take place and most decision-making occurs.

Every change in a population, in short, passes through a replacement process whose every result is affected by the C-type shaping (G reversed in time) of most of each successive age distribution. The ubiquitous consequences of this shaping that imbedded in the renewal process are demonstrated, on the one hand, by projecting populations with current birth and death rates and, on the other, by imposing historically familiar forms of gradual change or concentrated shocks upon schedules of fertility and mortality to show how various G-related patterns emerge (Ch. 9). Finally, the economic and social history of England once again serves to illustrate how population changes in G-connected forms have interacted with, shaped not just reflected, developments beyond the demographic regime. In fact, due to the way populations absorb change, G-based curvatures pervade the historical course of many aspects of human life.

Three types of conclusions emerge from the volumes of this study:

The historian can see where certain familiar phenomena have appeared, in what eras or cultural settings, observing better which of his/her own findings have been common human experience, which have been more distinctive and how. Recognizing the G-based shapes of trends facilitates and enriches categorization and comparison, improving interpretation of how various development unfolded historically.

The student of populations can better grasp how familiar demographic processes operated and connected, and took certain shapes because of the way that the process of demographic renewal continually reflected the G-in-reverse C imprint in age structure over the long, most significantly active segment of the life cycle between adolescence and old age. The elements of this G-based system of demographic change are all familiar: the proportionally accelerating nature of contraction in the C path for adult mortality, the .03 constant of unfettered log-linear growth, the momentum of stabilization toward log-linearity, and a significant root in replacement somewhat under 25 years, which makes the demographic regime most sensitive to random shocks at such an interval, are gifts from Gompertz, Franklin, Euler and his successors, and Coale. What the new analysis does is to show how they fit together in ways not observed before to create a more insightful way of looking at demographic change.

The economist or other social scientist, finally, can learn how the internal dynamics of populations imprint their own G-related forms upon many other types of change in human life. Relationships between or among: work and marriage; births and wages; population increase, urbanization, and economic growth; values, demographic stress, and illegitimacy; occupational change and urbanization; education, nuptuality, and fertility are shown in the history of England to have repeatedly taken G-based paths. This has been because each of these changes has occurred in a population that continually replaced itself along lines shaped by the G-based nature of its age structure. The implication is that today's projections of many sorts will comparably follow G-related trajectories generated by the way that this imprint is imbedded in the process of renewal, not an insignificant addition to the social sciences.

COMMON FORMS OF HISTORICAL DEMOGRAPHIC CHANGE

Certain patterns of demographic change have permeated the history of populations in diverse eras and cultural contexts. To what extent did these phenomena repeatedly occur for the same reasons? Or did a given result derive from a variety causes? As part of a conclusion for this study, it seems useful to summarize findings for a few prominent forms of demographic change.

Overall fertility decline in C shape, so pivotal for recorded demographic change in the 18th, 19th, and 20th centuries, has been first explored in England from 1558 to 1663 (Fig. 1.4). There it accompanied C-type decrease in infant mortality between 1580 and 1640, though losses for children 1 through 4 rose after falling this way from 1580 through 1610 and the crude death rate climbed via E (Figs. 1.8a, 1.1). The general reduction of fertility was accomplished primarily through a contemporary C trend for nuptuality (Fig. 1.4), which in turn was created by comparably shaped downward movement in the span of child-bearing during women's lives and the proportion who married young, and inverse E-type increase in the percentage of females never married (Fig. 1.5). These curtailments in nuptuality and fertility supported opposite E-shape increase in real wages from the 1610s into the 1690s and in national income per capita between 1600 and 1700 (Harris 1997, Tabs. 12.1 and 12.10, from Phelps Brown and Hopkins and from Mayhew 1995) and temporarily brought to an end the steady H-type growth of the English population that pertained between 1561 and 1726.

Meanwhile, however, marital fertility in terms of I_g changed little (Fig. 1.4), though for most age groups of married women reproduction shrank in C form (Fig. 1.6). Premarital pregnancy declined via C as the opportunity to earn improved inversely, even though nuptuality contracted via C--in part, thanks to a crude death rate that increased in E fashion (including losses between ages 5 and 15). The proportion of births that were illegitimate fell in rather steeper G' manner (Figs. 1.7, 1.1, Tab. 1.4). Limitation of marriage--with reduced, rather than increased, illegitimacy and premarital pregnancy--served as the main mechanism regulating the population in response to less mortality among the very young. Evidence of fertility control within marriage is slight (Wrigley et al. 1997, 458-59).

Much earlier, fertility decline in C fashion is likely in the genealogies of the ruling families of Europe between about 1175 and 1275. Later, it appears among certain local English replacement ratios from the 1270s to the eve of the Black Death in the 1340s, as food shortages are reported and life expectancy at birth fell in parallel C fashion. After the onset of the plague, in the Flemish district of Oudenaarde the average number of children per family contracted this way, especially in the countryside while the urban drop was more abrupt (Bulst 1997, 182, 186, 198-99).

Subsequently, contemporary with the Wrigley-Schofield findings, fertility decrease in C form appears among various European elites starting as of the late 1500s and early 1600s. By the second half of the 17th century it was taking place in this manner across such local groups from northern Italy across Switzerland and into France, among the ruling families of Europe, and also in more ordinary populations of Rouen, Meulan, Geneva, Florence, New Castile, the eastern Ardennes region of what became Belgium, and France as a whole--where, in the least, the crude death rate between 1680 and 1700 seems to have fallen in this fashion alongside total fertility in Rouen and Geneva, and among the families of French dukes and peers (Tabs. 5.3 and C.4; Gutmann 1991, 439-40; Dupâquier 1997, 449). In New Castile and the Ardennes, and for a while among the elites of Genoa and Geneva, the C trends paralleled that of England from the 1550s into the 1660s, targeting about 1700. Elsewhere the descents were at first flatter, aimed toward later zero years for C. In New Castile as in England, parallel C-type decline in childhood mortality was occurring, pressuring births downward (Tab. C.4). Elsewhere, that measure is unclear this early.

By the second quarter of the 1600s, fertility control within marriage was becoming substantial among the elites of northern Italy and francophone Switzerland, and probably also in the families of French dukes and peers (Fig. 5.4; Tab. 5.4). Though insignificant by comparison, it should be noted that low levels of *m* around 1575 and 1645 for the general population of England (Wrigley et al. 1997, 458-59) could have been increasing proportionally along a G path parallel to such advances among elites elsewhere in Europe, as might be expected from the comparable C-shape decline of total fertility found for the English peerage (Tab. 5.3). The percentage of females in the latter who never married, furthermore, increased from the second half of the 16th century to the second half of the 17th in G form, much as in the bourgeoisie of

Geneva from the early 1600s forward as far as the late 1700s and even more parallel in timing with the females of New Castile (Livi Bacci 1986, 186; Tab. C. 4). Celibacy in the general population of England, meanwhile, also increased substantially from the 1580s into the 1630s--though perhaps in G' rather than G fashion; and the average reproductive span for women contracted from 1615 or sooner to 1675 via C, accelerating downward only slightly faster than the current trend among the bourgeoisie of Geneva (Fig. 1.5; Livi Bacci 1986, 186).

Such particulars about the mechanisms of fertility reduction are scarce this early. In general, however, it would seem that both elite populations and those of whole regions or countries in several parts of Europe from the late 1500s into the 1700s reduced fertility in C form, sometimes more than once, in response to improving survival for infants and young children, employing later marriage, termination of child-bearing sooner in the female life cycle, and increased celibacy among women. The relative level of family limitation involved within marriage (*m*), reflected not nationality or culture so much as differences in the proportion of elite couples in the mix--as between the English population at large and other samples.

After it is first observed, the reduction of fertility in C form is not repeated continuously thereafter in every population. It disappeared in England from the 1660s to the 1840s (in spite of two successive C-type decreases of infant mortality between 1710 and 1810), alternated with increases in New Castile from 1640 through 1850, and apparently was absent in most of France during the first half of the 18th century (Tabs. 5.1, 5.2, 5.3). Nevertheless, this type of downward trend in fertility, by one measure or another, has been identified in more and more populations during the 18th and early 19th centuries, especially across France but also in central and southwestern Europe and among the British settlements of North America (Tabs. 5.5, 5.6, 5.7, C.4, C.5; 6.1, 6.3, and 6.4). Often it can be followed in age-specific terms. The tendency of C-form decrease in births to parallel reduction in infant and/or childhood deaths stands out--almost universally during the so-called 'demographic transition' of the modern era, but often before then (Tabs. 5.1, C.1, C.5). Sometimes the particular collective or individual mechanisms by

{<u>Please note</u> that the "lettered" Figures and Tables referenced in the Conclusion are not included at the end of the text (notes) as in the preceding chapters because, with few exceptions (some M Figures and Tables and all P Tables), none of them were in the printed-out notes. Harris produced the manuscript of his *History of Human Populations* on PCs, using word processing and graphing programs that were no longer available or supported when I attempted to retrieve them from the hard drives of his PCs or from the diskettes on which he had meticulously backed up his work. As a consequence, I could not produce those Figures and Tables that he had already prepared but not printed out. MSW 31 July 2015 which fertility was curtailed can be identified. All move in G-related patterns as they complement or supplant each other--delayed marriage, increased celibacy, a stopping of reproduction in later years of the fertile span, less frequent or interrupted coitus, more spacing between births, and eventually various forms of contraception.

Historical fertility decline in C fashion, furthermore, was not just an experience of Europe and her North American settlements. Off and on from the 1820s forward, the populations of several states of Mexico--heavily weighted in indigenous stock--saw birth rates contract via C, sometimes visibly pushing up the age of marriage via E (Fig. 7.2b; Cook and Borah 1974). Earlier, in the native missions of Paraguay from 1705 through 1765 fertility decreased in C fashion (Livi Bacci and Maeder 2004, 206), perhaps influenced somewhat by the way missionizing itself affected marriage and reproduction among indigenous peoples. In China, among [population] completed fertility shrank in C mode from 1710 through 1750, following similar trends of male infant morality and child mortality for both sexes. Female infant mortality, in contrast--particularly perinatal losses--climbed in opposite E form along a path comparable to that for adoption of sons, as a preference for boys was brutally exercised (Fig. 7.6). The zero years for these Chinese trends in the later 1700s, furthermore, happen to resembled those for contemporary C movements for fertility in Normandy and for the 1680-1742 birth rate in France (Fig. 5.1a), for TFR among several European elites and in more general populations of Geneva and Rouen from the later 1600s into the early 1800s (Tab. 5.3), and also for declining fertility ratios in all four districts of Suwa County, located at the heart of Honshu, the big island of Japan from the 1680s through the 1770s (Hayami and Uchida 1972, 500). These trends are all just a little steeper (have rather earlier zero years) than C-shape fertility contractions of the 18th century found in Paraguay and some of British North America. Did some change in the natural environment, perhaps arising from the end of the Maunder minimum in the solar impact on climate, facilitate human existence by reducing rates of early mortality, to which populations adjusted in order to preserve life style, whether at elite or at peasant levels? How likely are the parallel trends for Europe, North and South America, and East Asia to have been coincidental?

In short, C-type lowerings of fertility, clearly or possibly stimulated by C-shape reductions in early mortality in a wide range of cases from the 16th century through the 20th, suggest a very general pattern of human adjustment to "excessive" population. Whatever the origin, whatever the level of equilibrium targeted, by one or another of several well-known means--collective or individual--populations react in this manner. Historically, particularly as standards of living have risen, the emphasis has shifted from control of marriage to limitation of reproduction within marriage. Both approaches, nonetheless, are evident from the 1500s to the present time, as Caldwell has noted in populations of currently developing societies (2004, ?).

Fertility increase via G has been another fundamental, recurring phenomenon of historical demographic change. It, too, can be observed very early in population history: in the genealogies of the ruling families of Europe between 1175 and 1275; in Oudenaarde from the 1380s into the 1420s, then again between the 1460s and the 1510s (Bulst 1997, 182, 198-99); possibly reflected in the crude birth rate of England also during the last quarter of the 1300s and the first quarter of the 1400s (R. D. Lee 1973, 581-607; Harris 1997, Fig. 12.2).

Once more, however, the movement and its mechanisms are especially clear in the case of early modern England. There, death rates for infants and for young children rose in G fashion into the early 1700s as fertility increased in parallel manner. The expanded nuptuality that made increase in fertility (and population growth in spite of higher mortality) possible, was furthered by a decline in female celibacy--probably of G' shape (Tabs. 5.1, 1.4, 1.3; Figs. 1.4, 1.5). Prenuptial pregnancy and illegitimacy also increased, via H (Fig. 1.7). Supporting more, and more lasting marriage, real wages rose in G form into the early 18th century--especially in town though also in countryside--thanks to falling prices fostered by increased agricultural productivity and a new surge of urbanization that was aided by rapid development of colonies and international trade in general (Harris 2003, 238; 1997, Tab. 12.1; Fig. D.6). New opportunity, that is, was exploited in decelerating G manner by more marriage and more fertility per marriage during an era of relatively slow but steady expansion in population numbers following the overall mortality crisis and peak of emigration in the middle 1600s (Figs. 1.3, 1.4).

As during the preceding early modern era of fertility decline, contemporary parallels appear elsewhere. Fertility advanced in G fashion in Normandy and southwestern France during the first half of the 18th century. Before the 1720s evidence on early mortality seems to be lacking, but as of then in at least one community this was contracting in C shape rather than increasing via G, as in England (Henry 1965, 447). Though the marriage rate appears to be unknown this early, celibacy was in fact expanding (in G or H fashion: Fig. 5.1b)--also unlike the English experience--while illegitimacy and the abandonment of children rose sharply (via G') in at least one French community, movement observed also in German Frankfurt and Swiss Basel (Figs. C.4, C.7). From the 1680s to the 1780s, moreover, the age at which French women first married increased via G much like comparable trends for nearby Flanders and Brabant together and for the eastern Ardennes, both of which came to an end by the late 1600s--though in the British peerage, among the elites of Geneva and Milan, and (more flatly and for not as long) in the general population of England such G-shape advance in age of first marriage continued into the 1700s (Wrigley 1985b, 44; Devos 1999, 118; Gutmann 1991, pp; Livi Bacci 1986, 1185-86; Wrigley et al. 1997, 134).

In New Castile, from about 1640 to 1700 fertility also increased in G form even as the crude marriage rate also rose this way, parallel with advances in England and southern Sweden. This happened in spite of the fact that survival to age 25 gained comparably, pushing up celibacy along a similar G path, while child mortality declined via C (Tab. C.4). As noted, at least in the Spanish Netherlands the mean age of first marriage for women rose via G parallel with trends in both France and England while the rate of illegitimacy/premarital pregnancy surged in G' form, as in France but not in England.

In sum, from the later 1600s into the early 1700s--rebounding from the D-type mortality-driven contraction that all experienced in the middle of the 17th century (Harris 2001, 148-49)--the populations of England, France, and New Castile (to 1700, when C decline reappeared) display parallel G trends of rising fertility. In England, infant and childhood mortality also increased via G, allowing fertility rates to rise without adding much to demographic pressure. Nuptuality expanded in parallel G form as the rate of celibacy among women dropped markedly, helping the population grow in H fashion, supported by economic advances. In New Castile and France, in contrast, while the age of females at first marriage and the frequency of marriage seem to have increased in G fashion along with fertility[1] as in England (and southern Sweden), celibacy also took such a path rather than the marked English decline. Child mortality, meanwhile, fell in C shape[2] unlike the English G-type increase. Illegitimacy and premarital pregnancy in France and the Spanish Netherlands, meanwhile, surged in G' form, while in England more gradual but continuous H-type increase from low mid-17th-century levels appears. Insightful distinctions emerge in the demonomic development of European countries between common adjustments during 17th-century mortality crisis and widely shared 'demographic transition' of the 19th century.

During this era from the late 17th century into the early 18th, fertility also increased in G fashion in several populations of British North America--more strongly than in Normandy and southwestern France, which in turn out-paced England and New Castile, where the number of children per family actually turned around to decline via C after 1700 parallel with the trend in the Paris basin (Tabs. 6.1, C.4). Evidence at least for Nantucket, an internationally experienced seafaring community, indicates extension of intervals between births in G trends that parallel these movements, a pattern that does not appear in England at this time (Figs. 6.6a, A.2). In the relatively remote Mexican region of Mixteca Alta fertility also for some reason increased in G fashion from the 1670s to the 1740s (Fig. 7.2b).

G-shape increase in fertility likewise appears in certain lineages of China in this epoch (Liu 1990, 336-37), then later in some Japanese locales during the last century or so of the Tokugawa regime, reversing C-type decrease (Hayami and Uchida 1972, 500; R. J. Smith 1972, 445-51). By then--the second half of the 1700s and the first half of the 1800s--European and North American populations were widely, though not universally, in fertility decline via C (Chs. 5, 6; App. C). Still, G increase in fertility appeared in many populations around the globe as far as the end of the 20th century. Examples have been shown for Jamaica from about 1880 to 1910 and for at least one state of Mexico and for Peru across the first two-thirds of the 1900s (Figs. 7.3, 7.2b, 7.4). Illustrations into the middle of the 20th century have similarly been encountered in the Punjab, in China, and probably also Korea, Sri Lanka, Indonesia, Tunisia, and Lebanon (Fig. 7.5), and for African population overall into the 1980s (Tab. 7.3). Judging from more widely available evidence on crude birth rates, reproduction expanded in G shape also in Ireland from about 1930 to 1980, and in Northern Ireland, Austria, and Albania from the Depression to about 1960, a span also containing G-type gain in Jamaica, Trinidad and Tobago, and Fiji (Tabs. 2.3a and 2.3b). The G trend, in short, appears to be a very general way in which populations, given opportunity, expand their fertility.

Accelerating fertility increase in E form has played a special role in the history of demographic and also economic change. Its place in modern development is illustrated by trends in England and the Austrian Netherlands (Belgium) during the 1700s and early 1800s as sampled in Table S.1.

In both England and East Flanders by various measures or approximations (I_f, CBR, GRR, or ratio of births to marriages) the rate of reproduction pushed upward via E, making the population increase in this manner and moving more of it to cities and towns. Meanwhile, in both populations there is evidence of decline in mortality in C fashion. Still earlier and stronger E-type surges of fertility are evident in Verviers and the surrounding countryside in the eastern

Ardennes, at the other end of what is now Belgium; but these evaporated in D fashion after about 1740 (Gutmann 1991, 439-40).

In East Flanders more and more farms became small as fertility rose and protoindustrialization in the form of linen-weaving supplemented farm income, to the point where late in the 18th century about half the Flemish population was engaged fully or partially in such production (Devos 1999, 102-03). Whereas during the later 1600s and early 1700s the change brought higher wages for weavers and for others, and for weavers relative to day laborers (all in long-term G-form increase as population increased very little even as rather more of it was urban), by the 1740s the underlying trend for real wages--for weavers, day laborers, and urban workers--turned downward in C fashion opposite to population growth, though day laborers lost less than weavers, and urban earnings contracted less than rural ones, both also in C form (Fig. D.2; Tab. S.1). The crude marriage rate and--at least after 1796--nuptuality declined along comparable C paths while the percentage of women who never married and the average age of females at first marriage rose oppositely via E. Declining mortality for men and women in converse C shape and complementary E trends of rising average age at death in some Flemish communities (Deprez 1965, 615, 624-25) suggest that better health made higher fertility possible (and that, before the 1790s, I_m was in fact increasing). More and more of Flemish income came from agriculture as intensive farming in small farms expanded, while less per capita came from linens (Tab. S.1). Still, around 1800 Flanders as a whole remained prosperous relative to England and, rather less so, France (Devos 1999, 103).

In England, meanwhile, fertility, population size, urbanization, the ratio of urban to rural wages, and of agricultural wages in the industrializing North and Midlands relative to those in the South rose in E paths comparable to those of East Flanders while real wages in most sectors and early mortality rates similarly fell via C (Tabs. 1.1, 1.4; Fig. D.1; Clark ; Lindert and Williamson 1983, 13, 4; Harris 1997, Fig. 12.4;). There parallels cease. Though the crude rate of marriage declined in similar C fashion, nuptuality increased inversely via E as fewer English women failed to marry and their average age of marriage became younger--both in C form (opposite the Flemish movements). Per capita GNP, industrial output and private consumption also improved in E paths accompanied by trends of that shape in industrial innovation (in spite of the fact that real wages fell conversely, in a shift of earnings from labor to capital) as opposed to the decline observed for overall per capita income in East Flanders between 1725 and 1835. Reduced mortality rates made the population grow in both places but marriage became more difficult in East Flanders as income to be had from domestic linen production collectively contracted between 1700 and 1845 (Vandenbroeke 1984, 928, 916; Mendels 1984, 940, 950), rural families relied more upon intensive farming in small units (aided by potato cultivation, Devos 1999, 102-03) in contrast to the expansion of larger, proletarianizing agricultural operations in England (Harris 2003, 241), and mechanization of the textile industry affected Flanders--from foreign and from domestic sources (Devos 199, 103).

Both populations benefited from better survival rates, but the English used these gains differently: to create a new side to their economy. Until the 1800s, in contrast, the Flemish economy remained more sensitive to population pressure against agricultural and protoindustrial resources. One indicator of this was the continuation of a series of shorter-term G' movements across underlying rising and falling trends in both demographic and economic developments that are rare in the demonomic history of England. Which of these different demonomic dynamics applied when later trends of fertility and demographic growth took E shape in Europe and elsewhere?

Within Europe, as Table S.2 summarizes, through the 1700s and into the 1800s besides England and East Flanders total fertility and/or the crude birth rate also rose in E fashion and enlarged the size of populations this way in Germany, Denmark, and the Netherlands (affecting growth in areas outside the maritime provinces of North and South Holland). Simultaneously, C-type declines in rates of early mortality swelled these populations. Nuptuality?? check Lee. The E-shape thrust of demographic increase fostered urbanization in the same form, as in England

and what is now Belgium, in Germany, Denmark, and--appreciably more flatly--the Netherlands. This path of urbanization was shared by many European countries during the later 1700s and early1800s (Harris 2003, 277, 286).

While France shared decline of early mortality in C form along with population growth (briefly after the Revolution, preeminently in the vicinity of Paris and Lyon) and urbanization in E shape, already by the 18th century overall fertility there was contracting in C fashion as families began to limit the number of births. The marriage rate declined via C, as in Flanders and England, but there is no evidence of the E-type expansion of nuptuality observed in England between 1758 and 1818. Did nuptuality contract from the later 18th into the early 19th century in C form like the trend in Flanders? In any case, within a single generation demographic expansion via E in France was pulled over into a decelerating G path and never appeared subsequently.

Beginning in the mid- or late-19th century, as first noted in Volume I (Harris 2001), population increase in E shape spread across much more of Europe--sometimes along with second appearances, as in Germany and the southern provinces of the Netherlands (not Belgium). Table S.2 indicates how C-type lowering of early mortality, now widespread across Europe whatever pattern growth followed, almost always fed such increase in population. At this later stage in European history, however, fertility was usually being curbed in C fashion, following the earlier example set by France. Unlike the situation during the preceding era in parts of northwestern Europe, the consequences of accelerating fertility increase were not passively endured (except briefly in Austria, Hungary, and Romania). This diffusing control of reproduction allowed nuptuality mostly to expand simultaneously via G in spite of E-type population growth from the later 1800s into the early 1900s (except C declines in Spain, Hungary, Romania, and Russia) while urbanization advanced largely in the H form now so common across Europe (Harris 2003, 277)--except for very shallow late-cresting E trends begun by 1750 in the Netherlands and Portugal, and perhaps the Balkans. Agricultural yields per hectare improved in E fashion for Europe and parallel gains occurred in agricultural labor productivity in countries like Belgium, Germany, Italy, and Russia (Harris 2003, 291). These changes helped national economies 'carry' more people.

Before the middle of the 19th century, except in France, improved life expectancy in northwestern Europe both reduced early mortality via C and oppositely increased fertility in E paths. Typically, a cost was paid in terms of the opportunity to marry (how many, how young, how long), though nuptuality in England instead prospered with the 'invention' of industrial employment. These demographic dynamics enlarged several northwestern populations in E form, with agricultural change freeing up more people for towns and cities--the surplus that fed early industrialization with cheap labor.

Further C-shape improvements in mortality during the later 1800s and early 1900s spurred accelerating growth of population in other European countries. The pressures that this generated now were increasingly met by the response of family limitation, which allowed nuptuality to increase quite widely in G fashion, and eased by parallel E-type gains in agricultural productivity. Urbanization now proceeded mostly in H paths, like the courses of industrial employment and GNP per capita for developed nations during this era (Harris 2003, 294).

In the territories that became the United States of America, labor productivity in agriculture, urbanization, and growth of population advanced from about 1850 into the early 1900s along H paths much like those found contemporaneously in many countries of Europe (ibid., 294, 291; Harris 2001, 148-49). Evidence of population growth in E shape for colonies and states is almost totally absent in all eras, however. The exceptions occurred in Massachusetts and Rhode Island between 1790 and 1850 as manufacturing expanded in E fashion into the first half of the 19th century (Harris 2001, 42, 52-53; Tab. 6.2). Also missing, even there, is fertility increase in E form. Instead, reduced reproduction in C shape appeared in the American colonies as early as the 1720s--contemporary with France (Tab. 6.1)--and kept recurring across the continent as settlements matured (Tabs. 6.1, 6.2, 6.3, 6.4). Data on trends in the mortality of infants and children, to which fertility decline may have responded, unfortunately seem lacking before the 20th century. Though nuptuality is also unknown, other ways of curbing collective reproduction display patterns resembling those found in Europe: reproductive spans contracting in C fashion, longer spacing between births, and fertility control (*m*) that rose in G form during the 19th century comparable in timing and in level with trends in Germany and Hungary (Figs. 6.7a, 6.7b; 6.6a, 6.6b, 6.5a; Tab. 6.5).

The United States, while borrowing heavily from English industrialization, did not replicate the English demonomic system of development for the later 1700s and early 1800s. Even as parts of New England industrialized in E fashion, fertility rising in E shape was not behind the change (Figs. 6.3b, 6.3a). Instead, the trend was downward in converse C shape with similar zero year (Tab. 6.2) as young farm women first provided the bulk of labor as a way of attaining some independence and building a dowry (postponing marriage?), then toward mid-century were replaced by immigrants (Dublin 1979). Native population increase and the fertility that generated it were attuned to the availability of land: curbed in older areas of settlement, freed up nationally by the availability of new territory that permitted the still mostly agricultural population to grow at a constant, not decelerating, rate of 3 percent in the F path. Australia and New Zealand certainly, Canada probably, developed in a later era, when economic change was less inspired by a surplus of cheap, formerly agricultural, labor and more driven by the fruits of industrial development itself, including fertility control to allow ordinary families to benefit from economic growth even as more babies survived to maturity.

E-type fertility increase did, however, appear in later-developing populations of Latin America, Asia, and Africa during the last years of the 19th century and the first half of the 20th (Tab. S.3). In Mexico, Costa Rica, Venezuela, and perhaps Guyana, on the one hand, and Egypt, Mauritius, Sri Lanka, Singapore, Malaysia, the Philippines, Taiwan, and Korea on the other, such advances of fertility occurred in spite of C-shape reductions in infant mortality. Population increased in all of these countries, in E fashion except for more likely G trends in Guyana, Singapore, Malaysia, and Mauritius.[3] With that exception, this is the combination for fertility, early mortality, and growth seen in England and Flanders, and probably the Netherlands, Germany, and Denmark from the later 1700s into the early 1800s. Meanwhile, for Latin America at least (non-market Asia is not given) GNP per capita income improved in E fashion simultaneously, as had been the later-18th-century case in England--though opposite C movement appears in Flanders, suggesting (for the time being, at least) earnings losses for workers without the gains for employers and others that were occurring in England (Harris 2003, 295; Tab. 5.1, Fig. D.3). Did similar economic changes occur in these later populations of the waning 1800s and first half of the 1900s which had E-type fertility gains in spite of expansion in E form as had appeared a century before when northwestern Europe initiated industrialization? Chile and India, in contrast, while also experiencing growth in E form and reduced early mortality in C pattern, instead curbed fertility in C fashion like France following the Revolution and European countries that developed mostly after 1850 as limitation of births became more common (Tab. S.2).

The mechanisms through which modern populations reduced reproduction or let it expand in modern times famously involved more and more family limitation within marriage and less and less reliance upon control of marriage or crude Malthusian mortality. While extensive evidence on the trends of these contributing movements in so many recently documented societies exceeds the scope of this already wide-reaching study, illustrations indicate that the patterns have continued to take G-based shapes.

Examples of approximate **D-shape fertility decline** (Tab. S.4) appear in the historical record about as early as cases of increase in G form. Such movement seems to have occurred in English replacement rates from about 1250 through 1305 and in the English crude birth rate between about 1275 and 1325 (Blockmans and Dubois 1997, 187; Bulst 1997, 172). It emerges again in Oudenaarde in the 1350s following the arrival of the Black Death (Blockmans and

Dubois 1997, 199) and possibly in Verviers and surrounding villages from 1735 through 1785 (though the downward end of a G' surge may be involved instead; Gutmann 1991, 439-440). In Oudenaarde and the eastern Ardennes the pattern may be D' rather than D, with the bottom of the dips in the 1370s and 1770s before turning up. D' movement might also have occurred for GRR and NRR in the eastern Ardennes from the later 1600s into the middle 1700s, with lows in the vicinity of 1700.

Several, mostly parallel, D-type declines in reproduction can then be found in the crude birth rates of European countries during the first half of the 19th century--in England, Denmark, the Netherlands, Germany, Austria, and northern Italy (Lombardy and Tuscany; Tabs. 2.3a, S.4) and in marital fertility for the southeast Paris basin (Fig.5.1a). In England, the Netherlands, and Germany these declines were accompanied by opposite G-shape increases in infant mortality. The changing circumstances of life that trimmed nuptuality, the principal regulator of fertility at this time (Fig. 1.4), simultaneously increased the mortality of the very young. Yet the population managed to increase across the period in H form, chiefly because the initial margin of births over deaths as of the early 1800s was sufficient to support continued growth while contracting, keeping the gap between CBR and CDR larger than it was elsewhere (Tabs. B.1a and B.2a)--perhaps aided by reductions in mortality following infancy, which, in England at least, raised life expectancy during the 19th century (Tab. 1.1). The population of Denmark expanded in H fashion also; but there, infant mortality seems to have lessened via D.

Table S.4 indicates that, as earlier in Oudenaarde and the eastern Ardennes, there can be D' alternatives for some of these D trends. That dipping but then rising pattern appeared during the first half of the 19th century in England (accompanied by parallel movement in nuptuality, shows Tab. 1.4), in France (Fig. 4.1a), and in the larger towns of Massachusetts (preceded by similar movement between 1765 and 1810, indicates Fig. 6.3a). In Denmark, Italy, and Portugal, this type of trend occurred during the second half of the 1800s as it did then also, exceptionally, for extramarital fertility in Portugal and Ireland.

In recent decades, mostly the fourth quarter of the 1900s, declines of reproduction in D shape can be observed in Ireland, Austria, and Czechoslovakia, 17 populations of the Caribbean and Latin America, 11 in Asia, and 3 around the margins of Africa (Tabs. 2.3a, 7.1, 7.2). The D' pattern, meanwhile, appears recently in the United States, Canada, Argentina, and possibly Australia (Figs. 7.1 and 8.1), in Jamaica (Fig. 8.3, NRR accompanied by parallel movement in the crude marriage rate), and perhaps in Sri Lanka between 1927 and 1947 (CBR: Fig. 2.2j). Worldwide, in some of the populations having D-type decline in reproduction comparable trends in infant mortality or more inclusive death rates can be observed; in others, the pattern is absent while nonetheless appearing in populations that lack D-shape decrease in fertility.[4] For most populations, spreading family limitation now severed the direct link between early mortality and fertility.

G' surges in fertility will be most familiar to modern readers from the 'baby booms' of the mid-20th century. Systematic trends of this shape (as opposed to more abrupt upward shifts) are observed for marital fertility in Scotland, England and Wales, Belgium, France, Denmark, and possibly the Netherlands from the onset of the Great Depression through the third quarter of the 1900s, in Hungary beginning about 1960, and for overall fertility (though not I_g) in Sweden, Iceland, Ireland, and Spain contemporaneously (Figs. 4.1a through 4.1f). The pattern also appears in total fertility rates for Canada, the United States, and perhaps Australia from the 1930s to about 1960 before breaking into steeper forms of reversal (Fig. 6.1). In Latin America and the Caribbean and in Asia and Africa, to the contrary, the fewer fertility increases that did occur following World War II tended to take G or E shape instead (Tabs. 7.1 and 7.2), though patterns for adopting various types of contraception do seem to have taken this form (Tab. 8.5).

Whether or not such G' trends appeared in overall and/or marital fertility, meanwhile, for extramarital reproduction they emerged during the years after World War II in Ireland, Iceland, and Norway and in Luxemburg, France, Germany, Switzerland, perhaps Austria and

Czechoslovakia, Hungary, Yugoslavia, and Greece (Figs. 4.4a through 4.4f). Nuptuality, furthermore surged in even more common G' patterns across Europe (Tab. 4.2) as postwar 'marriage booms' accompanied the more often discussed 'baby booms.'

Looking further backwards, moreover, during the later years of the 1800s and the early 1900s G' movements in *extramarital* fertility were virtually universal across Europe--excepting only inverse D' patterns in Ireland and Portugal. Fertility data of this era for Argentina seem to follow comparable G' paths, which is not the case for the United States (Figs. 6.1, 7.1). In this period, furthermore, marital fertility also swelled slightly then contracted in G' shape for a dozen countries of northern and central Europe (Tab. 4.5). Some G' contemporary swelling of nuptuality is also possible in Denmark, the Netherlands, Germany, and perhaps Switzerland; but it is clear only for Ireland and Iceland (Figs. 4.2a, 4.2b, and 4.2c). Such bulges in nuptuality for *young* women appear meanwhile in England and Wales, the Netherlands, Germany, and Sweden, and perhaps Scotland and Portugal (Tab. 4.6).

Still earlier, various measures of reproduction in Europe took G' form through time, in the least here and there judging by available evidence. CBR in Belgium and children per family in New Castile did so during the first half of the 1800s (Tabs. 5.2, C.4). So did the crude marriage rate in Sweden. Starting in the 1830s, illegitimacy in Norway and Sweden peaked rather later. Before that, they had crested in G' fashion around 1820, a few years after comparable movement for CMR in Sweden, both CMR and prenuptial pregnancy in Flanders, and extramarital fertility in England (Figs.5.3, C.3a, 5.12, 1.4). Illegitimacy in several communities of France and surrounding territories similarly head for G' maxima in the early 1800s (Figs C.4, C7). About two decades previously, the crude marriage rate for France and extramarital fertility in England peaked in G' form (Figs. 5.2, 1.4).

Before that, CBR maximized via G' in Norway and Finland around 1760 and 1740, respectively, for stretches of time between 1723 and 1773 (Tab. 2.3a). Peaks comparable to 1740 appear in G' trends of GRR and NRR for the protoindustrial town of Verviers in the Ardennes (though not the surrounding countryside), in premarital conception for East Flanders, and for illegitimacy in some French communities. In the last, earlier cresting occurred in the vicinity of 1720, while the crude marriage rate for East Flanders peaked in G' fashion shortly after 1700 (Gutmann 1991, 439-40; Figs. 5.12, C.4, C.7).

In all, between about 1700 and 1850 are evident periodic G' movements in fertility and related demographic variables. While these are quite different indicators of fertility, the G' patterns in each would seem to reflect relatively short-term shocks to demographic systems. Data for Flanders suggest that such stimuli are linked to opportunities to marry and crises that magnified death for the very young in era when marriage, not family limitation within it, regulated reproduction (Fig. 5.12, Tab. 5.10). How general were such connections in other populations and eras where G' patterns are found?

North American evidence from new settlements seems to confirm this kind of interpretation. Where fresh (if often previously Indian-cultivated) land was occupied and developed as European settlement spread across New England, G' bulges in reproduction occurred--with crests appearing around 1660, the mid-1680s, the mid-1720s, and 1770 in the available data (Fig. 6.2).

Previously, during the English surge of urbanization across the later 1500s and early 1600s, extramarital fertility there between 1558 and 1648 crested in G' fashion about 1600 though total fertility fell as female celibacy multiplied greatly from the last quarter of the 16th century through the first quarter of the 17th--in G' form maximizing in the 1620s (Harris 2003, 184, 186; Fig. 1.4, 1.5). In New Castile, meanwhile, the crude marriage rate peaked via G' about 1590 during the years between 1578 and 1610 (Tab. C.4) as the Madrid-controlled wealth of the New World flowed into Spain. In Oudenaarde, finally, the number of children per family for some reason (apparently following a sharp rise in Flemish prosperity) crested between 1515 and 1565 in G' fashion about 1526, in turn driving down wages, which has jumped for both weavers and day laborers in the 1590s, and raising rents, which had been falling since the middle 1400s.

A still earlier possible G’ surge for children in Oudenaarde, between 1425 and 1465, topped out in the 1440s and likewise pressured wages to temporary lows (Blockmanns and Dubois 1997, 199; Fig. D.2).

HOW CHANGE IN THESE SHAPES HAS KEPT REAPPEARING

{Please note that Harris had indicated to change his earlier plans for the conclusion: instead of a very long conclusion with examples, he transformed parts of it into chapters 10 and 11. As a result of this rearrangement his notes fail to indicate whether he intended to add more after the preceding note, "How change in these shapes has kept reappearing."

The following chapters L and M might well have become chapters 12 and 13, respectively, but that decision had not been made and I kept the letter designations of the chapters since they correspond to respective Figures and Tables. MSW 31 July 2015}

Notes

1. The French marriage rate this early and the Spanish female age at first marriage are not found. In the Spanish Netherlands (Belgium) and among Geneva's bourgeoisie, however, the marriage rose in comparable G fashion.

2. Trends for infants and children in the countryside around Paris, recorded beginning only in the 1740s and lasting to about 1770, parallel fairly closely the 1690-1740 C movement of New Castile. The C for Norman evidence (Crulai) from 1725 through 1795 is somewhat flatter (Henry 1965, 446-47).

3. In Peru, fertility seems to have increased via G rather than E during the mid-twentieth-century period of E-shape growth and C-type reduction in infant mortality, though that trend is very brief.

4. Among populations for which late-20th-century trends in both fertility and infant mortality are described (Tabs 2.3a, 4.4, 6.1, 7.1, 7.2, and 7.6), only in Austria, Cuba, Costa Rica, and Sri Lanka did D shape for both appear. In Chile, Singapore, Japan, and the Philippines--and Belgium, the Netherlands, France, Germany, Hungary, Poland, and Bulgaria--mortality fell via D but fertility did not follow in this pattern. In Ireland, Czechoslovakia, Brazil, Mexico, Venezuela, Uruguay, India, and Mauritius, fertility lessened in D fashion without comparable movement in infant mortality. In Peru, Korea, and Egypt both still contracted via C--the pairing found in 19th- and earlier-20th-century 'demographic transition.' In the United States, Canada, and Argentina, D' dips in fertility occurred along with C-shape contraction in infant mortality.

APPENDIXES

{<u>Please note</u> that the "lettered" Figures and Tables referenced in Appendix A, B, C, D, and E are not included at the end of the text (notes) as in the preceding chapters because none of them were in the printed-out notes. Harris produced the manuscript of his *History of Human Populations* on PCs, using word processing and graphing programs that were no longer available or supported when I attempted to retrieve them from the hard drives of his PCs or from the diskettes on which he meticulously backed up his work. As a consequence, I could not produce those Figures and Tables that he had already prepared but not printed out. Also note that each Appendix is paginated separately. MSW 31 July 2015}

Appendix A

Additional Perspectives on Mortality and Fertility in England before 1850

Figure A.1a first of all graphs the percentage of children's names that were reused by families in Colyton, the community of Wrigley's path-breaking study that preceded the *Population History* (Wrigley, 1968; Razzell 1993, 755). Razzell employs this technique as a way of estimating how the proportion of children who died early in their lives changed over time. The chronological groupings are very broad (mostly by half-centuries); but the rate seems to accelerate upwards in E form from the years around the mid-point of 1559 to the second half of the 1600s, which is represented by 1675. Table A.1 (in part A) shows how parallel this trend is to that of the crude death rate in the *Population History* from 1556 to 1681. Subsequently, from the late 1600s to 1819, Colyton naming suggests that the death rate of children declined somewhat along a downwardly accelerating C path. Once again, part A of Table A.1 demonstrates how--at least from 1761 through 1831--the Wrigley-Schofield CDR also acquired downward momentum in C shape, with the t_0 for the curve set at exactly the same year, 1880, as in the Colyton evidence from naming. Then a new trend of the C type may have appeared across the year groups of 1801-1837 and 1837-1851 in the Colyton data. If the percentages at the two available mid-points of 1819 and 1849 are fitted hypothetically to a C curve, this has its base year at 1964 compared with the 1936 of the C path for the CDR in the *Population History* and subsequent census records from 1831 through 1923. In short, over a span during which infant and childhood deaths composed a very high percentage of pre-modern mortality, for most of the time between 1538 and 1851 the renaming indicator for them in the one community of Colyton, an indicator chosen by Razzell, very much followed the G-based movements of the CDR for England as a whole as computed by Wrigley and Schofield.[1]

A divergence between the two sets of data may seem to appear in the late 1600s and the first half or so of the 1700s. In this era, the crude death rate of the *Population History* took its two 1/G' dips: between 1681 and 1731 and then between 1731 and 1761. Taken only in fifty-year groupings, the rate for reusing children's names in Colyton during this period displays no shorter-term movement. That, however, is probably simply because so much broader categories of time are employed for the limited single-community data. In all, trends of mortality for infants and young children according to Razzell closely resemble patterns of the death rate found in Wrigley and Schofield.

Meanwhile, mortality among certain categories of *adults* fell away from the late 1600s into the 1700s in what could have been D shape (Fig. A.1a and Tab. A.1). Such movements approximate what are possible, if somewhat cruder, alternative D trendings (summarized in Table A.1) for the downward phases of the 1681-1731 and 1731-1761 1/G' sags in national CDR, with zero years around 1664 and 1708, respectively.

From 1693 through 1773 or 1789, death rates for males between 31 and 45 who joined a British state tontine declined along a D trend with t_0 at 1677. For males from 5 through 30 included in the tontine (roughly averaging, without weighting, those 5 through 15 and 16 through 30) between 1693 and 1745 comparable decrease would fit a D curve with zero year around 1685, in spite of building mortality thereafter. This makes the pattern for all males 5 through 45 apparently atrophy in D form from the end of the 1600s into the later 1700s (Razzell 1993, 764).[2] In short, it was only the 46-60 and 61-75 age groups of tontine nominees, the narrow peak of the life cycle pyramid, whose death rates moved in substantially different ways from the CDR of the *Population History* by dropping off via C 1693-1773 then jumping up for the years around 1789.[3]

A C-shape improvement in death rates is evident for another indicator of the mortality of adult men that Razzell employs: the percentage of fathers of brides in the diocese of Canterbury (East Kent) who were not present and consenting when their daughters married (Razzell 1993, 761). This C from 1633 through 1690, which may extend to 1765, is just a little steeper (dated somewhat earlier) than the tontine mortality rate for men over 45, the figure and the table both indicate. Between 1689 and 1765, however, it is also possible that mortality decline occurred in D manner with t_0 in the vicinity of 1670, close to the tontine changes for males 5 through 45 (Fig. A.1a, Tab. A.1).

Another, later improvement in these paternal death rates probably commenced across the later 1700s. If it took the C path that would fit the calculations just for 1765 and 1789, the trend resembled the somewhat flatter contemporary curves of that shape for the Wrigley-Schofield CDR and the childhood mortality indicator of reused names in Colyton and, even more, the very parallel C trend (target year at 1844) from 1745 through 1789 for death among tontine men 31 through 45. In contrast, an upward shift in mortality during the later 18th century appeared for the oldest tontine men quite abruptly after 1773. For males 5 through 30, meanwhile, from 1745 through 1789 such increase took extended E form opposite to the C-type decline for those 31 through 45. What shaped such divergent death rate trends among relatively well-off males of these different age groups in the later 18th century?

In the end, the one movement of the crude death rate calculated by Wrigley and Schofield that receives no support from Razzell's additional evidence is the roughly E-shaped (most precisely 1/G') rise 1701-1731. But this, it has been shown, is part of a pattern of short-term swinging in quinquennial data that is hidden in the broader time categories necessary for relatively small groups. Overall, it seems best to work with the CDR from the Wrigley-Schofield back projection as a reasonable approximation of the real shapes of the trends for England.

Razzell also offered further insight into changes in life expectancy (1993, 765; Fig. A.1b Tab. A.1). There are just a few data points for hazarding the G-based trends that might fit this evidence. Still, as for death rates, it is possible to see how far the conclusions of the *Population History* run along with or against patterns apparently existing in these other sources.

There is no time span covered in the figure that matches the Wrigley-Schofield C-shaped life expectancy at birth for the early series of 1576-1681. Nonetheless, the offsetting E's for the era 1560 to 1680 in both the CDR of the *Population History* and the reuse of children's names in Colyton strongly suggest the appropriateness of a fall in e_0 of C form for this period. Thereafter, E trends across the later 1600s and early 1700s of life expectancy for 25-year-old aristocrats, Scottish advocates, and Quakers from southern England--and perhaps also men who became M.P's in their 20s--all follow each other quite closely. The increases are considerably faster (with earlier t_0's) than the E's for Razzell's MP's over 40 and Wrigley-Schofield males of 25 (whose trends head for target years more like 1770 than 1730); but the accelerating shape of the curve is the same in this era for most known groups of adult men (the exceptions being MP's in their 30's and tontine participants age 25).

Later, extending towards 1800, the oldest and youngest groups of MP's, young aristocrats, Scottish lawyers, southern Quakers, and all tontine participants of age 25 apparently saw further improvement in life expectancy flatten out in G form--the youngest and oldest MP's and the aristocrats gaining more steeply than more middle-class groups of their contemporaries (with base years for the formula between 1666 and 1689 compared with 1612 to 1633). According to the *Population History*, meanwhile, life expectancy at birth for England in general rose approximately via G from 1681 to 1706 and then again from 1731 to 1756, in paths with t_0's at 1656 and 1705 (528-29; trended alternatively in Fig. 1.1 as G' patterns) or quite comparable to the G movements observed for most of Razzell's adults. And after the middle of the 18th century the accelerating rise of e_0 from the *Population History* closely paralleled the experience of MP's in their 30's.[4] The one place in which the Wrigley-Schofield data on life expectancy patently take a different path from most of Razzell's evidence is in life expectancy *at birth.* For adult life expectancies the trends are quite similar throughout.

Figure A.2 plots movements in certain birth intervals discussed in Chapter 1.

Figures A.3a and A.3b trend mortality rates for groups of children past their first birthday.

Notes

1. For Table A.1 the two 1/G' sags between 1681 and 1761 in the CDR of the *Population History* (Fig. 1.1) are re-approximated not quite so accurately by successive D, E, and D movements. These capture most of the shapes of change in this era and compare more simply with the more widely spaced estimates of Razzell.

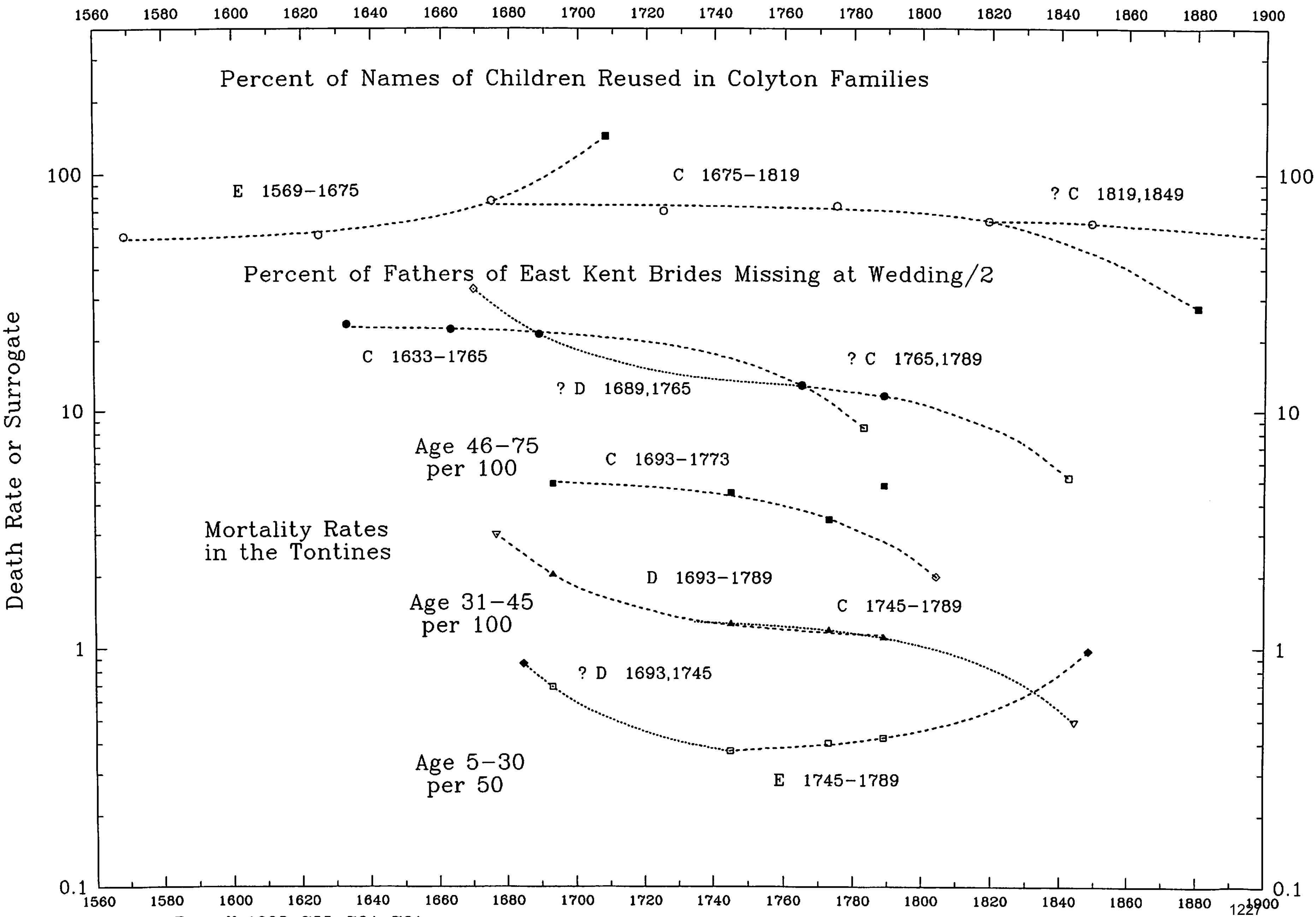
2. Graphed, but not plotted in the figure. No allowance is made for the proportions of nominees who fell into each age group. Most joined as children, but could reappear as adults in later tontines (Razzell 1993, 763-64, which gives the original sources). Tontines were insurance pools of accumulating annuities to go to the survivors, a system introduced into France abut 1653 by the Neapolitan banker Lorenzo Tonti. The British nominees were mostly gentlemen, professionals, and merchants. Their social composition changed little between 1693 and the late 1740s.

3. Compare patterns of adult mortality for both sexes together in the subset of parishes employed for reconstitution (Tab. 1.5, Fig. 1.9; Wrigley et al. 1997, 290).

4. The end of a G and the beginning of an E are both almost flat. Therefore, G trends for other groups that continued to around 1800 do not necessarily prevent the possibility that E's might be beginning for the new century. Mostly there just exist no data late enough to tell. The alternative G patterns for e_0 according to Wrigley and Schofield have been fitted, but are not shown in Figure 1.1.

Figure A.1a

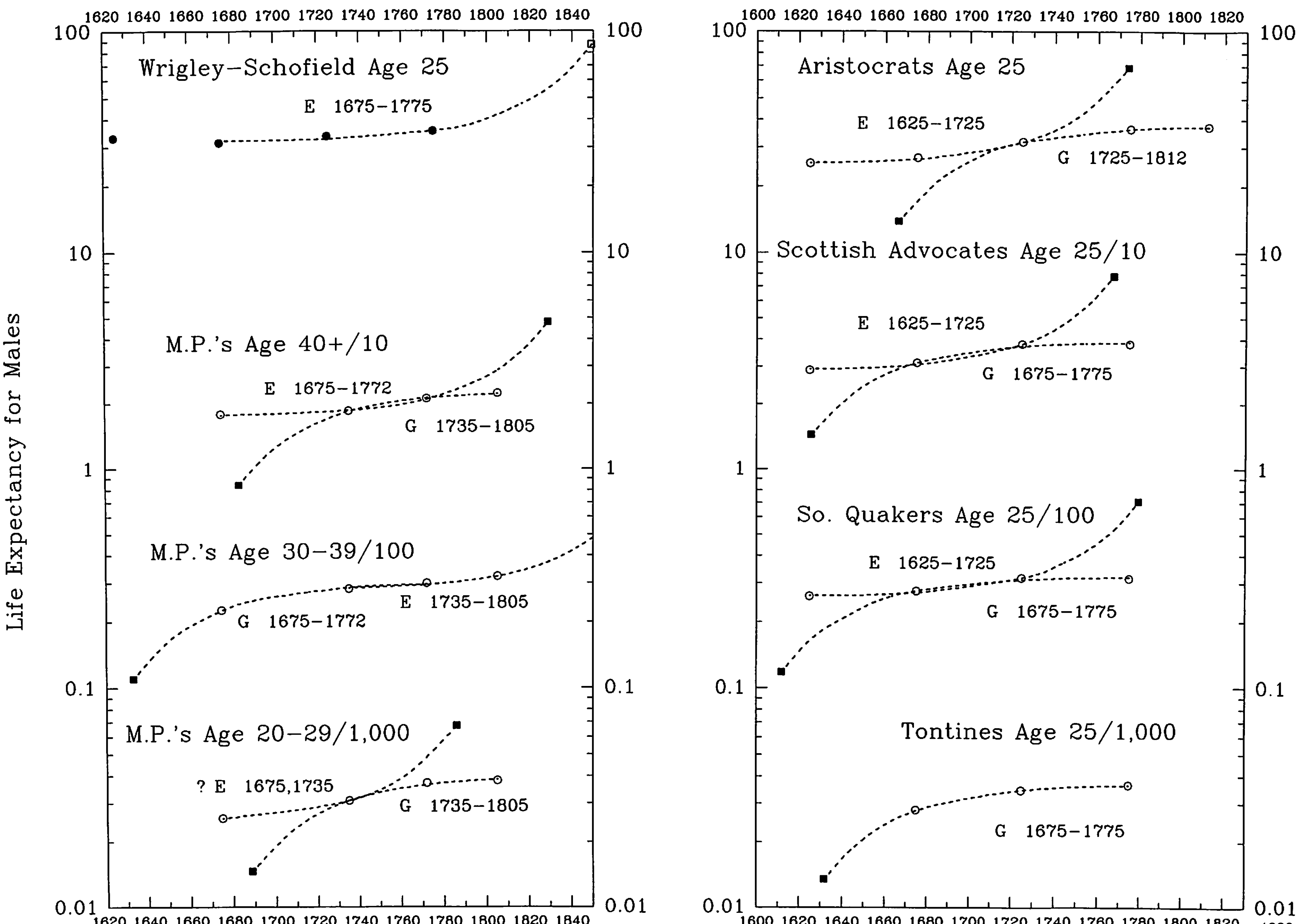
Apparent Trends in Razzell's Calculations of Mortality:
Evidence from Child–Naming, the Absence of Brides' Fathers, and British Tontines



Source: Razzell 1993, 755, 764, 761.

Figure A.1b

Apparent Trends in Razzell's Calculations of Mortality:
Life Expectancies for Various Groups of Males

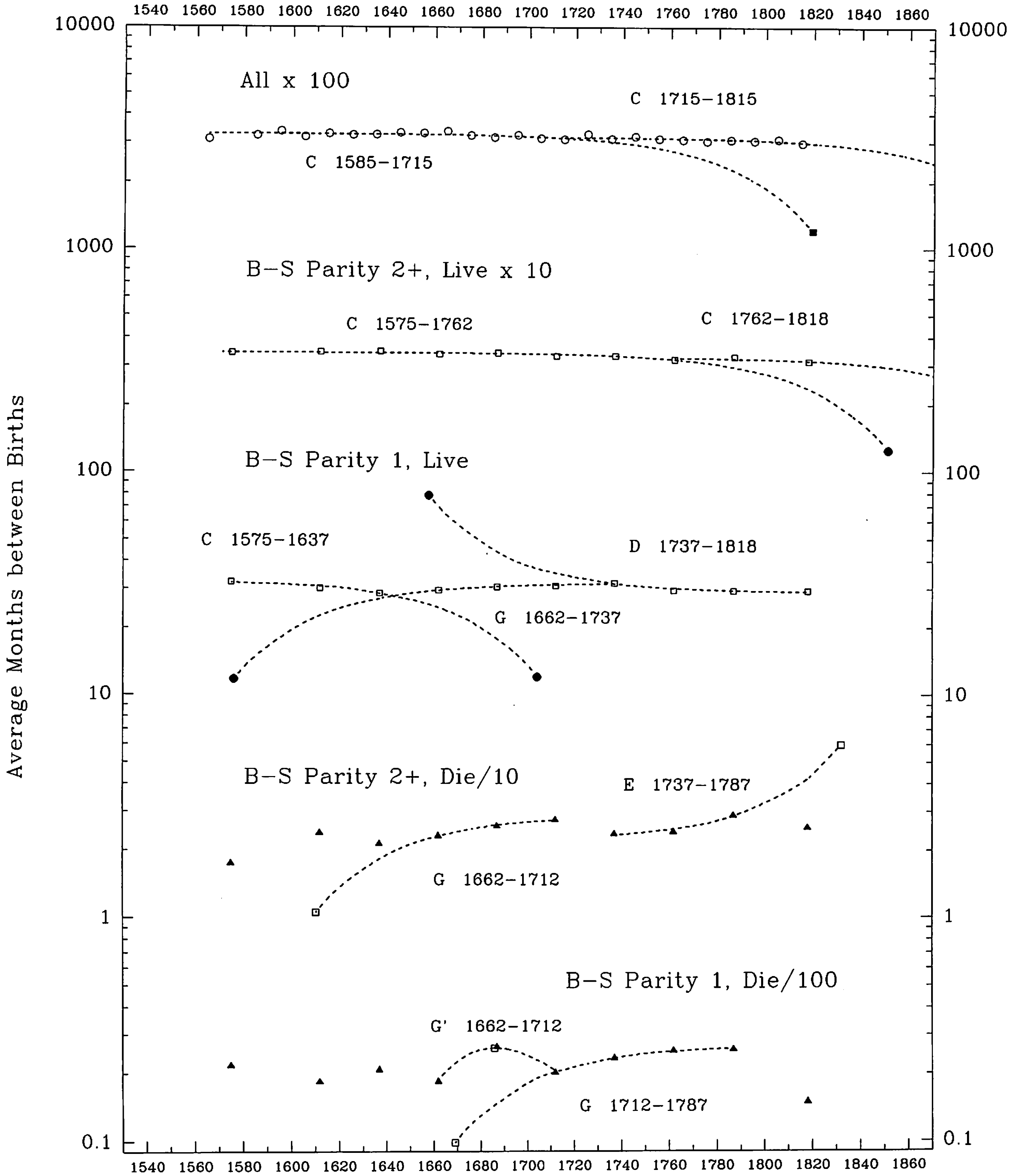


Source: Razzell 1993, 763, 765.

1228

Figure A.2

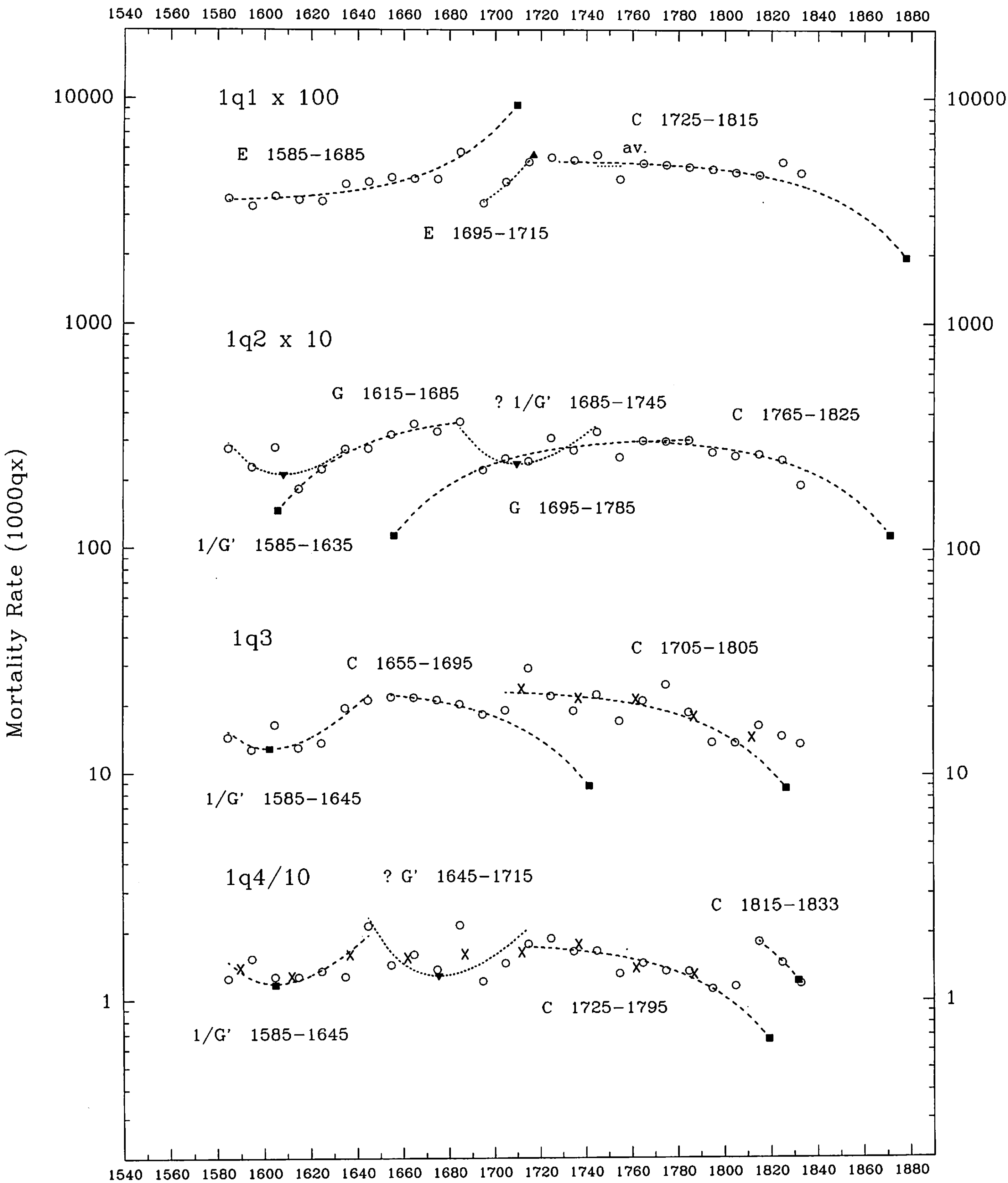
Average Total Birth Intervals
and Those for Bachelor–Spinster Completed Marriages



Sources: Wrigley et al. 1997, 447, 438–39.

Figure A.3a

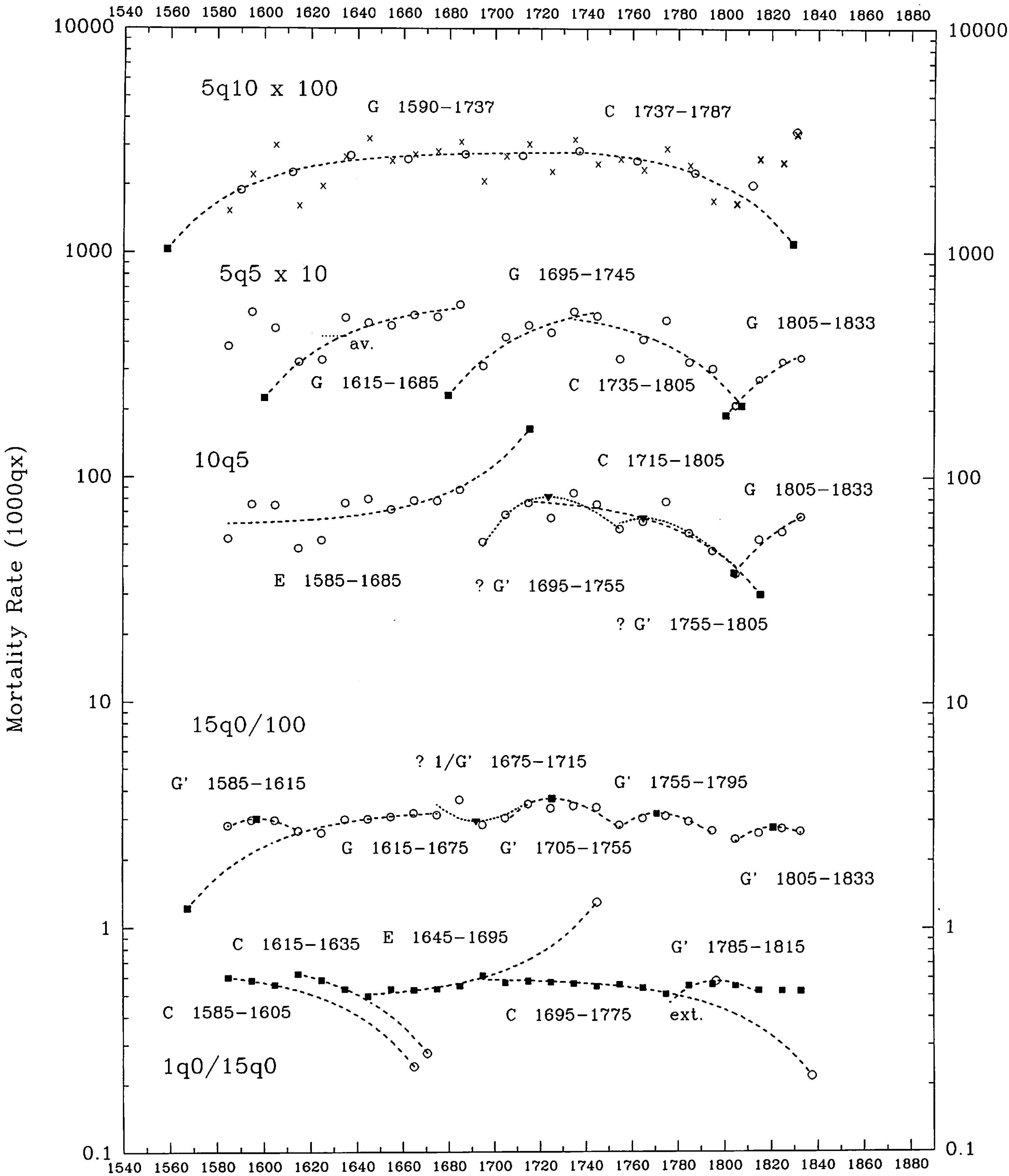
Trends of Infant and Childhood Death in England: Yearly between the First and Fifth Birthdays



X = quarter-century averages.
Source: Wrigley et al. 1997, 250–51.

Figure A.3b

Trends of Infant and Childhood Death in England: Between 5 and 15 and All under 15



x = decadal data for 5q10.

Sources: Wrigley et al. 1997, 250, 215.

Table A.1

Comparing Trends of Death Rate and Life Expectancy for Various English Populations

A. Death Rates

Population	I	II	III	IV
W-S CDR	1556-1681 E 1722	1681-1701 ?D 1664[a] 1701-1731 ?E 1750[a] 1731-1756 D 1708[a]	1761-1831 C 1880	1831-1923 C 1936
Colyton Names Reused	1569-1675 E 1708		1675-1819 C 1880	1819,1849 ?C 1964
% Kent Fathers Dead	1633-1765 C 1783	1689,1765 ?D 1670	1765,1789 ?C 1843	
Tontines 46-75 (av.)		1693-1773 C 1804		
" 31-45		1693-1789 D 1677	1745-1789 C 1844	
" 5-30 (av.)		1693,1745 ?D 1685	1745-1789 E 1849	
{ " 5-45 (av.)		1693-1789 ?D 1675}		

B. Life Expectancies

Population	I	II	III	IV
W-S at Birth	1576-1681 C 1729	1681-1706 G 1656 1706-1731 C 1754	1731-1756 G 1705	1761-1831 E 1892
W-S at Age 25		1675-1775 E 1849		
M.P.'s Age 40+		1675-1772 E 1829	1735-1805 G 1683	
" " 30-39			1675-1772 G 1633	1735-1805 E 1871
" " 20-29		1675,1735 ?E 1786	1735-1805 G 1689	
Aristocrats Age 25		1625-1725 E 1774	1725-1812 G 1666	
Sc. Advocates Age 25		1625-1675 E 1767	1675-1775 G 1626	
So. Quakers Age 25		1625-1725 E 1779	1675-1775 G 1612	
Tontines Age 25		-	1675-1775 G 1632	

[a] = alternative possible trends for successive 1/G' movements between 1681 and 1761 in Figure 1.1; [b] = alternative possible trends for successive G' movements between 1681 and 1761.

Sources: Wrigley and Schofield 1981, 528-29; Razzell 1993, 755, 764, 761.

Appendix B

Changing Levels and Interactions of Death and Birth Rates

Do the A-1, A-2, B-1, B-2 groupings proposed on the basis of the shape and timing of G-based trends in death rates insightfully relate to the previous mode of categorization that has stressed levels? Do they conform to its findings? Do they add to what is learned from that more familiar perspective? Table B.1a compares results of the two approaches for crude death rates in Europe (Tabs. 2.1a, 2.2; Chesnais 1992, 556-78).

As of the 1950s, in the 'A' countries most death rates had fallen to 10 per thousand or less.[1] In contrast, even in the early-adjusting 'B' populations of Belgium, Luxemburg, and Austria, CDR's did not go below 10 until the 1980s. Among the seven B-2 populations of Europe, too, crude deaths rates mostly have dipped under 10 on average for a quinquennium or more only very recently.[2]

Two decades earlier, in the later 1930s, the average CDR for all eleven A-1 populations was 12.1 compared with 15.5 for the A-2's. Among the B-1's, the mean was 12.9 compared with 15.5 for the B-2's. In other words, to have late-19th- and early-20th-century CDR declines culminate in the interwar years (the A-1 and B-1 pattern) was, on average, to achieve lower *levels* of death rate before World War II. For the 20th-century era of demographic change, classification by CDR level that had been reached by the 1930s or the 1950s or the 1980s generally coincides with the proposed categorization according to the timing of the C curve for death rates. The new system of organization is consistent with the old.

In a still earlier period, the years before World War I, among 22 European populations with substantial records the 10 lowest death rates for 1910-1913 prevailed in Denmark, the Netherlands, Norway, England and Wales, Sweden, Belgium, Scotland, Germany, Luxemburg, and Finland. Seven of these are A-1 populations; Finland is an A-2. Only Belgium (6th) and Luxemburg (9th) are ‘B’s, each a B-1. During the early years of the past century, the main departure of the new classification system from distinctions according to level of death rates is that A-1 countries of *eastern* European like Czechoslovakia, Hungary, and Yugoslavia join A-2’s like Russia, Romania, and Bulgaria in having CDR’s that were at the time high for Europe. More eastern Austria differed likewise from Belgium and Luxembourg among the B-1’s. In short, there prevailed at this time a delay of improvement for mortality in eastern Europe that generally gave all those regional populations (denoted ‘E’ in the 1910-13 column of Tab. B.1a) more severe crude death rates than Ireland, France, Italy, Spain, and Portugal, though those ‘B’-type western nations retained higher CDR’s than their non-eastern counterparts in category ‘A’.

Back further still, in the later 1860s, with the exception of Greece (where the data are incomplete and quite possibly imperfect) death rates were also higher in eastern Europe than in the West. Meanwhile Norway, Sweden, Denmark, Scotland, England and Wales, and Switzerland--all A-1’s--had six of the lowest eight CDR’s. France, Belgium, and Luxembourg followed, just ahead of the Netherlands and Germany, with Spain, Italy, and Austria already bringing up the rear in western Europe. Ireland’s position in the 1860s, with the lowest CDR of all (put in brackets), would seem to be a temporary consequence of the famine of the 1840s, which killed off the weak, and the massive exodus that followed, which took vulnerable children (and children that would be born to young adult parents) overseas in huge numbers. The mortality of the young was still a very important factor in determining crude death rates at this time.[3]

Even earlier, in the 18th and early 19th centuries--finally, it is possible in Table B.2a to see the ‘A’ and ‘B’ groupings of the future already begin to form. As of the start of their first modern sustained C-shape decline, commencing somewhere between the 1730s and the 1770s, crude death rates in Norway, Sweden, and England were all in the low to mid 20s, compared with more like 36 in France and Italy. Local German evidence, however, indicates an average of about 34 deaths per 1,000, lagging behind other populations of the future northern and western A-1 zone of 20th-century Europe.

Between the middle of the 18th century and the later 1810s, following the Napoleonic Wars, death rates in Germany seem to have improved more rapidly than they did in many other places; and by 1900 this population was--accompanied by the Netherlands--firmly established along with other A-1 leaders of historical mortality reduction in Europe. Among the ‘B’ group of populations, meanwhile, France and Belgium (and probably Luxemburg) witnessed even more substantial decline in their CDR’s from the 18th century forward into the first decades of the 19th.[4] Thus, by the 1860s they competed with most of Scandinavia, England, the Netherlands, and Germany as healthy places to live, in contrast to the other ‘B’ countries with records at this time: Italy, Austria, Spain, and Portugal. But such relative betterment in crude death rates proved to be only temporary in French-speaking Europe. Across the 20th century, France (B-2), and to a lesser extent Belgium and Luxemburg (both B-1’s), lagged in further reduction of their CDR’s thanks in part, though apparently not entirely, to the ravages of two wars.[5] Meanwhile, through the 19th century, future effective A-1 and A-2 curbers of death rates located from Czechoslovakia eastwards still retained high CDR’s very much like those of Italy, Austria, Spain, and Portugal.

Half a century ago, George J. Stolnitz captured most of the nature and location of these international movements in the data then available.[6] A generation of interest in historical demography since that time and several decades more of unfolding current data have added considerably more information with which to construct cross-country comparisons. In his 1974 return to the topic, for example, Stolnitz (225) noted how fast crude death rates had fallen in eastern Europe since World War II. That made levels of the CDR’s in these countries (here classified as A-2’s) catch up, or pass, the results of earlier declines in the leading area he now defined as ‘Northern and Western and Central Europe’ (closer to the boundaries of the A-1 classification chosen here than the ‘Western Europe’ of his 1955 survey). Stolnitz also now noted that crude death rates had been rising “in many higher income countries since the early 1960s.” (225).

What Tables B.1a and B.1b and Figures 2.1a through 2.1i add is: 1) Some of these increases began in the 1950s, though others have continued to emerge since Stolnitz wrote in 1974. 2) Over and over again these rises have taken the G form. And 3) as of the 1980s only five countries outside the A-1 and A-2 clusters in northern and eastern Europe (Argentina, Uruguay, Cuba, the Philippines, and Fiji) had so far shown convincing signs of similar upward trends in their CDR's (Tab. 2.2).

Clearly the geographical center of reduction in crude death rates since the mid 1700s has been centered in northern and western Europe.[7] A tendency for Belgium and France and Luxemburg to attach to this group in the early 19th century stalled, however.[8] Instead, in the early 20th century several countries in eastern Europe joined those of the northwest in pushing decline in death rates furthest of all, if doing this rather later (as A-2's rather than A-1's). By the end of World War II, however, CDR's actually began to rise precisely in these path-breaking 'A'-type countries while declines have generally continued among the 'B's, catching up to or surpassing the minimum levels reached by the 'A's, but in rather later timing.

Since more is said about them in the text of Chapter 2, comparable levels for crude birth rates are simple listed in Tables B.2a and B.2b.

The first thing to note from Table B.3 is the way that relatively sharp, significant increases or surges of natural increase clearly occurred at the beginning of 8 among 12 historical G trends of growth identified in these countries. In 3 of the 4 exceptions, the actual starting date for the first observed G (England before 1541, Sweden before 1723, France before 1752) is simply not known, making a determination impossible. The CRNI, however, fell over all or most of the known duration of these other trends, as was the case where the full span of years can be documented. The one real exception appears in Sweden, where--as noted--the surge did not reach full strength until some 10 years after a G trend began in 1783.

This finding about the initiation of G-shape population increase is scarcely surprising. A new trend of faster growth requires some fresh source of extra people; and in established populations natural increase is much more powerful than the alterative, change in migration rates. Equally to be expected is that, on average, the rate of natural increase will on the whole taper off as growth slows, as Figure 1.3, 3.1a, 3.1b, and 3.1c and the middle column of Table B.3 indicate. Less automatic, however, is the role of net migration in the process of deceleration in G form among populations.

Whether net immigration or net emigration is indicated depends, first of all, on how far the rate of natural increase surges relative to the pace of growth. During most G trends of expansion covered in Table B.3, there was not a wide discrepancy between the two, and therefore not substantial net migration. The most notable exceptions were the two G trends in France after 1919, during which that country avoided the depopulation that was predicted (Spengler 1938) by attracting in a significant flow of immigrants--in lieu of the modest net emigration which had been the average national imbalance since the 1830s (Fig. 3.1b). To a lesser extent from the early 1940s into the early 1970s Sweden experienced comparable conditions in the modern era with similar reversal in the sign of net migration (Fig. 3.1a).

The Swedish G-type growth trend from 1943 through 1990, however, illustrates another common feature of such movements besides closeness of level between growth and natural increase: the CRNI tends to contract more than the rate of overall demographic expansion, usually sloping downward from at or above its starting point to levels below it as the G trend plays itself out. This, except for the low rates of net migration at times in France, encouraged immigration--most notably in all four countries after World War II, but also in Sweden from 1723 to 1748 and from 1783 (actually 1793) to 1818 and in France between 1752 and 1792.

As G-shape growth unfolded 12 times in these four long-documented populations, in every case but one the crude birth rate declined in C fashion. The exception is came in the fifteen opening years of the English record (1541-1556), where the CBR did decrease, but its path cannot be clearly determined because of insufficient information.

The ways that the crude death rate moved relative to the birth rate as G-form population growth appeared and ran its course, on the other hand, were considerably more diverse--as the rightmost column of Table B.3 indicates. In Sweden (Fig. 3.1a), a stimulus for the first recorded G movement in growth would seem to have been the way the CDR sagged to a low in the 1710s while the CBR remained quite level. Then, between 1748 and 1848 the long-term tendency was for the CDR to decrease along a C path that was steeper than the C for the CBR. The first of three G trends of population increase during these 100 years was triggered as the death rate stopped surging upwards in the later stages of a 1/G' pattern to meet the birth rate. The second and third growths, however, began with short-term movements across the diverging long-term C trends of the separate vital rates. Substantial implied shifts in net migration in the late 1740s, the 1780s and after 1803 may have played a significant role, but require verification.

In France, meanwhile, recorded G-type growth began in the 1750s as the CDR dropped somewhat while the CBR held close to level along the early stage of a C trend that had started by 1740 (Figs. 3.1b). The G increase that began in the 1820s commenced as the death rate, via a steeper C path, reached its lowest level relative to births, and dwindled as C movements in the two vital rates progressively re-converged across the next nine decades up to World War I, first more rapidly then more slowly because of the shift in the CDR from a steeper C trend to a flatter one that was more parallel with the current trajectory of the CDR. Such convergence appeared again in the period of G-shape population increase between the wars, and once more between 1948 and 1975, in both instances as jumps in fertility that had welcomed peace shrank away. Decline in growth rate for the French population continued to 1990 or later in spite of a widening gap between births and deaths because immigration, which had filled a substantial shortfall of natural increase below growth rates since 1919, apparently contracted significantly.

In Sweden, Denmark, and England, meanwhile, as increases in birth rates after World War II generally shrank away in C manner over the second half of the 20th century, death rates rose in G form to meet them, closing the gap. In England, the trends both down and up were least pronounced: the G in CDR may have turned into a C by about 1980; and the C of the CBR bounced on its way down (Fig. 1.1). The results were comparable, however: decelerating growth in G form, propped up--particularly in the later years--by net immigration to supplement natural increase as it fell below the growth rate (Fig. 1.3). In England back in the middle of the 16th century, finally, the data between 1541 and 1556 are too short to trend meaningfully; but before dropping off significantly in the later 1560s to launch a new trend of expansion (in H form), the CDR rose to 1561 while the CBR fell. This pushed the CRNI below the growth rate in spite of a modest level of net emigration over the 1540s and 1550s, which average out the sharp but temporary impact of the Marian exile.

The H trends of population increase next covered in Table B.3 also quite generally, and again predictably, began with or shortly followed a rise in the rate of natural increase (though the start of the 1890-1945 movement in Denmark seems to have been delayed by a spurt of heavy emigration, shows Fig. 3.1c). One difference in behavior from the G trends was that generally these gains in CRNI were more gradual (though fairly abrupt in England during the years around 1556 and 1686). The principal tendency thereafter, furthermore, was for the rate of natural increase to bow out above the growth rate, with swelling then contracting net emigration reconciling their two movements. In Denmark (Fig. 3.1c), between 1801 and 1845 and again between 1850 and 1890 the CRNI did not recede much this way toward the end of the H trend; between 1890 and 1945, moreover, while bowing occurred, it played out at a level lower than the growth rate, rather than above it, thanks to high rates of implied net immigration. In England (Fig. 1.3), natural increase rose gradually to the level of the growth rate at the beginning of the 1816-1861 trend, then above it during the last years in the typical gain for a new H pattern.

Unlike quite uniform movements of that kind during G trends, meanwhile, only in half of the H cases covered in Table B.3 did the birth rate come down in C form as this type of growth occurred. More usual during H-type population increase (6 of 8 instances) was C-type reduction in the *death* rate. The two exceptions appeared in England before 1730.

During the H trends of expansion for Sweden from 1848 to 1943 and Denmark from 1890 to 1945, the crude birth rate adhered to a single C path while the death rate abandoned a relatively parallel C trend for an appreciably flatter one. In England between 1861 and 1939, each vital rate displays a C pattern followed by a second flatter one. In Denmark from 1850 to 1890, the CDR took a C path while the CBR first climbed somewhat via E then sagged in 1/G’ fashion. In that same country, between 1801 and 1845 the H trend of slowly decelerating growth involved a shift from a C trend to a flatter C in the birth rate, but a D-type decline in the CBR. The English population of the same era (1815 through 1861) likewise experienced D-shape decrease in the CBR as a C trend in the CDR gave way to flatter C movement. In the earliest H trend documented, the English had a long C decline from 1561 to 1656 in birth rate while the death rate rose to meet it along a somewhat later-targeted E trajectory. The most unusual H case among these national examples involved G-type increase in the CBR and a 1/G' sag in the CDR for England between 1686 and 1726. In all, the more exceptional dynamics producing H-type population increase both appeared in England before 1730. 'Transition'-era H trends have more in common.

New E trends summarized in Table B.3, like growth in G and H form, began with a surge in natural increase or a high level of it. As in the dynamics of H expansion, natural increase rose above before falling below growth rates. This movement took bow form in England but behaved more erratically in Denmark. In the short French E trend that followed the Revolution, CRNI went above, below, and ended back above the growth rate. In both Denmark and England a long E-shape acceleration in CBR accompanied a 1/G' dip then C decline in CDR. Did the temporary 1/G' sag in death rate trigger E-shape population increase? Not necessarily, because in Sweden, Norway, Finland, Germany, and Bohemia and Moravia such 1/G' slumps in the CDR were not accompanied by E-shape trends of population growth (Tab. 2.1a; Harris 2001, 148-49). The E form of growth is totally missing from the historical record in the three northern Scandinavian populations, and arrived only much later in Germany and the Czech lands. Doing the most to drive accelerating growth of the E form in England and Denmark, moreover, was the divergence between E trajectories for CBR and C paths for CDR. In France, no 1/G' dip in death rate is observed since 1740. Instead, the CBR switched from one C movement to a flatter successor while the CDR kept going down along the old C track. The take-off for E growth, however, did appear near where the CBR switched from the old C path to a flatter one. The Revolution temporarily slowed the downward drift of births in France but not the accelerating C decline in deaths, as mortality continued to improve faster and faster into the 1820s.

The use of implied mortality movements and smoothed trends of CBR and CDR in this analysis of Table B.3 clearly limits the firmness of some of these conclusions. The exploration that this preliminary approach allows, however, does help in beginning to understand the demographic dynamics of key, repeated forms of population growth, their common components, their typical differences, and less systematic variations. The analysis can be expanded to include other cases with adequate evidence, advancing command over what is general and what is not, and how such patterns of increase so frequently recur.

10

Notes

1. The 3 exceptions in 17 cases were postwar Germany, where the CDR reached down to just above 10 (around 1950), and England and Scotland, where it bottomed out only near 12. This undoubtedly had something to do with the subsequent British G's being flatter than in comparable populations.

2. As of the later 1950s, in 10 European B-1 and B-2 populations the 2 exceptions had occurred in Italy and Spain.

3. In his historical survey of death in Europe, Chesnais focuses heavily on *infant* mortality rates. Some *total* European CDR's for the 1860s--in the English translation, at least--are labeled "Infant mortality rate" (1992, 75).

4. Location of this most significant death rate improvement of the time in the neighboring countries of France, Belgium, the Netherlands, and Germany merits further investigation. Chesnais, for instance, has emphasized developments that reduced mortality within France. Something more than that was apparently involved. What changes, for example, did French armies and French administrations take with them as much of Europe came under French sway?

5. For example, in the 1930s parents traveling from America and England were warned that milk was not safe in France because control of tuberculosis was suspect.

6. Stolnitz 1955 and 1956. He, however, grouped Ireland, Belgium, and France with 'the West,' as well as the U.S.A., Canada, Australia, New Zealand, white populations in South Africa and Rhodesia, and the Jewish population of Israel. These are all 'B's, not 'A's, in the present categorization--except for the two white African populations, which are not included in this survey. Finland, Czechoslovakia, Poland, Hungary, Russia, and the Balkans, however, appear as later A's (A-2's) here though Stolnitz, emphasizing their tardier adjustment, and not having evidence of their recent increases in CDR (which occurred mostly *after* his path-breaking study), grouped them with Austria, Italy, Spain, and Portugal in 'Non-Western Europe' (1955, 26).

7. Chesnais comes to this same conclusion of diffusion from the North and West to the South and East

on the basis of trends in infant mortality rates (1992, 61).

8. Vallin (1991, 44-45), for one, recognizes how the death rate in France fell more slowly in the late 19th century than that in England, but follows Henry and Blanchet (1983) in judging that lower mortality in England than in France earlier on, in the 18th century, “was apparent rather than real.” Table B.1a would seem to challenge this conclusion, since Norway, Denmark, and Sweden also have lower CDR’s than France in the first, 18th century column, while Germany, Finland, and Italy have levels about like France.

Chesnais, meanwhile, argues that modern “progress” in reducing crude death rates began in France, Czechoslovakia, and Scandinavia (except Finland), passed later to England and Wales, Belgium, the Netherlands, Switzerland, Germany, Austria, Hungary, Poland, and Russia, and finally reached “Mediterranean countries” like Italy and Yugoslavia. (1992, 54-55) The evidence of Table 2.1.a and Figure 2.1.a through e, in contrast, shows the earliest C trends to have appeared in Denmark, France, and Norway (and, local data hint, perhaps at least parts of Germany); then England and Sweden, followed by the Netherlands. Only behind them came Belgium and the Czech lands, which had t_0’s for their initial C curves as late as the 1930s along with Austria, Northern Italy, Switzerland, Hungary, Finland, and Russia.

Table B.1a

Comparative Crude Death Rate Levels at Selected Times: In Europe

Period:

Population:	Early	1815-19	1860s		1910-13	1935-39	1955-59		1980-82
A-1:									
England	27.7[a]	25.5	22.5	*	13.8	12.0	11.6	^	11.7
Scotland			21.3	*	15.3	13.2	12.1	^	12.3
Norway	22.3[b]	19.1	18.0	*	13.4	10.2	8.8	^	10.1
Sweden	26.1[c]	24.5	20.2	*	13.9	11.7	9.6	^	10.9
Denmark	27.7[d]	19.9	19.9	*	13.0	10.7	9.1	^	11.0
Netherlands		29.5	25.4	*	13.2	8.7	7.6	^	8.2
Germany	34.0[e]	30.4	26.9	*	16.0	11.9	11.2	^	11.6
Switzerland			23.0	*	14.9	11.6	9.9		9.2
Czech Lands		31.0	29.7	*	21.9[f]E	13.2	9.7	^	11.9
Hungary			32.7	*	23.6 E	14.3	10.3	^	13.6
Yugoslavia			31.3	*	23.7 E	15.9	10.5		9.1
A-2:									
Finland	32.3[g]	25.1	25.8	*	17.3	13.2	9.1	^	9.2
Russia/USSR			37.0	*	28.2 E	17.9	7.7	^	10.4
Poland				*		14.0	9.0	^	9.5
Romania			25.6	*	24.8 E	19.6	9.7	^	10.2
Bulgaria				*	23.5 E	13.9	8.9	^	11.1
Greece			21.0?	*	?	14.4	7.3	^	8.9
B-1:									
Belgium		[25.6]	[23.8]	*	[14.9]	12.5	11.8		11.4
Luxemburg			[23.9]	*	17.7	12.2	11.9		11.2
Austria		34.0	31.5	*	21.0 E	13.9	12.5		12.1
B-2:									
France	36.3[h]	[26.6]	[23.6]	*	18.2	15.3	11.7		10.1
Italy	35.5[i]	35.6	30.9	*	19.6	13.9	9.5	^	9.6
Ireland			(16.9)	*	16.8	14.3	12.0		9.3
No. Ireland				*		14.3	10.9		10.4
Spain			30.3	*	22.5	17.8	9.2		7.6
Portugal		30.7	?	*	20.5	16.0	11.5		9.6
Albania				*		17.2	11.5		6.1

[a] 1736-40; [b] 1735-39; [c] 1744-48; [d] 1735-39; [e] 1750-59, 5 communities; [f] 1905-09; [g] 1760-64; [h] 1750-54; [i] 1770-75, Lombardy; E eastern Europe.

Sources: Chesnais 1992, 555-78; see text and notes for additional local data.

Table B.1b

Comparative Crude Death Rate Levels at Selected Times: Outside Europe

Population	Period: 1925-29	1955-59	1980-82
A-1:			
Argentina	14.6	8.6	8.7
A-2:			
Uruguay	11.2	8.0	9.6
Cuba	12.1	6.2	5.9
Philippines	19.0	8.7	7.7
Fiji	17.3	7.5	6.2
B-1:			
U.S.A.	11.8	9.4	8.6
Canada	10.2	8.1	7.0
Australia	9.4	8.8	7.3
New Zealand	8.6	9.1	8.2
Panama	17.1	10.9	5.4
Jamaica	20.4	9.6	5.8
Trin. & Tob.	23.0	9.6	6.3
B-2:			
Puerto Rico	23.0	7.1	6.5
Mexico	25.5	13.2	7.1
Costa Rica	23.1	10.7	4.2
Guyana		10.7	5.9
Venezuela	19.5	12.3	5.6
Chile	26.4	12.8	7.7
Brazil	20.0?	13.6	8.4
Japan	19.8	7.8	6.1
Singapore	29.5	7.3	5.2
Hong Kong		7.2	4.9
Sri Lanka	24.9	9.9	6.1
Cyprus	15.2	6.2	8.3
Korea	26.0	16.1	6.4
China		16.7	6.7
India	35.0	22.0	11.9
Egypt	26.4	17.0	10.3

C:

Palestine/Israel	12.7	6.2	6.7
Taiwan	22.4	8.0	4.8
Malaysia	22.0?	11.3	6.0
Mauritius	26.8	12.0	6.8
Reunion		14.1	6.6
Tunisia (? type)		8.9?	10.0

Source: Chesnais 1992, 555-78; also see text.

Table B.2a

Comparative Crude Birth Rate Levels at Selected Times: In Europe

Population:	Period: Early	1810-15	1845-54	1871-80	1895-04	1921-30	1948-52	1971-80
A-1:								
England	34.1[a]	40.7	35.4	36.0	29.1	18.7	16.4	13.3
Scotland				35.0	29.7	22.3	17.9	14.0
Denmark	30.2[b]	30.0	31.2	31.4	29.7	20.8	18.7	13.3
Netherlands		33.8	33.0	36.2	32.0	24.5	23.3	13.8
Belgium			29.3	32.3	28.5	19.4	16.7	12.9
Germany	39.8[c]	40.2	35.6	39.1	35.5	20.3	16.2	10.2
Switzerland				30.7	28.2	18.5	18.1	12.6
Imp. Austria		40.5[d]	37.5	39.0	36.5	-	-	-
No./All Italy	39.5[e]	37.4[f]	37.1[f] /	36.9	33.5	28.1	19.6	14.2
A-2:								
Hungary				43.5	38.9	27.7	20.4	15.9
A-3:								
Portugal			33.5	33.5	30.9	32.0	25.2	18.9
Romania				35.0	40.2	36.5	25.5	19.1
A-4:								
Russia				50.4	49.1	42.7	26.7	18.1
B-1:								
Sweden	32.8[g]	32.9	31.3	30.5	26.7	17.5	16.7	12.5
Norway	29.4[h]	27.1	31.5	31.0	29.6	20.1	19.3	14.2
Luxembourg			33.5	32.6	29.9	20.5	14.8	11.5
B-2:								
France	39.8[i]	32.6	[26.7]*	[25.4]*	[21.7]*	18.8	20.7	15.0
Finland	35.1[j]	37.0	35.8	37.0	32.9	23.6	24.9	13.4
Czech Lands	44.2[k]	43.4	40.0	39.8	35.2	25.2	22.8	18.3
Bulgaria					40.8	36.0	23.4	15.9
Greece				27.7?	25.7?	-	19.6	15.8
B-3:								
Spain				35.8	34.8	29.2	21.1	19.1
Poland						33.5	30.1	18.6
Yugoslavia				40.5	40.1	34.6	29.0	17.8
C-1:								
Modern Austria						19.8	15.9	12.5

C-3:

No. Ireland				21.1	18.1
Ireland	30.2	23.2	20.8	21.6	21.8

C-4:

Albania				37.5	31.0?

[a] 1739-43; [b] 1735-44; [c] 1750-59 local; [d] 1820-24; [e] 1770-75 Lombardy; [f] Lombardy & Tuscany; [g] 1736-45; [h] 1736-45; [i] 1740-49; [j] 1721-30; [k] 1785-89.

Sources: Chesnais 1992, 517-41; see text and notes 3 and 4 for some additional data.

Table B.2b

Comparative Crude Birth Rate Levels at Selected Times: Outside Europe

Population:	Period: 1871-80	1895-04	1921-30	1948-52	1971-80
A-3:					
Japan	25.2	31.3	34.1	28.7	16.8
A-4,a:					
Cyprus		29.4	27.6	28.9	18.7
Korea			44.0	41.0	27.0[a]
Sri Lanka			40.0	40.0	28.1
Taiwan			43.0	47.0	24.1
Singapore			31.0?	46.5	19.3
Philippines			52.5	50.0	37.2
A-4,b:					
China				40.0	25.4
Malaysia				42.0	34.2
Thailand				47.5	35.1
Mauritius			37.3	46.8	25.8
Tunisia				36.7[b]	35.7
Puerto Rico			41.1[c]	38.4	23.2
Cuba?			16.8[c]	27.1	20.7
Mexico		46.9	44.8	44.8	40.2
Costa Rica	42.0[d]	39.7	41.7	46.0	30.9
Panama			37.9	34.0	33.4
Venezuela		29.7[e]	29.8	42.3	35.3
Guyana		32.9	32.0	42.4	32.0
A-4,c:					
Reunion				45.9	27.3
Egypt			43.6	42.4	36.4
Chile		46.9	42.2	34.9	24.7
B-3:					
Argentina	49.1	35.2	31.7	25.1	24.2
Uruguay	41.6	33.0	25.2	22.7	20.7
B-4:					
Brazil		43.0	44.0?	44.6	32.8
Pal./Israel			34.6	31.5	26.7
India			46.0	41.0	37.2
C-2:					
United States	36.1	32.3	24.3	24.6	15.5

Canada	36.5?	30.5	25.3	27.3	15.7
C-3:					
Australia	31.8	26.4	22.5	23.1	17.4
New Zealand	40.4	26.3	21.0	25.1	18.7
C-4:					
Fiji			32.3	39.9	28.8
Jamaica		38.6	36.6	32.6	28.1
Trin. & Tob.		35.5	32.0	37.2	26.4

[a] South Korea; [b] 1946-48; [c] 1932; [d] 1885-89; [e] 1915.

Sources: Chesnais 1992, 517-41; see text and notes 3 and 4 for some additional data.

Table B.3

Characteristics of G, H, and E Growth Trends in Sweden, Denmark, England, and France

	Period	CRNI Up	CRNI vs. CGR	CBR Trend	CDR Trend
G's:					
SWEDEN	1723-1748	?	falls below (I)	long C	1/G' rising end
	1748-1783	surge	stays close	long C	steeper C
	1783-1818	late surge	above (E)-below	long C	steeper C
	1823-1848	surge	stays close	long C	steeper C
	1943-1990	surge	runs below (I)	jumps to C	rises via G
DENMARK	1945-1990	surge	above-below (E-I)	jumps to C	rises via G-G
ENGLAND	1541-1556	?	stays close? (I)	falling	more than CBR
	1951-1991	surge	close-below (I)	bumpy C	flat, G-C
FRANCE	1752-1792	?	little below (I)	long C	C parallel
	1826-1921	surge	close (but I to E)	C, long C	long C falls less
	1921-1936	surge	runs well below (I)	C	steeper C
	1951-1990	big surge	runs below	C-flatter C	steeper C-C
H's:					
SWEDEN	1848-1943	gradual rise	bows above (E)	long C cont.	new C parallel
DENMARK	1801-1845	gradual rise	rises, stays up (E)	falls via D	C-flatter C
	1850-1890	gradual rise	rises, stays up (E)	E-1/G'sag	C continues
	1890-1945	early rise	bows up, below (I)	long C	C-flatter C
ENGLAND	1561-1656	surge?	bows above (E)	long C	flatter E
	1686-1726	surge	bows above (low E)	long G	1/G' sag
	1816-1861	gradual rise	close, rises (E)	falls via D	C-flatter C
	1861-1939	gradual rise	bows above (E)	long C	C-flatter C
E's:					
DENMARK	1735-1801	high start	up-down-close (E-I)	long E	1/G'-C
ENGLAND	1726-1806	surge	above-below (E sags)	long E	1/G'-C
FRANCE	1792-1827	surge	up-down-close (mixed)	C-flatter C	steeper C cont.

Sources: Figures 3.1a, 3.1b, 3.1c, 1.1, 1.3.

Appendix C

Additional Insights into European Demographic Trends

FERTILITY AND ITS LEADING CONCOMITANTS

[Table C.1]

The relative timings of various kinds of trends summarized in Table 4.3 from Table C.1 involve somewhat different results from those put forward by Francine van de Walle (1986, 231). In her comparison of national declines in infant mortality and marital fertility, Norway, Sweden, and Ireland alone among 18 better-documented countries of Europe display the sequence of change that is posited by transition theory. Using the criteria of when M_i and I_g each respectively fell below certain *levels*, she concluded that "we cannot report that the historical evidence confirms that the declines of infant mortality led to the declines of fertility" and that "Sometimes infant mortality was the forerunner in the decline, sometimes it was marital fertility. In other circumstances the declines were synchronous." (233; 230-331). While the second statement remains technically true from the perspective of the present analysis, if one recognizes the paired G-based C trends that are involved, the continuous, decade-by-decade, roughly parallel movement in all nations becomes more precisely understood; and the weight of conclusion shifts back in the direction of seeing marital fertility in fact after all mostly follow or accompany decline in infant mortality downward across the era of transition.

Upon close inspection, however, the differences between her conclusions and those presented here seem to be mostly ones of degree and perspective. By her own terms of dates of decline for infant mortality and marital fertility in eight reliably documented countries, for example, van de Walle (1986, 230) found positive correlations, three of them statistically significant, in six populations (the Netherlands, Switzerland, Germany, Sweden, France, and England in descending order) and negative in two (significant in Denmark but not Norway).

In any analysis of timing for the impact of the death of offspring upon fertility, it should be remembered that, as van de Walle points out (ibid., 206-07), *infant* mortality--though important--composes only a part of the loss of offspring while mothers are still fertile and have a chance to bear replacements. The death rate among children 1 through 4, she notes (presenting evidence for Germany, Norway, France, and Sweden to that effect), came down toward mid-20th century levels sooner in the third quarter of the 19th century than the mortality rate for infants. Just judging by eye from her graphs, these losses of children past their first birthday would seem to have signaled to parents appreciably sooner than infant mortality that more offspring would survive.

Taking all the provinces analyzed in the Princeton project together, meanwhile, around 1870 for 298 territories a low correlation of I_g with M_i was nonetheless significant, while for 443 localities around 1900 a more substantial correlation was equally significant. By 1930 or so, however, when most of the European countries examined were approaching the end of their fertility transitions, paired movements for 302 documented places produced virtually zero correlation (ibid., 221). In such overall aggregation, the correlations with infant deaths for proportion married and overall fertility are stronger than those for marital fertility. By the same criterion of levels in the vicinity of identical points in time, in contrast, *country-by-country* provincial relationships were fewer, less significant, and more often negative between proportion married (I_m) and infant mortality than for marital fertility both around 1900 and around 1930 (223). For overall fertility (224)--dominated by change in marital fertility as I_f was during transition--the net results were not too surprisingly about the same as for I_g. It is taking all studied provinces together as one large, indiscriminate unit during each period that makes the correlations between I_m and I_f bigger and significant. Such conglomeration ignores how changes in the different variables were taking place in different timings from different initial levels in diverse populations or historical contexts, though it has the advantage of ignoring often misleading categorization by national boundaries. However, a better way to grasp what regional or provincial populations within countries were doing, it is suggested, would be to explore their trend shapes, timings, and varieties of starting points with G-related patterning the way countrywide populations have been reexamined here.

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The Swiss insights provided by van de Walle, on the other hand, elegantly depict and substantiate the widely held conclusion concerning how during the fertility transition the impact of proportion married gave way to the rate of childbearing within marriage as the primary determinant of overall fertility. While any generalization from Switzerland must keep in mind that an exceptional 1/G' sag in I_m, perhaps unique for Europe, occurred there between 1910 and 1950 (Table 4.2 and Figure 4.2d), which may affect the correlations, the findings of van de Walle are very useful for the main line of interpretation. They suggest, though, that following the 1930s the connection of marital fertility with infant mortality *remained* moderately strong even though the negative relationship to proportion married weakened. There was no simple going back to the dynamics of the pre-transition epoch and the key role of nuptuality in them. Once parents could readily adjust the number of surviving children, this power continued to limit aggregate reproduction significantly.

A *new* insight emerges from a fresh look at the details of her research, however. Namely, the uncoupling through time of nuptuality and infant mortality and the rising correlation of M_i to marital fertility each seem to have taken G-based trends (like the m index developed by Coale and Trussell for assessing the degree of birth control present in a population, whose repeated characteristic G-shape pattern is demonstrated in Chapter 5). A picture begins to emerge of spreading, conscious family limitation that unfolds across modern populations in G-based trends as the dominant factor in determining collective fertility. Such movements illustrate the way that *social* and *cultural* changes, not just demographic and economic developments, have evolved in patterns related to the ubiquitous bending of G as they permeated populations and filtered through demographic structure and its alterations. Previous examples of such socio-cultural change in G-related forms from the second volume of this inquiry (Harris 2003) include the readiness to migrate (whether to a new territory or from country to city), the commitment to slavery by European colonial populations, and the willingness of one African people after another to wage war for acquiring slaves and to sell weaker individuals from their own societies into captivity as an intercontinental economic system provided inducements. The desire to control reproduction--even if it is more cultural than economic, as some argue--appears also to have diffused among populations in historically familar G-based ways.

[SPACE]

Yet another perspective on how the demographic particulars of change in fertility played out in an environment of European social and economic development between the mid-1800s and the mid-1900s is provided by patterning the amount of local variability in nuptuality among the several separately documented provinces that lay within countries (Watkins 1986a, 320-21). Figures C.1a and C.1b plot and trend the standard deviations from date to date. Table C.2 summarizes which countries display what movements in this measure of internal variation.

In England and Wales, the Netherlands, and Belgium across the later 1800s more and more difference in the proportion of women currently married (I_m) appeared across the recorded sub-regions of the country, rising in G form. Then, somewhere from 1900 to 1930, the standard deviation for provincial nuptuality turned around to recede--via C trends in England and the Netherlands, possibly though not clearly this same way in Belgium. Probably in Germany and Norway, more certainly in Italy, meanwhile, the standard deviation of I_m among documented regions within each country also increased via G movements, with base years in the 1860s--comparable to that of Belgium (1864) rather than the earlier and flatter G trend segments appearing in the Netherlands (1829) and England and Wales (1807). In these three other nations, however, provincial variability in nuptuality did not before 1970 then turn around to decline in C fashion like the standard deviations for the Low Countries and England, as Figure C.1a shows. In Ireland (Figure C.1b), local differences increased in G form from 1910 through 1960, based upon a t_0 at 1892, about thirty years later than those for Belgium, Norway, Germany, and Italy.

Elsewhere in Europe, including Ireland before about 1900, the standard deviation for local nuptuality *declined* across the later 1800s and early 1900s. The at first quicker D-type decrease occurred in northern and central Europe (Denmark, Sweden, Ireland, Switzerland, though C trends show up in Finland and Scotland and in Switzerland before the 1880s).

After about the time of World War I, second trends appeared in 7 of the 15 European countries covered in Table C.2. These generally reversed the previous patterns of increase and decline.

Comparison of these trends with other changes affecting modern European fertility that have been examined in this chapter--marital and extramarital fertility rates, regional nuptuality, infant mortality and its urban component relative to the total, and the participation of young women 20 to 24 in marriage--reveals no simple parallel or connection. Nor did the variability of I_m move like probable trends of urbanization (from Volume II) for countries in which both can be followed. One can still suspect, nevertheless, that how urbanization was distributed geographically across a nation had much to do with trends in the standard deviation of nuptuality. The measure just reflects developments *within* countries rather than *between* them.

In Italy, for instance, the cities of the North--Piedmont and the Po watershed--bloomed with industrialization relative to centers in the rest of the country. Within Germany, what happened in the cities of the Rhine lands and Saxony is well known to have contrasted to much of urban experience in eastern and southern parts of the country. Chapter 4 in Volume II has traced periodic shifts like this in growth among the leading cities of all European countries from the 1500s into the 1800s. Similarly, Chapter 6 of Volume I has demonstrated how population especially surged during the 19th century in the Rhine provinces within the Netherlands and, once the diaspora wound down, the eastern or Leinster portion of Ireland, dominated as that province was by Dublin.[1] Such concentration of urbanization within these countries probably underlay how G-form increase in the standard deviation of provincial I_m appeared across the later 1800s into the first years of the 1900s. Then, one would hypothesize, regional variability in city development started to contract in earlier and more fully urbanized nations like England and Wales and the Netherlands, where C trends replace G movements in Table C.2. In contrast, Ireland and Portugal (perhaps France, Belgium, and Switzerland as well) the marriage-friendly developmental advantage of just a few centers occurred only in the 20th century.

Though questions remain to be addressed, it would seem that the hypothesis that a shifting distribution of urbanization within countries underlies the trends for the standard deviation of nuptuality (Figs. C.1a and C.1b) is worth pursuing. It is interesting to note, furthermore, how movements in a complex measure of a variable crucial for fertility such as the standard deviation of local nuptuality indices are captured by G-related trends much as has been found for the geographers' concept of 'potential' for the relationships of key cities to each other as it was employed by de Vries for the earlier 1500-1800 period in Europe (Harris 2003, 261-65).

[SPACE]

Figure C.2 trends crude marriage rates in England, France, and Sweden for certain periods between about 1650 and 1900. However, when one examines proportions of females of different ages who were married, the patterns look rather different.

Figures C.3a and C.3b trend nuptuality for young women--and some contrasts for older women or all females of fertile age--in several European countries. On the whole, there is more movement in nuptuality for the young than among older or all women, and for northern Europe (especially Belgium, the Netherlands, and England and Wales) than in Mediterranean or southern countries (including France).

THE SOCIAL CONTEXT OF DEMOGRAPHIC TRENDS IN KNODEL'S GERMAN VILLAGES

Table C.5 compares trends in childhood mortality, age-standardized marital fertility, and family limitation for the categories of German villages studied by Knodel. Similarities and contrasts in these movements can be assessed with some knowledge of local religion, inheritance, growth in population, and occupational structure (1986, 340-41, 343).

The 3 Bavarian communities were Catholic in religion and practiced impartible inheritance. Collectively, among all 14 villages that Knodel studied these places had a low proportion of farmers, on average, but a high percentage of men who were just laborers, cottagers, or unskilled workers (though Kreuth was less distinctive in these respects than Anhausen and Gabelbach). The weight of artisans, businessmen, and professionals in this set of local populations, meanwhile, was about average. The rate of demographic increase between about 1700 and 1850 is known only for Gabelbach. If this pattern is characteristic of the group as a whole, however, population grew slowly but steadily in the vicinity of 0.3 percent annually from 1700 to 1800, from 1800 to 1850, and from 1850 to 1900 (though Anhausen and Kreuth display, respectively, less and more expansion from 1850 to 1900, their only evidence).

In this cluster of Bavarian communities, childhood mortality and age-standardized marital fertility declined together between 1775 and 1812 (perhaps via C) and then rose in rather less parallel E fashion. Across the last decades of the 19th century, finally, closely similar changes in C shape resumed (Figure 5.13b)--that patterning now being supported by what was happening in Bavaria as a whole (Figure 5.12a). The downward movements of child mortality, first into the first quarter of the 19th century and then across the second half of the 1800s almost exactly resemble contemporary C trends in fertility.

In a village setting where impartible inheritance prevailed and the proportion of men who were very ordinary workers was high relative to comparatively few farmers (and just an average proportion of those engaged outside agriculture), *changes* in rates for fertility and for death before the age of 5 seem to have been linked in the Bavarian countryside. Moderating fertility reduced risks of a "positive check" among the young, one would think especially for those who were denied, or from the start had no hope for, family land. The relative *levels* at which the two variables stood when the records begin in the 1700s, however, seem to have produced a fairly constant rate of modest demographic growth. This generated some population pressure that no doubt helped create a comparatively large under class. It also raised the average age of first marriage for females a little more than the change found in the other communities that were studied by Knodel; but from the early 1700s into the early 1800s such moderate increase in E form with zero year in the vicinity of 1900 was virtually universal for his sample of villages, as was the comparable decline of marriage age in C fashion to the end of the 19th century that followed. Demographic pressure also, apparently, encouraged some families to begin to limit fertility in the first quarter of the 1800s (Figure 5.14).

In the phase of paired upward E-shape change that followed between 1812 and 1862, a rise in early death, which was general across Germany according to Figure 5-12a, was rather steeper than the gain in marital fertility that accompanied it in the Bavarian villages. This, along with now parallel increase in the age of first marriage that peaked around 1837, relieved population pressure there, and the tentative tendency to take up family limitation observed in the previous quarter of a century collapsed (Figure 5.14).

By the second half of the 19th century, in contrast, a durable, if only moderate, shift toward family limitation appeared in these samples of the Bavarian countryside. Now *m* rose systematically via G through the second half of the 19th century pushing I_g* down in C fashion which allowed childhood death to decrease in the same pattern.

The persistent positive relationship or parallelism between changes in young mortality and fertility in these Bavarian communities between 1750 and 1900 (midpoints 1775 and 1887) under conditions of impartible inheritance, a comparatively large proportion of people in the community who had only fragile resources, and probably steady, slight population growth for a century and a half suggests first simple Malthusian interaction and then its complication by means of fertility control. From the 1700s into the early 1800s an early start towards family limitation suggests that families by some means responded to losing fewer children at early stages. Then, general worsening of mortality for the young in Germany allowed marital fertility to rise in the Bavarian villages from the early into the middle 19th century. This reproductive change, however, took a more modest, lagging E pattern that allowed families to abandon previous tendencies toward initiating fertility control. Finally, as young mortality turned to improve across the later 1800s and early 1900s--again in much the same way all across Germany, it seems (Figure 5.12a)--a spread of family limitation allowed Bavarian villagers to retain a demographic balance between births and deaths and keep local population increase at the same modest pace experienced since 1700 even as it became possible for women to marry 2.8 years younger, though still about half a year older around 1887 than around 1725.

Where and how did the Catholicism of these villagers contribute, if at all? One possibility might be in providing a more fatalistic attitude that accepted longer into the 19th century the key role of losing children in the dynamics of the Malthusian equilibrium.

The ***4 Baden villages*** were also Catholic in religion; but they practiced partible rather than impartible inheritance. The proportion of men in lower, vulnerable occupations (laborers, cottagers, the unskilled) was near the bottom for Knodel's sample: 25 percent vs. the 42 percent for the Bavarian communities. There were, on average, as many or more farmers than these common workers (especially in Grafenhausen): 1.2 to 1 as opposed to the significantly reversed 1 to 2.5 ratio found in Bavaria. Also, the proportion of artisans, businessmen, and professionals was near the top for Knodel's villages (34 percent), particularly in Herbolzheim and Rust (40 percent). Yet even with relatively more landowners and skilled men, these local populations of Baden from 1700 through 1800 grew on average 1.6 percent annually not the quiet 0.3 percent seen in Bavaria. The fact that between the first half of the 1700s and the first or second quarter of the 1800s the C trend for marital fertility in these communities came down more slowly than its paired path for childhood death--unlike the close parallelism of the two C's in Bavaria--fostered such robust growth. Before the second quarter of the 19th century, meanwhile, family limitation was virtually absent. No earlier tentative "feeler" of such practices as in Bavaria appeared. One can suspect that the partibility of inheritance facilitated entry into crafts and commerce to support families. The higher number of farmers than in Bavaria, meanwhile, should be at least in part the consequence of partitions of land among children made possible by the different inheritance system at work here (perhaps supplemented by multi-occupationalism, as Chapter 6 discusses with regard to Flanders). Only in Herbolzheim did the age of women at first marriage approach the degree of increase to hold back population growth that was characteristic of the Bavarian villages. In Rust and Kappel the "give" to accommodate demographic pressure was instead only about 1.7 years not 3.0 or 3.2. In Grafenshausen, with all its farmers, the rise was a meager 0.8 years, fostering the greatest 18th century population growth of all of Knodel's communities.

Subsequently, across the remainder of the 19th century, as the death rate for the very young in these villages of Baden exchanged improvement in C form for the widely encountered German increase of the time (probably via E) before resuming modern decline into the last quarter of the 1800s, marital fertility first rose more flatly, in G fashion (except for the most agricultural village, Grafenhausen), managed by family limitation that mostly came a generation earlier in the sample communities of Baden than among those of Bavaria. This ascent of *m*, finally, allowed marital fertility to trend every which way across the last years of the 19th century: a C rather steeper than the Bavarian one in Grafenhausen, the exceptionally agricultural village of the Baden group, where age of marriage simultaneously declined 2.2 years; a gentle E in Rust, one of the two communities with most artisans, businessmen, and professionals, in which age of marriage ended up around 1887 where it had stood at 1775; and quite flat decelerating G movements in Kappel and Herbolzheim, in both of which women married on average 1.3 and 1.7 years older in the last quarter of the 19th century than in the first quarter of the 18th.

The outcome in population size of these generally limited changes in I_g, when matched with child mortality that increased to about 1870 before starting down in modern improvement and marriage age--on average for the group--back down within half a year of where it had commenced in the first half of the 1700s, was quite different from what one would at first expect. Rather than demographic expansion, some modest population *loss* appeared in the Baden villages of Knodel's sample between 1850 and 1900, probably thanks to net outmigration that the excess of fertility increase over mortality gains through the middle of the 19th century had triggered and that the custom of dividing inheritances facilitated. Southwestern Germany has long been noted as a major source of migrants to the United States in the middle and later 19th century (as by Marcus Hansen and Oscar Handlin). The more recent work of von Hippel, for instance, indicates a G' surge of total emigration out of Württemberg, next to Baden, from about 1820 forward that crested near 1870 (Harris 2003, 82, graphs this).

Catholicism, as in the Bavarian communities, perhaps helped Baden villagers accept the death of children as demographic regulator well into the 19th century. Partible inheritance, on the other hand, may have encouraged them to calculate rationally sooner, in the shifting cultural climate of the 1800s, the interaction of resources and numbers of children. The conscious consideration of this trade-off has been deemed central for the development of family limitation in any religious setting (including Catholic, the next section of this chapter shows from the historical literature on France and Belgium). It can be suspected of playing a significant role, for the most part pushing up *m*, systematically if only moderately, a generation earlier than in the sample localities from Bavaria.

In ***<u>Öschelbronn</u>***, a Protestant community within neighboring Württemberg, partible inheritance was the custom--as for the four villages of Baden. Unfortunately the rate of demographic expansion cannot be estimated before the second half of the 19th century, where it resembles that in Bavaria rather than the atrophy by then current in Baden. Occupationally, Öschelbronn was distinctive within Knodel's sample for having the lowest proportion of laborers, cottagers, and unskilled workers (just 16 precent), fewer even than Grafenhausen. Like Grafenhausen, Öschelbronn also contained an above average proportion of men who were farmers (though not Grafenhausen's extreme 46 percent). The community also had--like Herbolzheim and Rust (even more closely, Baden on average)--a high level of artisans, businessmen, and professionals.

In a community with these characteristics, appear not parallel but *opposite* trends in death under 5 and I_g from the 1700s into the early 1800s: a C in young mortality and an E in marital fertility (Figure 5.13b). Having partible inheritance and supporting an above average proportion of non-agricultural workers while producing a relatively small under class undoubtedly helped the community cope with rising fertility, as did an average age at first marriage for females that increased 2.8 years by the second quarter of the 19th century in the typical E pattern of Knodel's sample villages--not much less than in Bavaria and Baden. The fairly large share of farmers and their high number relative to men who were probably mostly farm laborers, however, also signals division of land among heirs--and probably out-migration rather than staying around to work for somebody else. Even with a shift upward in the C trend of childhood death for the period from 1812 through 1837 (Figure 5.12a), the demographic movements at work can be expected to have driven population size upward in E fashion. While there are no estimates for Öschelbronn itself, ample data for Württemberg as a whole make it clear that from 1759 through 1802 the population enlarged in accelerating E form toward a target date of 1830 (Harris 2001, 206, 208). Baden and Bavaria, on the other hand, display no such pattern of demographic growth until the later decades of the 19th century, growing from 1816 or sooner up into the 1860s in decelerating G fashion instead.[2]

Very early for Knodel's villages, already from the second half of the 1700s into the first quarter of the 1800s, Öschelbronn displays a modest tendency to experiment with fertility control (Figure 5.14). From 1812 through 1862, however, this preliminary development in *m* eroded away systematically in D fashion. The shift up in the trend for childhood death around 1812 relieved some of the pressure from marital fertility as did the way the accelerating increase in the average age of first marriage for females lasted on into the second quarter of the 1800s. By mid-century, furthermore, Württemberg--as noted--was accompanying Baden as a major source of emigration. One result was that population increase for the region gave up its accelerating E trajectory for decelerating G growth from 1818 through 1871 (Harris 2001, 208).

Then, across the second half of the 19th century, quite parallel G' humps appear for Öschelbronn in both death under 5 and marital reproduction. This balance between change in mortality and fertility was aided by the late return of some family limitation, though not as much as in the sample villages from Bavaria or Baden. This low level of *m* may in large part result from the fact that, among all the communities in Knodel's sample, Öschelbronn experienced the least reduction in the age of marriage across the later 19th century--about 0.5 years, which, after increase through 1862, left this component of restraint upon net reproduction as much as 2.3 years above where it had stood around 1725.

The likely G' pattern for I_g, it should be noted, links Öschelbronn to a trend in marital fertility that has been found throughout predominantly Protestant northwestern and central Europe (excepting Iceland and Scotland) but only in Belgium and some Hapsburg domains among primarily Catholic countries that lay, except Ireland, to the south and to the east (Table 4.5). The latter populations shared G' patterns in *extramarital* fertility but not I_g with their Protestant northwestern counterparts.

[Even in the material of Perrenoud just examined, moreover, Geneva-born females of 40 through 44, 35 through 39, and perhaps also 30 through 34 who had been married between 20 and 25 display G' surges in their age-specific fertility among those wed from 1635 to 1687 or

1702 that crest around 1646, 1652, and perhaps 1656 respectively (1990, 256). Translated into the time at which the births took place, these patterns indicate a peak of later-life reproduction around 1670. This was probably to replace losses of children during the plague-ridden years of the middle of the 17th century.

In this era of the later 17th century, the G’ pattern is not evident for women of the same age groups who had migrated into the city. They, furthermore, generally had fewer children than native females of the same age.

In the later period between 1747 and 1805, in contrast, from one age cohort to another immigrant women often had *more* children; and now they shared with those born in the city the tendency of females aged 20 through 24 and 25 through 29 to display something of a G’ hump in their age-specific fertility (again just examining those married 20 to 24 for a preliminary insight) that crested in the vicinity of 1770. In this later instance, affecting young women rather than those nearer to the end of their fertile years, were urban employment and other life chances of the city rather than the loss of previous children the dynamic behind the G’ surge?]

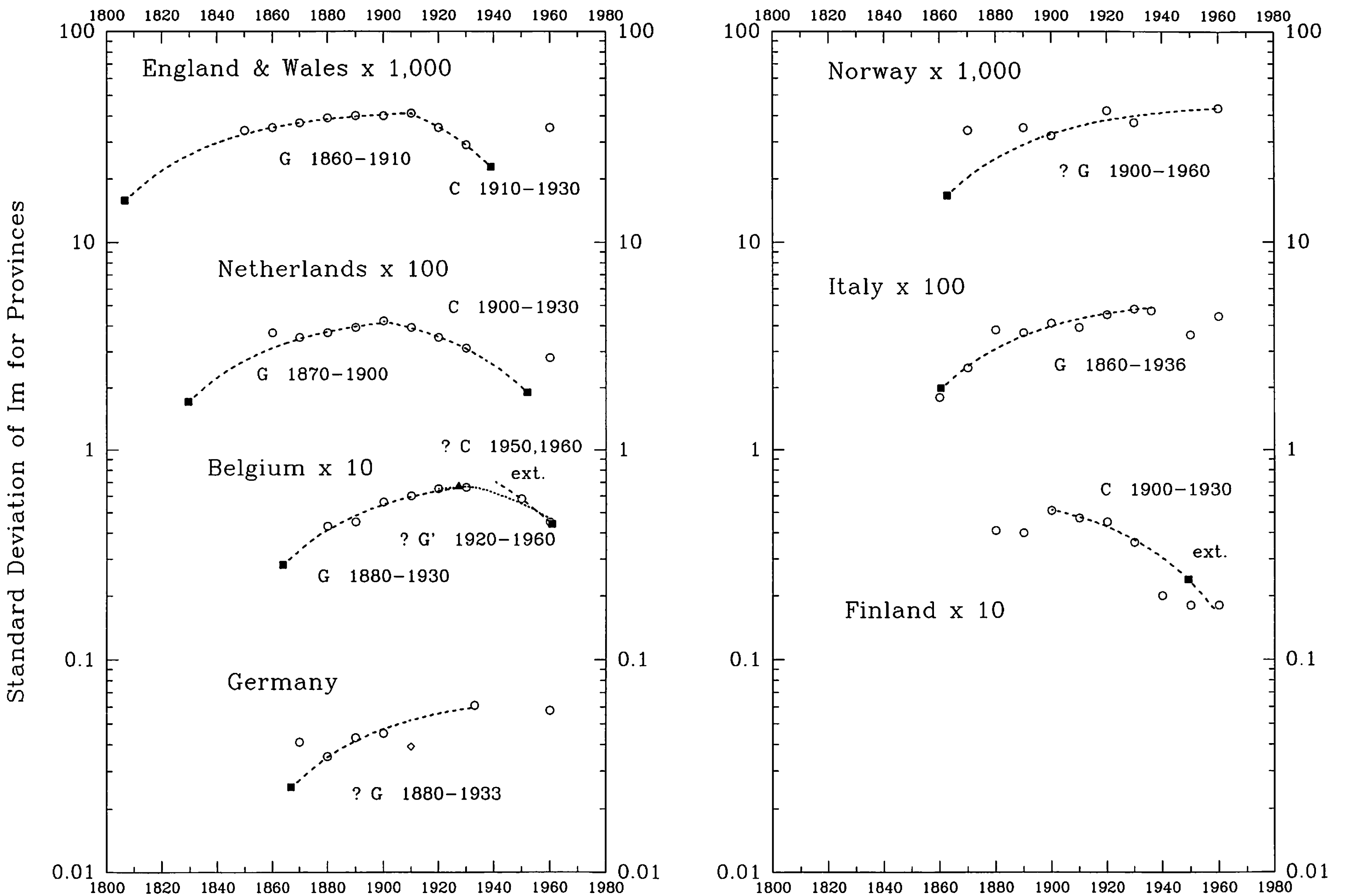
Notes

1. The steep equalization of provincial nuptuality in D form from where the record begins for Ireland at 1870 to the turn of the century is easy to hypothesize as a consequence of massive emigration overseas rather than to cities until the new century began. Other D patterns, later and less severe, in Sweden and Switzerland--and perhaps Denmark--are less readily explained. Did Stockholm and Copenhagen perhaps yield opportunity to local competitors during the suggested periods?

2. In Volume I the expansion of the Württemberg village of Neckerhausen was trended in G form from 1775 through 1805. For the longer span of 1765 to 1815, however, an E pattern not unlike that for Württemberg as a whole is suitable (Harris 2001, 367).

Figure C.1a

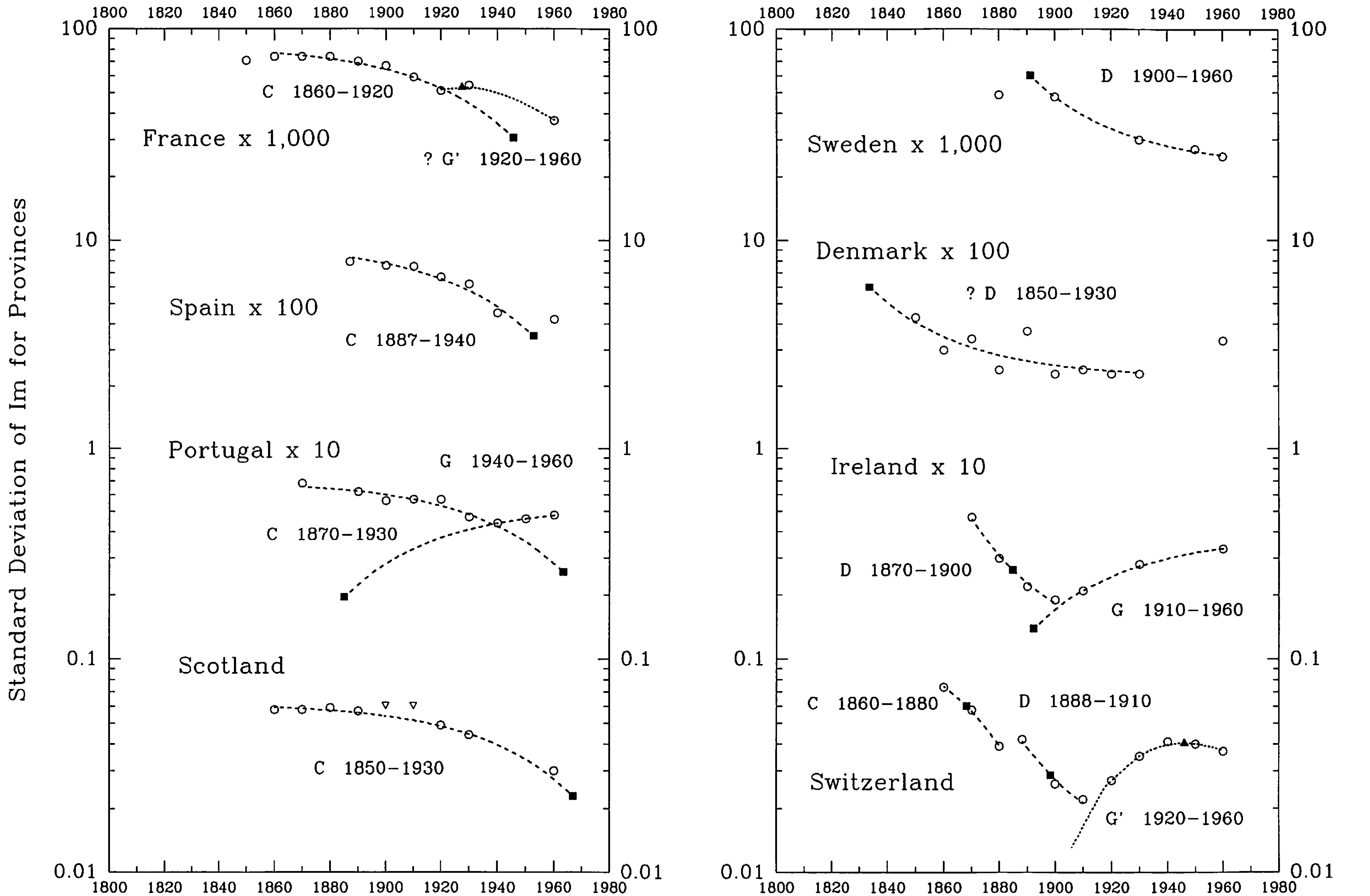
National Variability in Provincial Nuptuality in Europe 1850–1960:
England and Wales, the Low Countries, Germany, Norway, Italy, and Finland



Source: Watkins 1986a, 320–21.

Figure C.1b

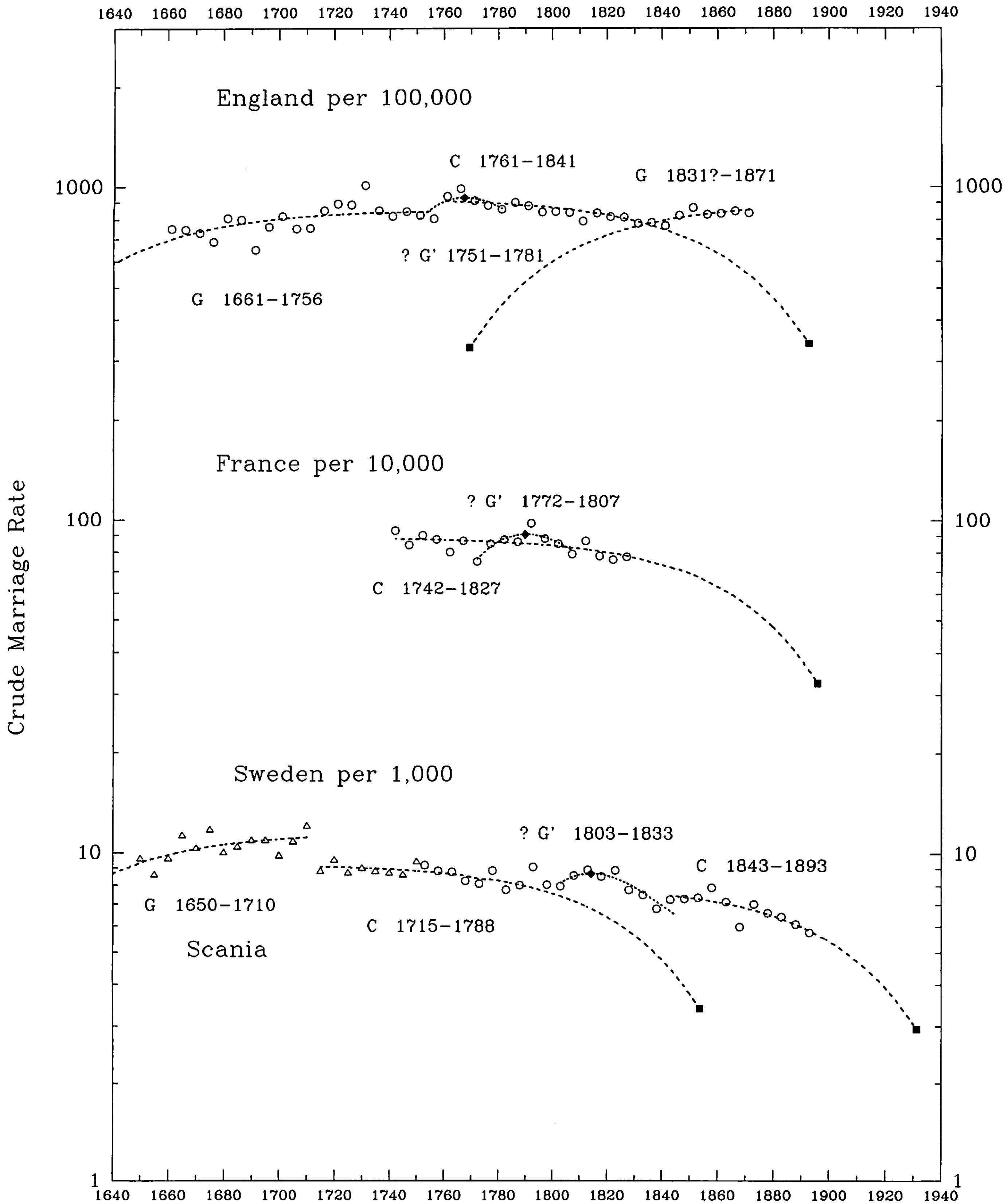
National Variability in Provincial Nuptuality in Europe 1850–1960:
France, Spain, Portugal, Scotland, Sweden, Denmark, Ireland, and Switzerland



Source: Watkins 1986a, 320–21.

Figure C.2

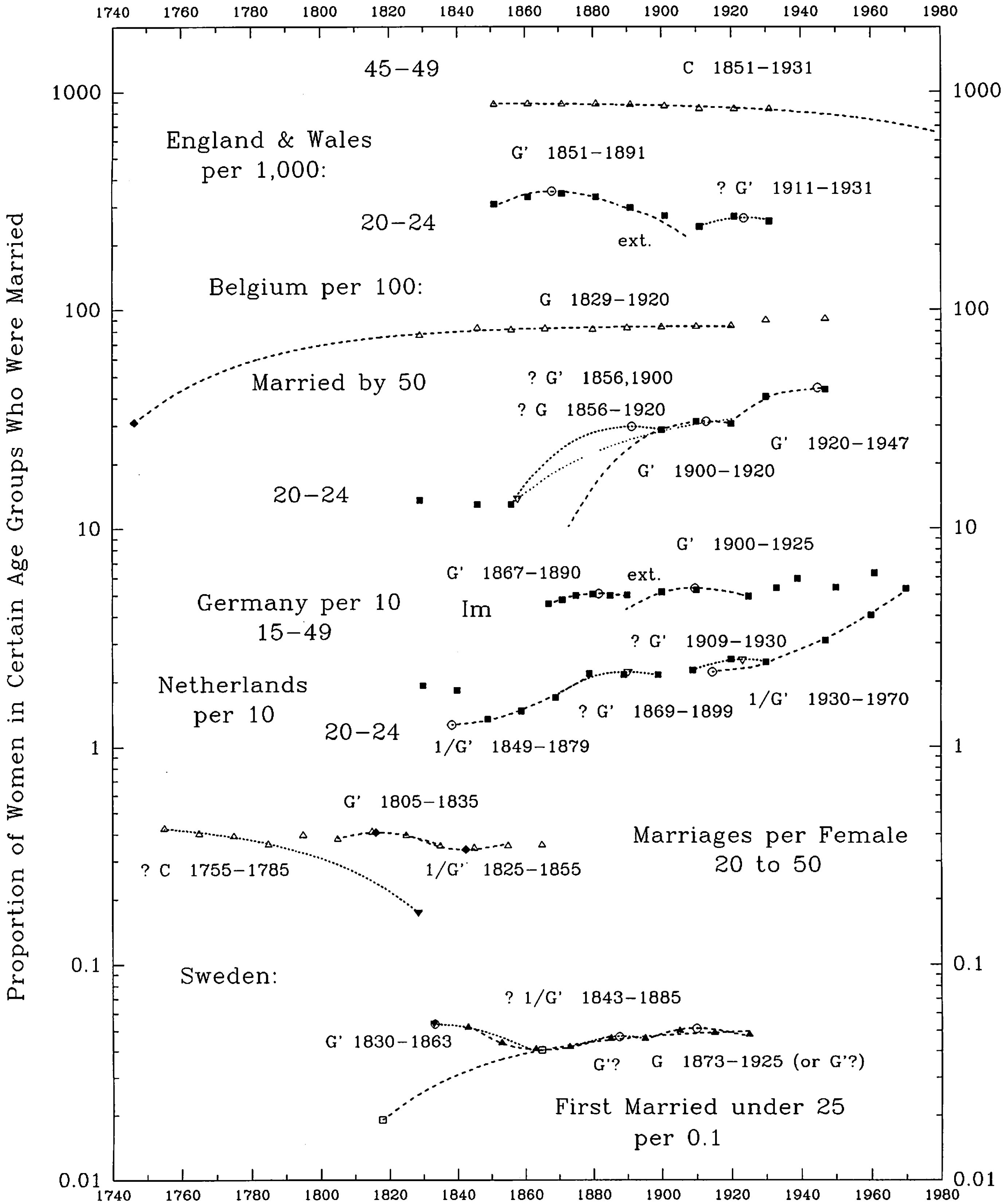
Crude Marriage Rates in England, France, and Sweden from the 1600s into the 1800s



Sources: Wrigley and Schofield 1981, 528–29; Henry and Blayo 1975, 109; Historisk statistik 1969, 89, 91; Lundh 1999, 220.

Figure C.3a

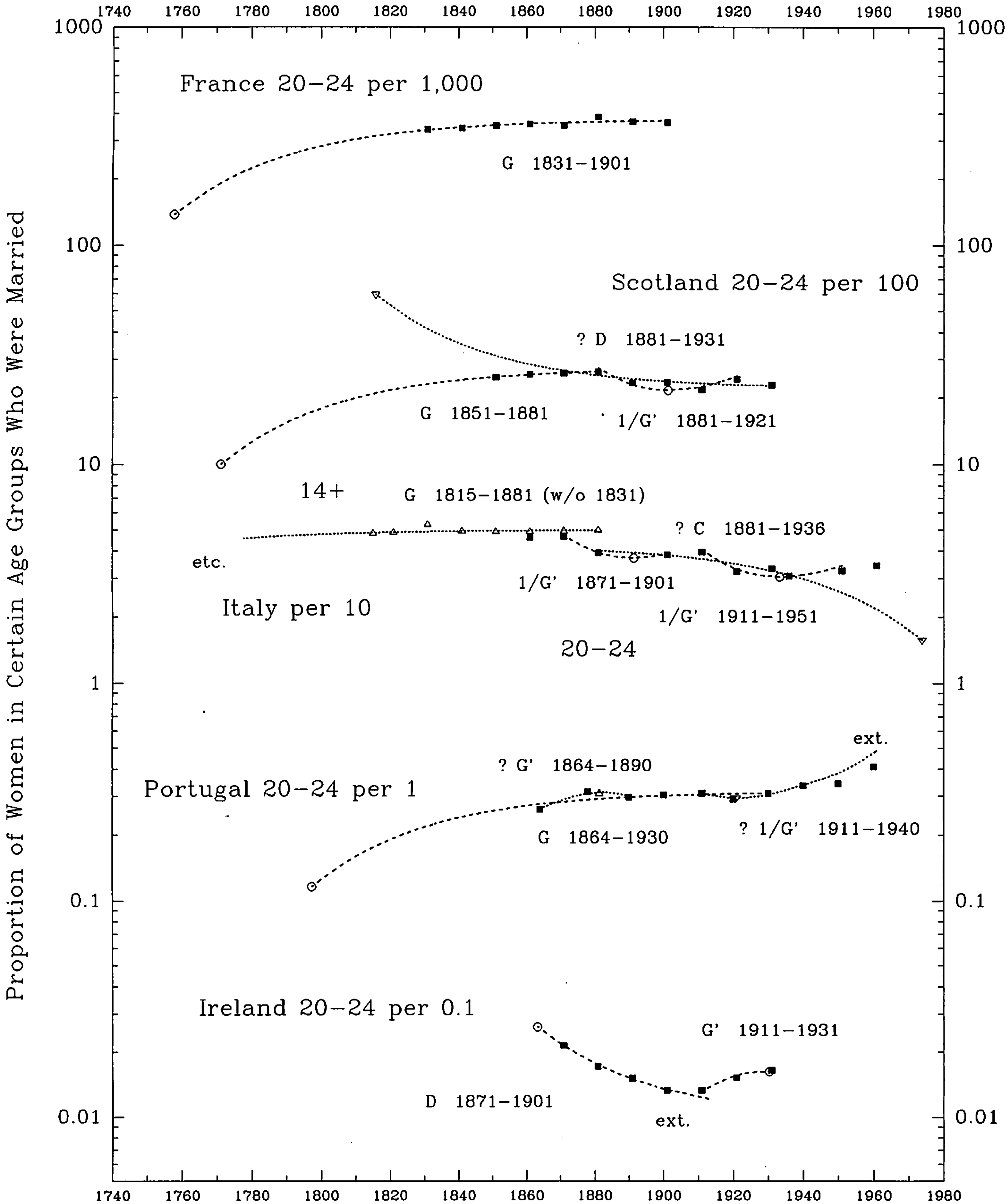
The Involvement of European Females in Marriage: England and Wales, the Low Countries, Germany, and Sweden



Sources: Teitelbaum 1984, 98, 101; Deprez 1979, 269, 272; Knodel 1974, 39; Fridlizius 1979, 375, 377.

Figure C.3b

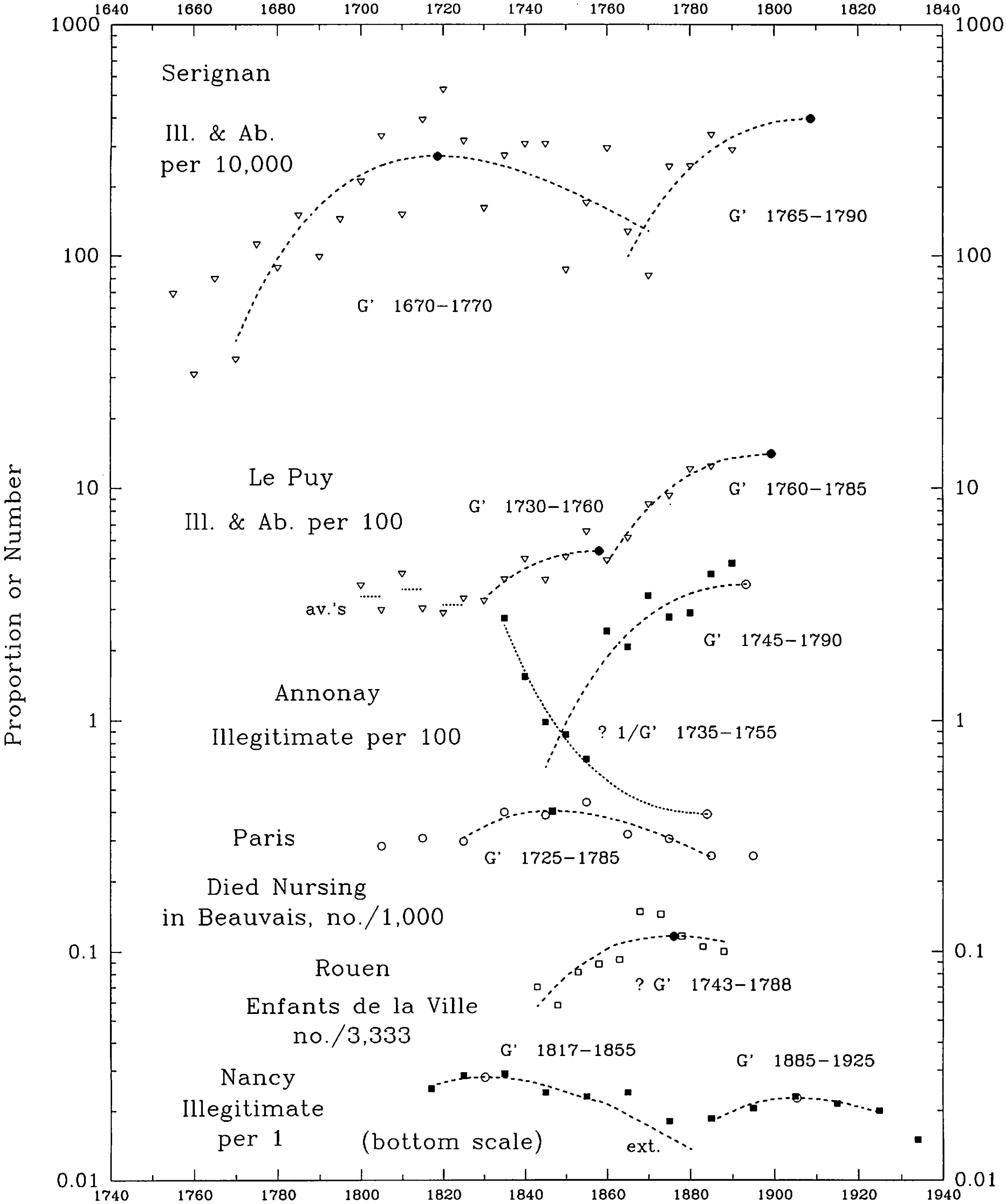
The Involvement of European Females in Marriage: France, Scotland, Italy, Portugal, and Ireland



Sources: E. van de Walle 1974, 138 ("aggregate"); Teitelbaum 1984, 101; Livi-Bacci 1977, 33 (Tuscany), 100; Livi-Bacci 1971, 47.

Figure C.4

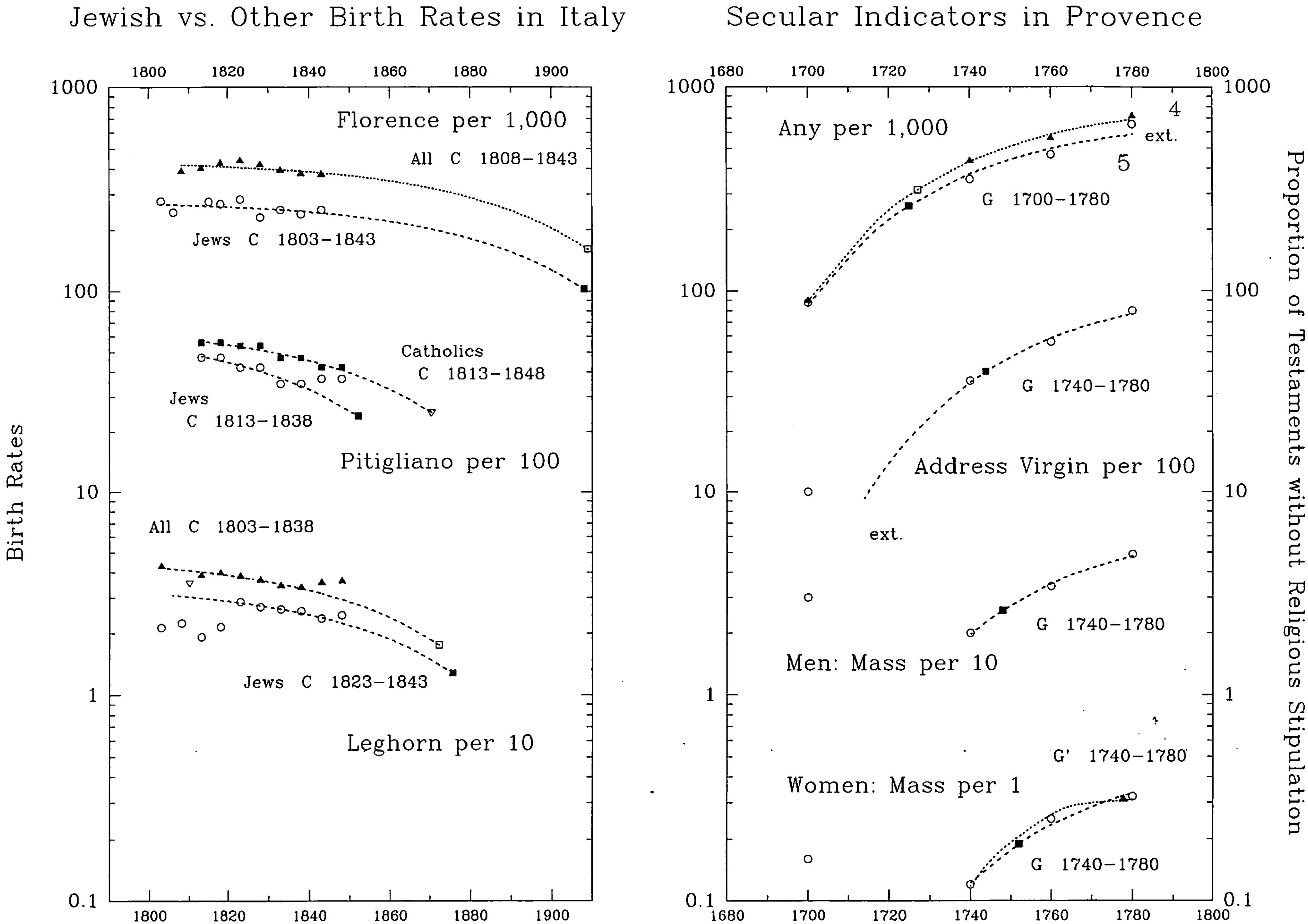
Illegitimacy, Child Abandonment, and Neglect in Certain French Communities 1655–1934



Sources: Molinier 1973, 460–61; Ganiage 1973, 272; Bardet 1973, 43; Clemendot 1973, 131.

Figure C.5

Religion and Secularization in Italy and Provence:

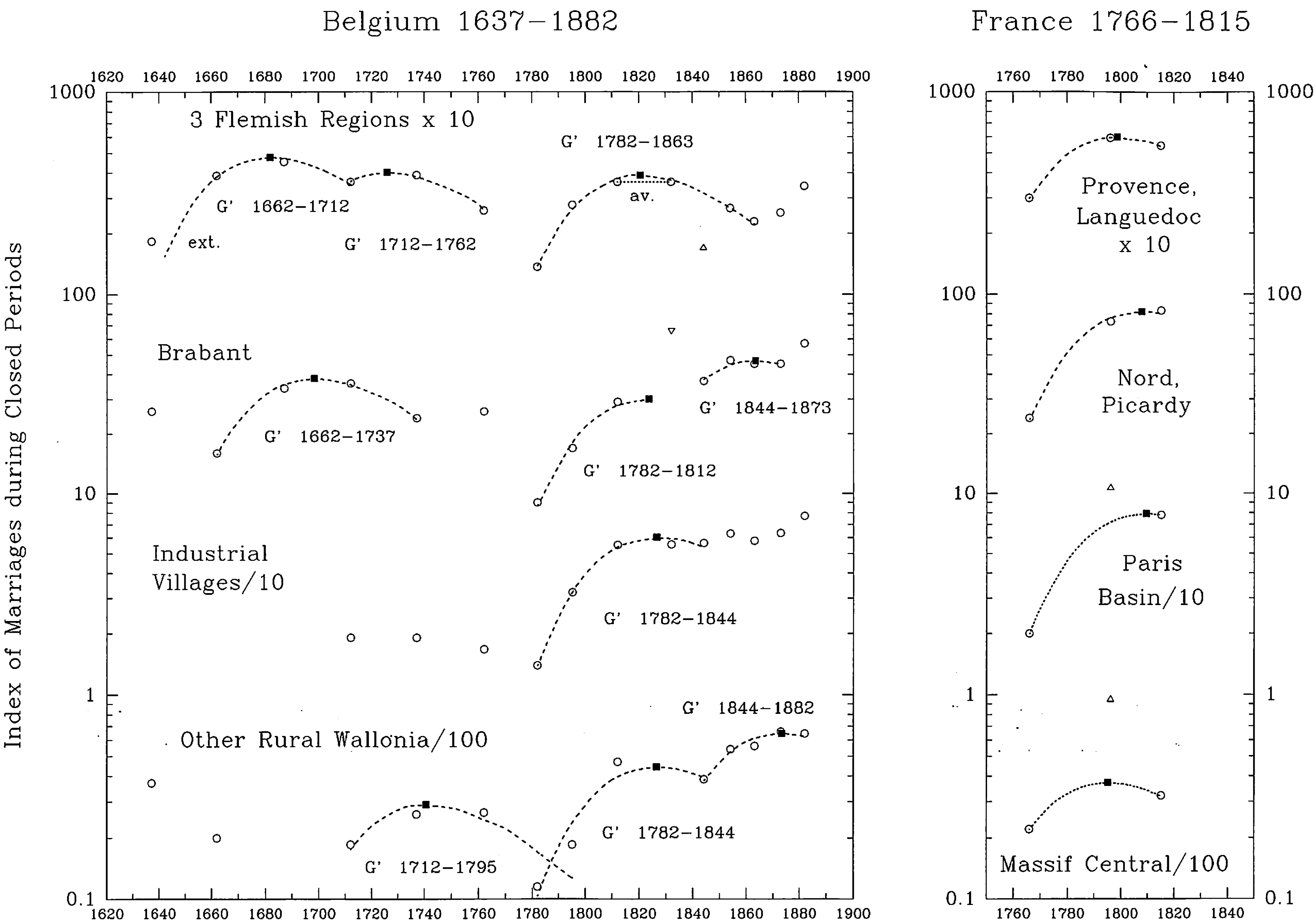


5 = all five localities of Vovelle; 4 = without Toulon.

Sources: Livi–Bacci 1986, 192; Lesthaeghe 1992, 9 (originally M. Vovelle).

Figure C.6

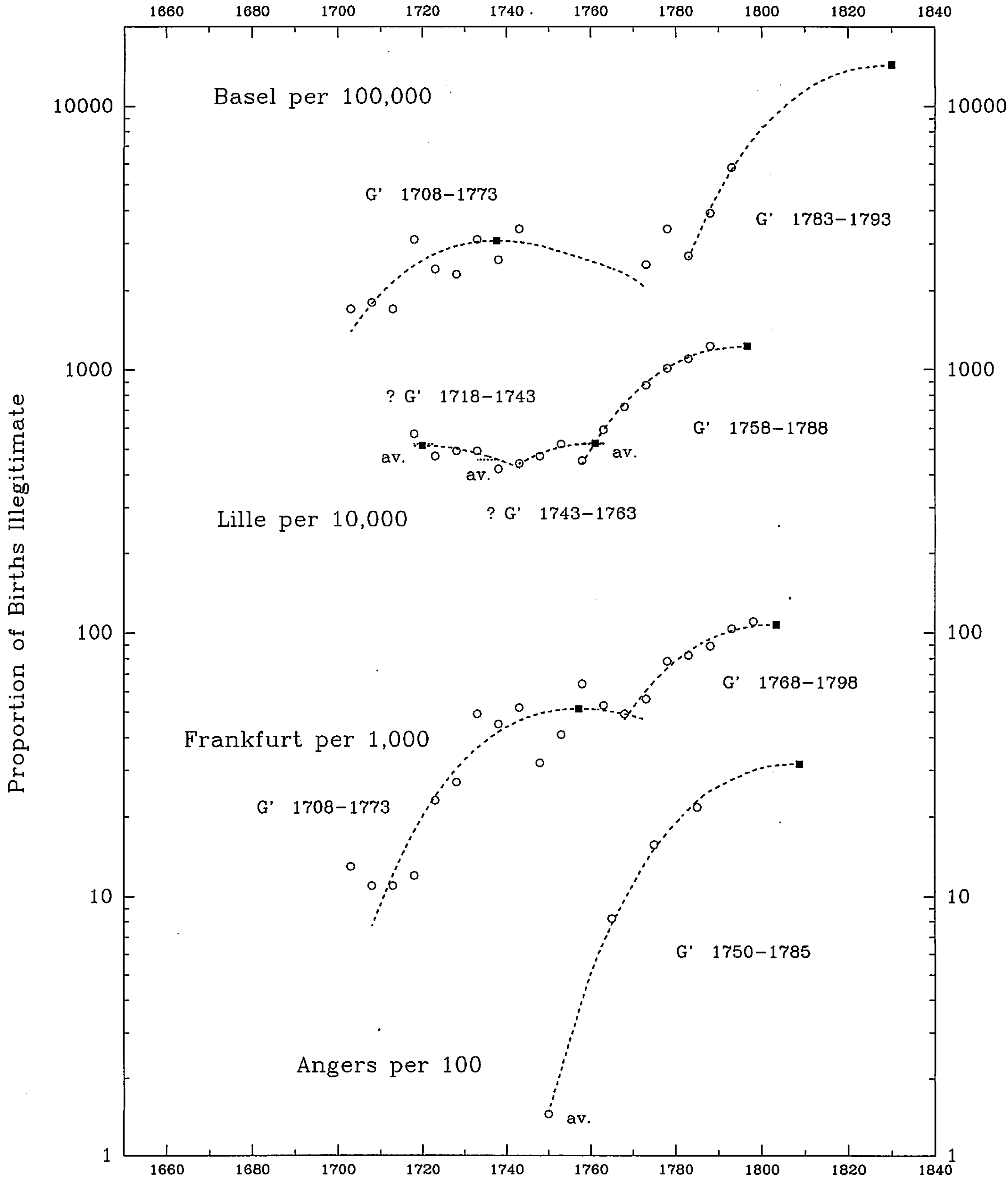
Marriages during March and December in Belgium and France



Sources: Lesthaeghe 1992, 9 (French regions from J. Houdaille); Lesthaeghe 1991, 276–79.

Figure C.7

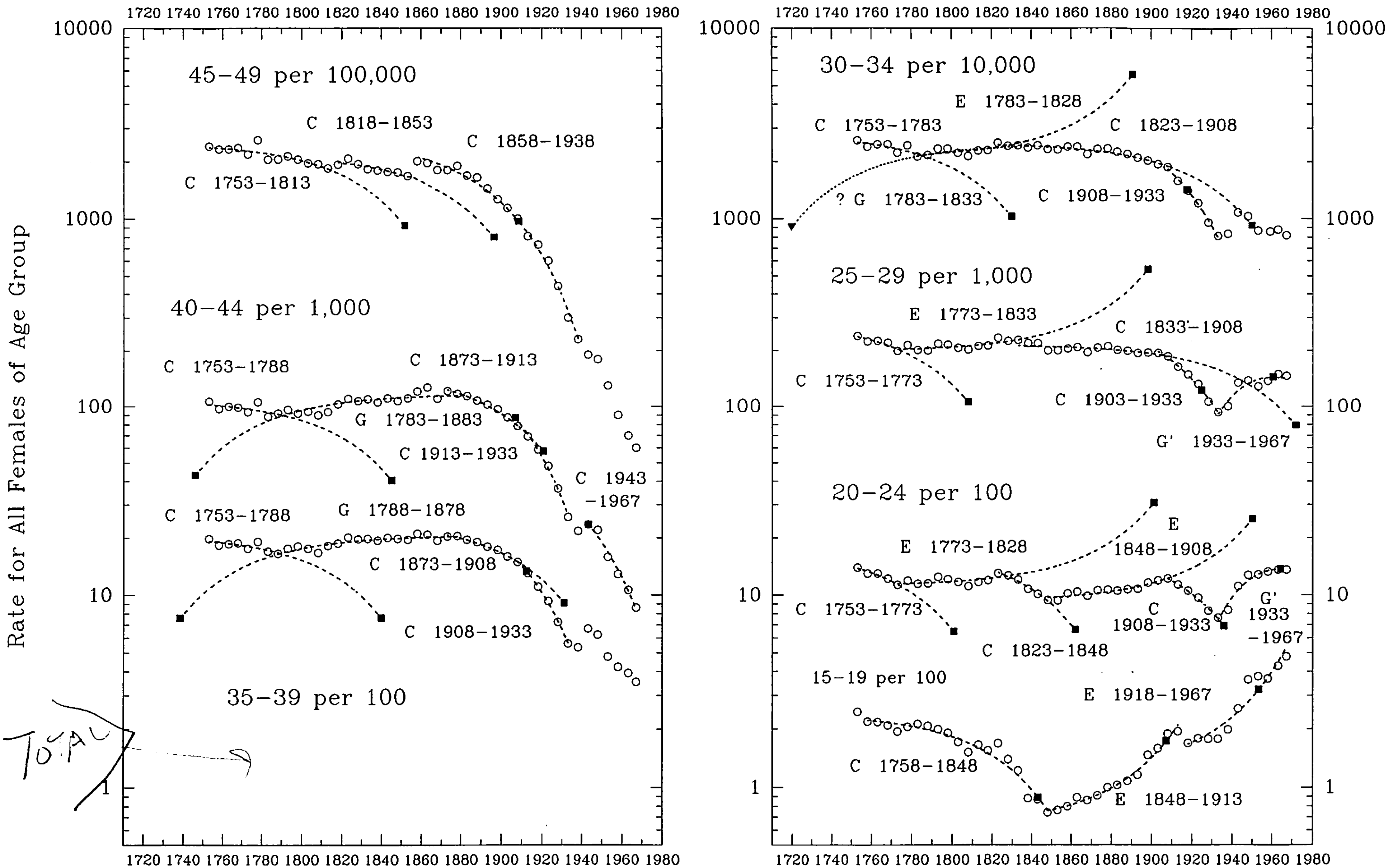
Illegitimacy in Basel, Lille, Frankfurt/Main, and Angers



Source: Imhof 1975, 536–37.

Figure C.8

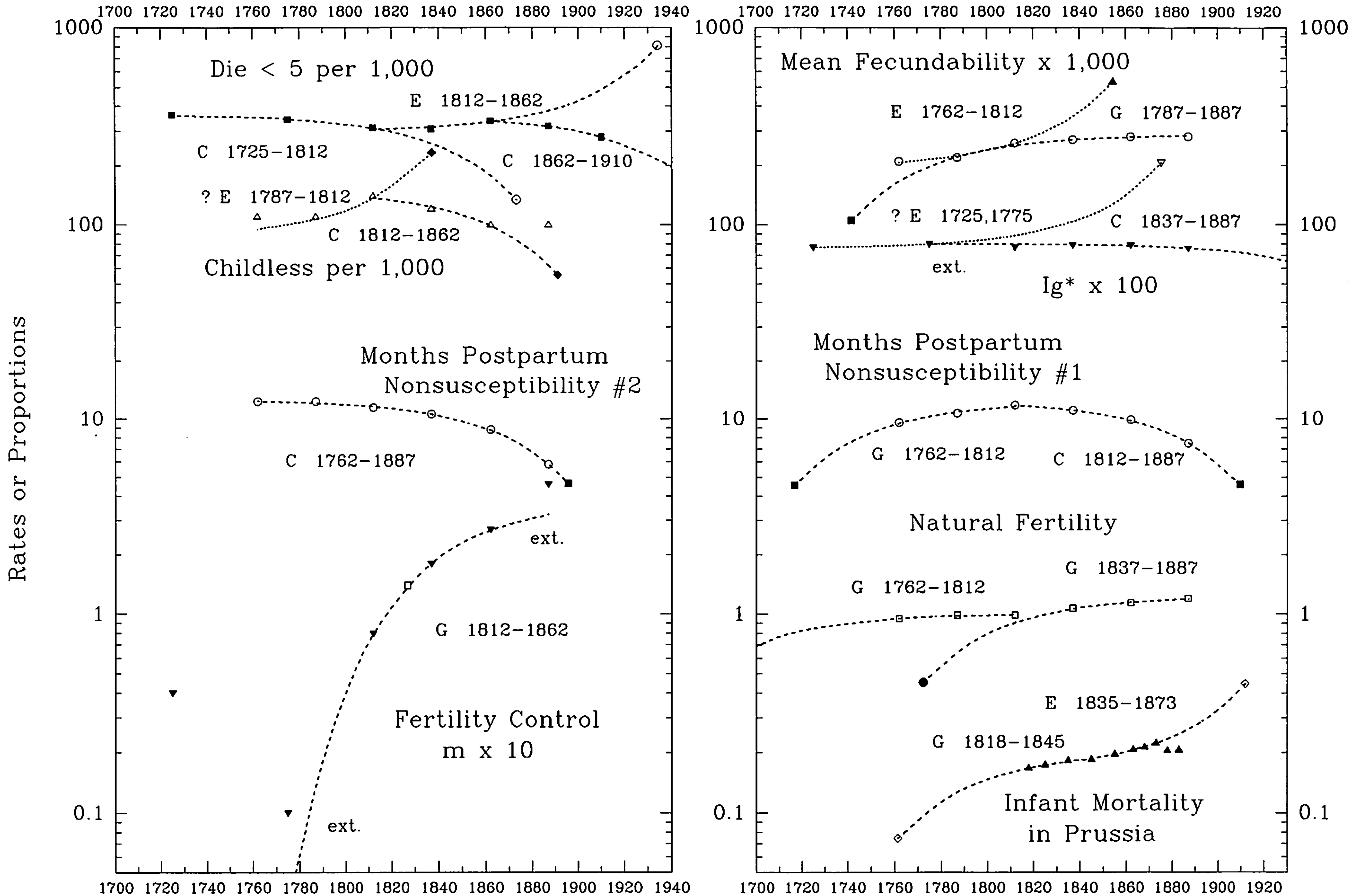
Age-Specific Fertility Rates in Sweden 1753-1967



Source: Historisk statistik for Sverige, 105.

Figure C.9

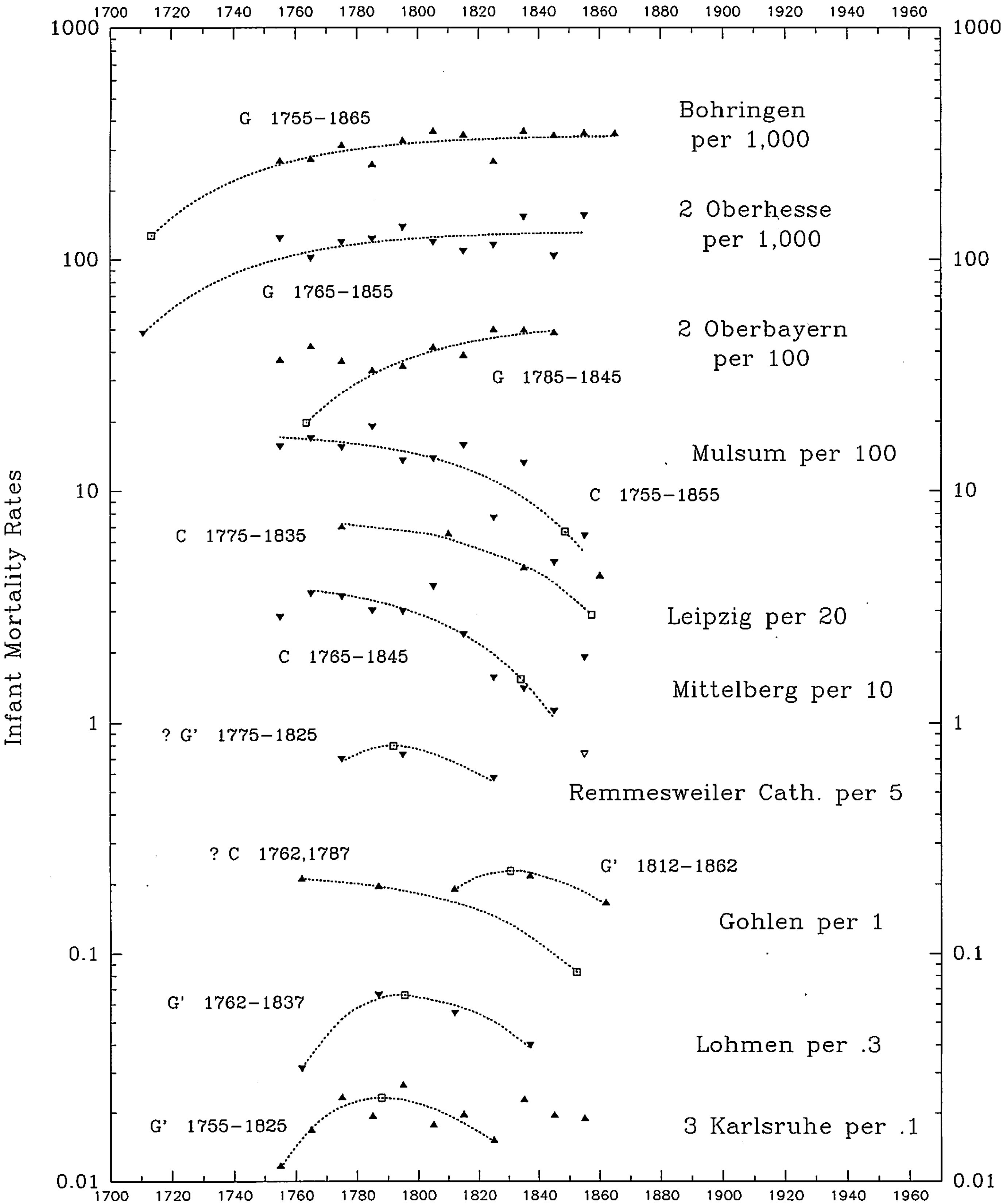
Fertility–Related Trends in a Selection of German Communities 1725–1910



Sources: Knodel 1986, 348–49, 363, 368, 356; Knodel 1974, 159.

Figure C.10

Infant Mortality in Other German Communities



Source: W. R. Lee 1979, 186.

Table C.1

Transition Era C Trends in Modern European Fertility, Infant Mortality, and Crude Birth Rate, and Concomitant Changes in Proportion Married

	M_i	I_g	I_f	CBR	I_m
Country:	Infant Mortality	Marital Fertility	Overall Fertility	Crude Birth Rate	Proportion Married
Belgium	1893-1932 C 1938	1866-1910 C 1914	1880-1920 C 1926	1872-1942 C 1941	1856-1890 G 1814
					1900-1947 G 1866
	D,D	1961-1980 C 1988	1961-1980 C 1986	1947-1985 C 2001	1947-1980 G' 1965
England & Wales	1848-1957 C 1932	1881-1931 C 1928	1871-1931 C 1929	1851-1933 C 1933	1851-1871 G 1780
					1891-1931 *E* 2015
	1957-1986 C 1971	1961-1981 C 1992	1961-1981 C 1991	1933-1990 C 2032	1961-1981 G' 1967
Germany	1863-1937 C 1918	1875-1939 C 1928	1875-1939 C 1932	1877-1932 C 1929	1867-1910 G 1806
					1925-1939 G 1902
	D	1962-1980 C 1972	1962-1980 C 1974	1937-1985 C 1994	?
Denmark	1893-1957 C 1933	1880-1921 C 1934	1880-1921 C 1941	1877-1937 C 1944	1870-1930 G 1803
	1957-1977 C 1953	1930-1970 C 1995	1960-1980 ?C 1981	1942-1985 C 1987	1960-1980 G' 1958
Switzerland	1873-1927 C 1912	1860-1930 C 1936	1880-1930 C 1933	1872-1937 C 1942	1860-1910 G 1807
					1910-1950 /*G'* 1924
	1927-1967 C 1949	-	1960-1980 C 1977	1947-1984 C 1989	1941-1970 G 1912
Bohemia/Czech.	1907-1947 C 1941	-	-	1837-1937 C 1943[b]	1890-1930 G 1811[b]
	1947-1967 C 1916				
	1967-1986 C 1980	-	-	1942-1990 C 2008[c]	1930-1980 G 1893[c]
Netherlands	1873-1932 C 1911	1879-1930 C 1937	1879-1930 C 1941	1878-1938 C 1950	1859-1889 G 1806
					1899-1930 G 1839
	D,D	-	1960-1980 C 1968	1948-1979 C 1973	1960-1980 G' 1970
Scotland	1902-1937 C 1947	1861-1931 C 1941	1871-1921 C 1940	1862-1937 C 1943	1861-1881 G 1778
					1891-1931 *E* 2021
	1952-1986 C 1962	-	1961-1981 C 1983	1947-1984 C 1995	1961-1984 G' 1967

Sweden	1753-1888 C 1900				
		1860-1900 C 1962[k]			
		1910-1930 C 1920[k]			
	1888-1957 C 1931	1880-1930 C 1926	1880-1930 C 1930	1693-1933 C 1941	1880-1930 G 1771
	1957-1982 C 1962	1930-1960 C 1996	1950-1980 C 2003	1943-1985 C 2001	1930-1970 G' 1956
Finland	1753-1843 C 1896				
	1843-1967 C 1935	1900-1940 C 1945	1890-1930 C 1932	1808-1930 C 1952	1880-1920 C 1958
	1962-1982 C 1952	1950-1970 C 1961	1950-1970 C 1963	1943-1973 C 1972	1940-1980 G' 1962
				1973-1988 C 2051	
Norway	1907-1957 C 1941	1875-1920 C 1947	1890-1920 C 1941	1818-1923 C 1959	1875-1920 G 1764
	1957-1982 C 1962	-	-	1948-1985 C 1992	1930-1960 G' 1959
Iceland	?	1850-1870 C 1898	1850-1880 C 1907	?	1850-1880 G' 1856
	?	1870-1940 C 1953	1880-1940 C 1980	?	1880-1940 G 1851
	?	-	-	?	1950,1960 ?G' 1965

Ireland	1893-1982 C 1951	1871-1936 C 1979	1871-1891 C 1921	1887-1932 C 1978	1871-1891 G' 1867
			1891-1936 C 2000		1901-1936 G 1848
		-	-	1932-1980 *G* 1980	1936-1970 G' 1960
Luxemburg	?	1900,1930 ?C 1920	1900,1930 ?C 1930	1897-1942 C 1944	1839-1900 *C* 1975[w]
			1871-1947 C 1943[x]		1900,1930 ?G 1863
	?	1930-1980 ?C 1993	-	1942-1987 C 2014	1960-1980 G' 1966
France	1745-1805 ?C 1833				
	1858-1937 C 1933	1831-1911 C 1933	1831-1911 C 1940	1848-1912 C 1944	1831-1876 G 1735
					1876-1901 G 1759
	D,D	1961-1980 C 1990	1961-1980 C 1992	1948-1975 C 1992	1901-1960 G 1847
				1975-1989 C 2054	
Italy	1863-1912 C 1927	1881-1951 C 1959	1864-1936 C 1953	1862-1942 C 1955	1864-1921 *C* 1986
					1921-1951 G 1856
	1952-1986 C 1952	1951-1970 C 2014	-	1936-1975 C 2024	1951-1970 G 1912
				1975-1988 C 1971	
Portugal	1927-1952 C 1960	1900-1940 C 1959	1900-1940 C 1967	1922-1942 C 1955	1864-1911 G 1795
					1920-1940 G 1851
	D	1940-1980 C 2008	1940-1980 C 2034	1942-1962 C 2045	1950-1980 G 1911
				1962-1988 C 1979	
Spain	1878-1932 C 1951	1887-1950 C 1969	1887-1920 C 1954	1859-1932 C 1966	1887-1940 *C* 1974
	1947-1986 C 1947	1950-1980 C 2019	-	1936-1975 C 2024	1940-1980 G 1919
				1975-1988 C 1971	
European Russia	1893-1939 C 1952	1897-1970 C 1961	1897-1970 C 1958	1862-1967 C 1964	1897,1926 ?*C* 1984
	D			1967-1984 ?*E* 2031	1926-1959 G' 1938
					1959,1970 ?G 1931
Romania	1893-1942 C 1983	1899-1970 C 1962	1930-1970 C 1963	1887-1937 C 1969	1899,1930 ?*C* 1995
	D			1942-1970 C 2018	1956,1970 ?G 1914
				1970-1990 C 1898	
Austria	1883-1942 C 1927	-	-	1872-1912 C 1952[l]	1890-1910 G 1820
				1908-1932 C 1917[s]	
	D,D	1960-1980 C 1976	1960-1980 C 1979	1932-1967 *G* 1897	1960-1980 ?G' 1969
				1962-1985 *D* 1960	
Hungary	1853-1947 C 1952	1880-1910 C 1968	-	1882-1937 C 1938	1880-1930 *C* 1982
	D	1930-1960 C 1963	-	1937-1990 C 2002	1930-1980 G 1886

Yugoslavia	1952-1977 C 1950	1931-1970 C 1969	1931-1970 C 1971	1862-1971 C 1974	1900,1931 ?*C* 1975
				1971-1990 C 2006	1960,1970 ?G 1864
Greece	1962-1986 C 1958	1928-1970 C 1972	1900-1951 C 1952	1927-1989 C 1983	1900-1951 *C* 1993
			1951-1980 C 2023		1951-1970 G 1935
Poland	1927-1952 C 1960	1931-1970 C 1975	-	1922-1937 C 1941	1897,1931 ?*C* 1980
	D			1948-1990 C 1997	1931-1970 G' 1953
Bulgaria	1907-1947 C 1990				
	1947-1962 C 1922	?	?	1897-1962 C 1958	1934-1970 G 1839
	D			1962-1990 C 2010	

[b] = Bohemia; [c] = Czechoslovakia; [k] = Knodel and van de Walle; [w] = Luxembourg 1990, all females 15+; [x] = Luxembourg 1990, births/women 15-49; [l] = large pre-1919 Austria; [s] = small modern Austria.

Sources: Tables 4.1, 4.2, 2.4; Figures 4.1a through 4.1f, 4.2a through 4.2f, 2.2a through 2.2k; Knodel and van de Walle 1986, 397; Luxembourg 1990, 18, 54

Table C.2

European Trends of Variability in Provincial Nuptuality (I_m)

England & Wales	1860-1910	G	1807	1910-1930	C	1939
Netherlands	1870-1900	G	1829	1900-1930	C	1952
Belgium	1880-1930	G	1864	1950,1960	?C	1961
"				1920-1960	G'	1927
Norway	1900-1960	?G	1863			
Germany	1880-1933	?G	1867			
Italy	1860-1936	G	1860			
France	1860-1920	C	1946	1920-1960	?G'	1927
Spain	1887-1940	C	1953			
Portugal	1870-1930	C	1963	1940-1960	G	1885
Finland	1900-1930	C	1949			
Scotland	1850-1930	C	1967			
Denmark	1850-1930	?D	1834			
Sweden	1900-1960	D	1891			
Ireland	1870-1900	D	1885	1910-1960	G	1892
Switzerland	1860-1880	C	1868			
"	1888-1910	D	1898	1920-1960	G'	1946

Sources: Figures C-1a and C-1b.

Table C.3

Trends for Death Rates, Birth Rates, and Growth in European Populations of the 18th, 19th, and 20th Centuries

	CDR	CBR	Growth
England	1736-1831 C 1880	1726-1816 E 1862	1726-1806 E 1822
	1831-1923 C 1936	1816-1846 D 1779	1816-1861 H 1758
		1851-1933 C 1933	1861-1939 H 1794
	1923-1948 C 2030	1933-1990 C 2032	1951-1990 G 1899
	1948-1978 G 1848		
	1973-1990 C 2044		
Scotland	?	1842-1857 E 1903	1755-1821 E 1839
	1857-1922 C 1943	1862-1937 C 1943	1811-1871 H 1741
			1871-1911 H 1779
	1922-1957 C 2008		1891-1975 G 1896
	1962-1984 G 1860	1947-1984 C 1995	1975-1990 D 1878
Ireland	?	?	1725-1771 E 1812
	?	?	1777-1841 H 1729
	1864-1877 E 1907	1864-1887 G'1871	1851-1961 D 1826
	1877-1921 C 1964	1887-1932 C 1978	
	1921-1957 C 1997	1932-1980 G 1872	1966-1990 G 1928
	1957-1984 C 2006	1980-1990 D 1990	
Denmark	1757-1811 C 1846	1737-1817 E 1936	1735-1801 E 1857
	1817-1922 C 1935	1817-1842 D 1760	1801-1845 H 1706
		1848-1878 E 1938	1850-1890 H 1725
	1922-1952 C 1981	1877-1937 C 1944	1890-1945 H 1833
	1957-1974 G 1913	1947-1985 C 1987	1945-1990 G 1906
	1974-1990 G 1944		
Netherlands	1803-1913 C 1919	1808-1823 E 1842	1750-1839 E 1866
		1823-1853 D 1767	1815-1869 H 1728
		1847-1872 E 1922	1869-1889 H 1799
	1913-1937 C 1945	1878-1938 C 1950	1899-1947 H 1849
	1953-1990 G 1899	1948-1979 C 1973	1947-1990 G 1931
Belgium	1815-1922 C 1935	1872-1942 C 1941	1815-1866 H 1717
			1870-1910 H 1790
	1922-1988 C 2038	1947-1988 C 2001	1920-1947 G 1874
			1947-1990 G 1897

[l] = local; [v] = de Vries; [a] = Imperial Austria through 1914, Trianon thereafter; [h] = Imperial Hungary through 1914; [s] = population for Serbia only; [d] Danish CDR and CBR; [n] = Lombardy, Lombardy and Tuscany; [p] = also possible population trend of 1700-1800 E 1877 from de Vries.

Sources: Tables 2.1a and 2.3a; Harris 2001, 148-49; de Vries 1984, 36.

Table C.3 (cont.)

Trends for Death Rates, Birth Rates, and Growth in European Populations of the 18th, 19th, and 20th Centuries

	CDR	CBR	Growth
Germany	?	?	1700-1800 E 1821[v]
	1805-1845 C 1894[l]	1817-1857 D 1761	1816-1864 H 1743
	1795-1845 C 1906[l]		
	1827-1862 C 1938	1857-1877 E 1925	
	1867-1932 C 1929	1877-1932 C 1929	1864-1910 E 1923
			1910-1950 E 1977
	1952-1975 G 1902	1937-1985 C 1994	1939-1990 G 1905
	1971-1990 C 2051		
Switzerland	?	?	1700-1800 E 1833[v]
	?	?	1837-1888 H 1712
	1872-1932 C 1930	1872-1937 C 1942	1880-1910 E 1943
	1922-1957 C 1991	1947-1984 C 1989	1910-1970 E 1985
	1957-1975 C 2016		
	1975-1990 G 1917		
Austria[a]	?	1822-1847 D 1778	1821-1857 G 1786
	1832-1932 C 1934	1847-1872 E 1951	1850-1880 E 1910
		1872-1912 C 1952	1880-1910 E 1934
	1932-1990 C 2043	1932-1967 G 1897	1923-1961 G 1847
		1962-1985 D 1960	1961-1990 G 1897
Romania	1872-1962 C 1951	1862-1887 E 1907	1844-1914 E 1918
		1887-1937 C 1969	
	1962-1990 G 1929	1942-1970 C 2019	1948-1970 G 1928
		1970-1990 C 1898	
Portugal	?	1843-1878 E 1859	1841-1890 E 1920
	1887-1957 C 1966	1877-1897 C 1942	
		1892-1922 E 2002	1890-1920 G 1853
		1922-1942 C 1955	1930-1970 G 1897
		1942-1962 C 2045	
	1957-1988 C 2028	1962-1988 C 1979	1970-1990 G 1938
France	1752-1827 C 1853	1742-1802 C 1857	1752-1792 G 1702
		1802-1848 C 1895	1792-1827 E 1876
	1828-1912 C 1951	1848-1912 C 1944	1826-1921 G 1774
	1912-1959 C 1974	1923-1937 C 1945	1921-1936 G 1862
		1948-1975 C 1992	1951-1990 G 1925
	1959-1989 C 2030	1975-1989 C 2054	

Table C.3 (cont.)

Trends for Death Rates, Birth Rates, and Growth in European Populations of the 18th, 19th, and 20th Centuries

	CDR	CBR	Growth
Spain	?	?	1797-1887 H 1680
	1867-1957 C 1946	1859-1932 C 1966	1857-1920 E 1952
	1957-1982 C 2015	1936-1975 C 2024	1920-1960 H 1829
		1975-1988 C 1971	1960-1990 G 1932
Czech Lands	1787-1812 D'1767	1787-1837 C 1885	1818-1861 G 1790
	1817-1932 C 1939	1837-1937 C 1943	1851-1890 H 1739
			1880-1910 E 1945
			1910-1930 E 2004
	1942-1957 C 1952	1942-1990 C 2008	1947-1990 G 1913
Hungary[h]	?	1862-1887 E 1947	1817-1880 G 1808
	1887-1932 C 1934	1882-1937 C 1938	1880-1910 H 1811
	1932-1957 C 1966	1937-1990 C 2002	1949-1990 G 1897
	1962-1988 G 1949		
Yugoslavia/Serbia[s]	1862-1939 C 1944	1862-1971 C 1974	1884-1910 H 1839
	1937-1962 C 1962		
	1967-1990 G 1887	1971-1990 C 2006	?
Russia/Soviet Union	?	?	1762-1815 H 1675
	?	?	1815-1857 H 1707
	1867-1957 C 1938	1862-1967 C 1964	1858-1897 H 1821
			1897-1939 H 1830
	1962-1984 G 1959	1967-1984 E 2031	1959-1987 G 1937
Sweden	1743-1843 C 1881	1693-1933 C 1941	1783-1818 G 1737
			1823-1848 G 1795
	1843-1923 C 1941		1848-1943 H 1757
	1923-1953 C 1983	1943-1985 C 2001	1943-1990 G 1909
Norway	1738-1823 C 1860	1748-1813 C 1869	1748-1818 H 1632
	1823-1933 C 1948	1818-1923 C 1959	1818-1893 H 1758
			1893-1948 H 1797
	1933-1958 C 1987	1948-1985 C 1992	1948-1990 G 1917
	1958-1990 G 1918		

Table C.3 (concl.)

Trends for Death Rates, Birth Rates, and Growth

in European Populations of the 18th, 19th, and 20th Centuries

	CDR	CBR	Growth
Iceland[d]	1817-1922 C 1935	1848-1878 E 1938	1850-1890 G 1810
	1922-1952 C 1981	1877-1937 C 1944	1901-1940 H 1833
	1957-1974 G 1913		1950-1990 G 1946
	1974-1990 G 1944		
Italy	?	1770-1800 E 1870[n]	1771-1821 G 1717
	1820-1912 C 1935	1825-1855 D 1778[n]	1820-1861 G 1790
	1912-1952 C 1955	1862-1942 C 1955	1861-1936 H 1755
	1952-1989 C 2080	1942-1989 C 1986	1951-1990 G 1910
Luxemburg	1842-1932 C 1947	1842-1857 C 1908	1839-1867 G 1796
		1857-1942 C 1944	1871-1895 G 1810
			1895-1915 G 1868
			1922-1939 G 1889
	1932-1987 C 2046	1942-1987 C 2014	1947-1970 G 1908
			1970-1989 G 1918
Finland	1763-1878 C 1929	1753-1808 C 1854	1748-1793 G 1742
			1793-1808 G 1772
		1808-1938 C 1952	1808-1833 G 1801
			1838-1873 G 1809
	1873-1953 C 1959		1873-1908 G 1860
			1908-1943 G 1878
	1958-1988 G 1882	1943-1973 C 1972	1943-1989 G 1911
		1973-1988 C 2051	
Poland[p]	?	?	1823-1863 G 1793
	1922-1962 C 1955	1922-1937 C 1941	1863-1931 G 1863
	1967-1990 G 1952	1948-1990 C 1997	1946-1990 G 1931
Bulgaria	1892-1962 C 1951	1897-1962 C 1958	1893-1920 G 1881
			1920-1956 G 1907
	1962-1989 G 1952	1962-1990 C 2010	1956-1990 G 1912
Greece	1862-1947 C 1965		1870-1907 G 1856
		1927-1989 C 1983	1920-1949 G 1914
	1952-1989 G 1923		1951-1971 G 1912
			1971-1990 G 1935
Albania	1932-1973 C 1962	1932-1957 G 1929	1945-1960 E 1959
		1957-1989 C 1994	1955-1990 G 1964

Table C.4

Some Approximate Demographic Trends in New Castile

Compared with English, French, and Swedish Movements

NEW CASTILE	ENGLAND	FRANCE	SWEDEN
Child/Infant[a] Mortality:			
1630-1670 C 1711	1580-1640 C 1701		
1690-1740 C 1781	1640-1730 G 1596		
	1710-1750 C 1791		
1760-1810 G 1718	1750-1810 C 1856	1745-1805 C 1833	
1820-1860 /G' 1833	1815-1848 G 1768	1805-1843 C 1873	1753-1888 C 1900
Children per Family:[b]			
1600-1640 C 1688	1556-1661 C 1701		
1640-1700 G 1562	1661-1726 G 1615		
1700-1750 C 1840			
1750-1790 G 1702	1726-1816 E 1851	1742-1807 C 1855	1758-1808 C 1880
1790-1810 C 1855			
1820-1850 G' 1834	1816-1851 D 1787	1817-1837 C 1875	1813-1908 C 1965
Crude Birth Rate:			
1590-1610 C 1645	1556-1661 C 1710		
1610-1640 C 1681			
1640-1880 G 1595	1656-1751 G 1602		
	1726-1816 E 1862	1680-1807 C 1849	
	1816-1846 D 1779	1802-1848 C 1895	1693-1933 C 1941

Crude Marriage Rate:

1578-1610 G' 1590	1556-1651 C 1684		
1600-1640 D 1560			
1640-1710 G 1580	1661-1756 G 1607		1650-1710 G 1599
1720-1790 D 1635	1761-1841 C 1895	1742-1827 C 1896	1715-~~1838~~ 1788 C 1898 (1803-1833 G' 1814
1840-1870 G' 1854	1841-1871 G' 1869		1838-1914 C 1931

Celibacy Index:

1600-1630 G 1554	1599-1694 H 1460		
1630-1660 C 1685			
1670-1760 G 1618	1684-1739 D 1690	1695-1735 G 1668	
	1704-1754 C 1756	1735-1775 G 1708	
1770-1820 D 1578	1749-1844 H 1711	1775-1815 G 1751	
1820-1860 G' 1840	1814-1844 ?G' 1841	1815-1875 D 1778	

Crude Death Rate:

1578-1610 G' 1588	1556-1681 E 1722		
1620-1640 G' 1640			
1640-1700 C 1750	1681-1731 /G' 1704		1673-1743 /G' 1716
1700-1770 C 1837	1731-1761 /G' 1752		
1780-1830 G' 1804	1761-1831 C 1880	1752-1827 C 1853	1743-1843 C 1881
1840-1880 G 1792	1831-1923 C 1936	1828-1912 C 1951	1843-1923 C 1941

Survive to 25:	Die under 15:
1573-1610 D 1547	1585-1615 G' 1597
1610-1640 E 1677	1615-1675 G 1568
1640-1720 G 1574	1675-1715 /G' 1692
1720-1800 D 1650	1705-1755 G' 1726
	1755-1795 G' 1771
1810-1850 /G' 1864	1805-1833 G' 1821
1850-1880 C 1922	

[a] = M_i for England, France, and Sweden; [b] = TFR for England, France, and Sweden.

Sources: Livi Bacci and Reher 1993, 75, 76; Tabs. 5.1, 1.4; Figs. 1.5, 5.1a, 5.1b, 5.2, C.2.

Table C.5

Comparing Trends of Childhood Mortality, Marital Fertility, and Fertility Control in Knodel's German Villages

3 Bavarian Villages	*Die 0-4*	*1775,1812 ?C 1874*	*1812-1862 E 1904*	*1862-1910 C 1939*
	I_g*	*1775,1812 ?C 1877*	*1812-1862 E 1923*	*1862,1887 ?C 1938*
	m		*1837-1887 G 1862 = .259*	
2 Friesland Villages	*Die 0-4*	*1730-1812 C 1830*	*1812-1862 G 1753*	*1862-1910 G' 1865*
Werdum	I_g*	1725-1812 C 1860	1812-1862 G 1746	
	m		1812-1862 G 1769 = .121	
Middels	I_g*	1775,1812 ?C 1879	1812,1837 ?G 1753	
	m		1775-1837 G 1784 = .055	1862,1887 ?G 1875 = .341
4 Baden Villages	*Die 0-4*	*1725-1812 C 1855*	*1837,1862 ?E 1909*	*1862,1887 ?G' 1870*
Kappel	I_g*	1775,1812 ?C 1897	1812-1887 G 1742	
	m		1837-1887 G 1832 = .088	
Herbolzheim	I_g*	1725-1837 C 1901	1837-1887 G 1731	
	m		1812-1887 G 1837 = .318	
Grafenhausen	I_g*	1775-1837 C 1896	1837-1887 C 1914	
	m		1837-1887 G 1840 = .366	
Rust	I_g*	1725-1812 E 1906	1775-1862 G 1692	1837-1887 ? E 1979
	m		1837-1887 G 1866 = .333	
4 Waldeck Villages	*Die 0-4*	*1775,1812 ?C 1851*		*1837-1887 G' 1851*
	I_g*	*1725-1837 E 1902*	*1812-1862 G 1748*	*1862,1887 ?G' 1864*
	m			*1862,1887 ?G 1914*
Öschelbronn (Württ.)	Die 0-4	1725,1775 ?C 1864	1812,1837 ?C 1876	1862-1910 G' 1869
	I_g*	1725-1837 E 1879		1862,1887 ?G' 1877
	m	1775,1812 ?G 1761 = .128	1812-1862 D 1811	1862,1887 ?G 1873 = .191

Sources: Knodel 1986, 356, 348-49, 368; Figs. 5.9, 5.11.

Table C.6

Some Aspects of the Environment of Fertility in Certain Urban Areas and the Provinces of Belgium

Urban Areas:	I_g	Provinces & Nations:	I_g	% Males in Agric.	Low in Sec.
		BELGIUM	1846-1930 G' 1863		
Antwerp & Ghent	1846-1900 G' 1862	East Flanders (F)	1846-1930 G' 1866	G' 1863	1844
		Antwerp (F)	1856-1930 G' 1869	G' 1848	1844
Brussels	1846-1910 G' 1857	Brabant (F-W)	1846-1930 G' 1859	G' 1848	1844?
Flemish P. Towns	1856-1900 G' 1874	West Flanders (F)	1866-1910 G' 1876	G' 1863	1844
		Limburg (F)	1890-1930 G' 1893	D 1815	?
		NETHERLANDS	1879-1930 G' 1886		
		GERMANY	1867-1939 G' 1874		
		DENMARK	1870-1930 G' 1881		
Liège	1846-1900 G' 1859	Liège (W)	1856-1930 G' 1861	G' 1850	1863[a]
Hainaut I. Towns	1866-1910 G' 1854				
Walloon P. Towns	1846-1910 C 1911	Hainaut (W)	1802-1910 C 1910	G' 1850	1844[b]63[a]
		Namur (W)	1846-1910 C 1916	D 1815	1844[b]
		Luxembourg (W)	1856-1930 C 1939	D 1815	1844[b]
		LUXEMBURG	1900,1930 ?C 1920		
		FRANCE	1831-1911 C 1933		
			1861-1891 ?G' 1868		

I_h in Provinces & Nations:

East Flanders	1846-1866 G' 1863	1880-1900 G' 1890		1900-1947	$e^{-.03}$
Antwerp	1846-1866 ?G' 1862	1880-1900 ?G' 1894	1846-1890 ?E 1898	1890-1947	$e^{-.03}$
Brabant	1846-1866 ?G' 1856	rise to 1880	1846-1880 ?E 1920	1900-1930	$e^{-.03}$
West Flanders	1846-1866 G' 1866	1880-1900 G' 1890		1900-1947	$e^{-.03}$
FRANCE	1851-1876 G' 1863	1881-1921 G' 1896	1831-1851 G' 1835		
DENMARK	1852-1880 G' 1864	1890-1930 G' 1895			
NETHERLANDS	1859-1930 G' 1865				
BELGIUM	1846-1930 G' 1872		1806-1846 G' 1820		
GERMANY	1871-1933 G' 1881				
LUXEMBURG		1900,1930 ?G' 1906			
Liège	1856-1930 G' 1878				
Hainaut	1846-1930 G' 1873				
Namur	1856-1930 G' 1870				
Luxembourg	1880-1930 G' 1878	1856-1920 C 1944			
Limburg	1866-1930 G' 1885	1890-1947 C 1934			

F = Flemish, W = Walloon. [a] industrial villages of Liège and Hainaut (Liège population assumed mostly this); [b] other rural Wallonia.

Sources: Urban areas: Lesthaeghe 1977, 116. Nations: Tabs. 4.1, 4.5. Provinces: I_g, Lesthaeghe 1977, 103, 101; % of men in agriculture, ibid., 31 (provinces grouped); lows in index of secularization, Lesthaeghe 1992, 8, 1991, 276-79; I_h, Lesthaeghe 1977, 120.

Table C.7

Estimated Recent Trends of TFR in European Countries

France	1938-1963[a] G 1915 = 1.2	1963-1978 C 1970 = 2.3	1978-1993 C 2035 = 0.80	
England and Wales	1938-1963 G 1926 = 1.3	1963-1978 C 1969 = 2.4	1978-1999 C 2046 = 0.73	
Switzerland	1938-1963[b] G 1917 = 1.12	1963-1978 C 1967 = 2.3	1978-1998 C 2057 = 0.60	
Belgium	1943-1963[a] G 1922 = 1.2	1963-1978 C 1972 = 2.1	?	
Netherlands	1938-1963[a] G 1902 = 1.3	1963-1978 C 1956 = 3.8	1978-1994 flat	
Denmark	1938-1963[b] G 1908 = 1.1	1963-1987 C 1972 = 2.0	1987-1999 up then flat	
Sweden	1938-1963[b] G 1906 = 0.94	1963-1978 C 1980 = 1.55	1983-1999 hump	1993,1999 C? 1986 = 2.3
Norway	1938-1963 G 1928 = 1.4	1963-1978 C 1966 = 2.7	1983-1999 hump	
Finland	1938-1953[a] G? 1922 = 1.15	1948-1973 C 1964 = 2.2		
Portugal		1963-1988 C 1969 = 2.1	1988-1997 C 2046 = 0.64	
Ireland		1973-1996 C 1982 = 3.0		
Romania		1968-1998 C 1988 = 1.9		
Czechoslovakia[c]	1948-1968 C 1973 = 1.8		1978-1998 C 1990 = 1.7	
Poland	1953-1968 C 1957 = 3.3		1968-1988 C 2050 = 0.90	1994,1997 drop
U.S.S.R.	1948-1968 C 1996 = 1.35		1968-1983 C 2043 = 0.95	
Belarus & Ukraine				1983-1999 C 1999 = 1.22
Russian Federation				1987-1999 /G' 2023 = 0.84
Hungary	1953-1963 C 1950 = 3.0	1963-1978 G 1928 = 0.9	1978-1994 C 2034 = 1.0	1999 drops
Italy	1953-1963 C 1951 = 2.8	1963-1978 G 1927 = 0.9	1978-1995 /G' 2012 = 1.05	
Austria	1953-1963 G 1964 = 2.2		1968-1994 /G' 1999 = 1.4	1999 drops
Germany[d]	1943-1963 G 1922 = 1.15		1968-1983 /G' 2003 = 1.05	1983-1997 flat?
Spain	1953-1968 G 1920 = 1.28		1973-1997 /G' 2012 = 1.07	1983-1997 C 1996 = 1.1
Greece	1958-1978 G 1890 = 0.88		1978-1998 /G' 2011 = 1.2	
Bulgaria	1948-1968 /G' 1971 = 2.1		1968-1988 C 2048 = 0.9	1988-1997 C 1967 = 4.5

[a] = w/o 1948; [b] = w/o 1943, 1948; [c] = averaging Czech Republic and Slovakia in 1990s; [d] = FRG weighted 3, GDR 1 to estimate 1980s.

Sources: Chesnais 1992, 549-50; U.N. *Demographic Yearbook*, 1992, 1995, 2000.

Table C.8

Some Interacting Dynamics in the Onset of 'Demographic Transition'

A. Later 1700s into Early 1800s: Rising Fertility and Growth, Even with Declining Early Mortality

	Early Mortality	Crude Birth Rate	Fertility	Marriage	Population
England I	1750-1810 C 1856	1726-1816 E 1862	1726-1816 E 1851[t] 1718-1818 E 1860[f]	1758-1818 E 1860[n] 1761-1841 C 1895[m]	1726-1806 E 1822
Germany I	1725-1812 C 1874[K]	1775-1805 E 1854[L] 1818-1836 E 1880[W]	1762-1812 E 1855[Kmf] 1725,1775 ?E 1854[Kg]	?	1700-1800 E 1821
Belgium I	1716-1776 G' 1740[EF] 1776-1826 G' 1804[EF]	1710-1760 E 1800[L]	 1806-1846 G' 1821[g]	1796-1856 C 1884[n] 1750-1848 C 1870[m]	1650-1800 E 1828 1700-1806 E 1828[AB] 1750-1831 E 1835[EF]
Netherlands I	?	1808-1823 E 1842	?	?	1750-1839 E 1866
Denmark I	?	1737-1817 E 1936	?	?	1735-1801 E 1857
Lombardy I?	?	1770-1800 E 1870	?	?	1700-1800 G 1684 1800-1838 G 1778
New Castile I	1760-1810 G 1718	1640-1880 G 1595	1750-1790 G 1702c	1720-1790 D 1635	1740-1810 G 1710[LR]

B. Later 1700s into Early 1800s: Fertility Contracts Facing Less Early Mortality and Rising Population

	Early Mortality	Crude Birth Rate	Fertility	Marriage	Population
New Castile II	1760-1810 G 1718	1640-1880 G 1595	1790-1810 C 1855[c]	1790-1840 ? [m]	1790-1896 G 1724[LR]
France I	1748-1805 C 1833	1742-1802 C 1859	1742-1807 C 1855[t] 1755-1817 C 1853[g]	1742-1827 C 1896[m]	1792-1827 E 1896
Sweden I	1753-1823 C 1871	1693-1943 C 1941	1758-1808 C 1880[t]	1715-1788 C 1854[m]	1748-1783 G 1706 1783-1818 G 1737

Finland I	1753-1843 C 1896	1753-1808 C 1854	?	1753-1788 D 1722[mF]	1748-1793 G 1742
					1793-1808 G 1772
Norway I	?	1748-1813 C 1869	?	?	1748-1818 H 1632

C. Subsequent Group "A" Adjustments with Rising Mortality--and Partial Parallels (?) Elsewhere

England II	1815-1848 G 1767	1816-1846 D 1779	1816-1851 D 1787[t]	1831-1871 G 1769[m]	
			1823-1858 D' 1845[f]	1828-1868 D' 1848[n]	1816-1861 H 1758
Germany II	1812-1862 E 1935K	1817-1857 D 1761	1787-1887 G 1742[Kmf]	?	1816-1864 H 1743
	1838-1868 G 1725	1852-1877 E 1925	1837-1887 G 1772[Knf]		
			1775-1887 C 1985[Kg]		
Belgium II	1843-1863 G 1787	1847-1872 E 1922	1846-1866 E? ? [f]	1829-1866 E? ? [n]	1815-1866 H 1717
	1868-1893 G 1822				
Denmark II		1817-1842 D 1760		?	1801-1845 H 1706
	1833-1853 C 1907	1842-1857 E 1903			
	1853-1893 G 1740	1857-1877 D' 1868	1852-1880 D' 1864[g]		
Netherlands II	1838-1873 G 1804	1823-1853 D 1767	1838-1938 C 1944[fH]	1859-1889 G 1806[n]	1815-1869 H 1728
		1848-1878 E 1938			
Austria ?	1808-1873 G 1783	1822-1847 D 1778	?	?	1821-1857 G 1786
		1847-1872 E 1951			
Romania ?	1868-1902 G 1814	1862-1887 E 1907	?	?	1844-1912 E 1918
Hungary ?	1853-1947 [C] 1955	1862-1887 E 1947	?	?	1817-1880 G 1808
Portugal ?	?	1843-1878 E 1959	1864-1890 D' 1875[g]	1864-1911 G 1795[n]	1840-1890 E 1920

Table C.8 (cont.)

Some Interacting Dynamics in the Onset of 'Demographic Transition'

D. Curbing Fertility without Reducing Nuptuality: The Spread of 'Demographic Transition'

Early 1800s:	Early Mortality	Crude Birth Rate	Fertility	Marriage	Population
France II	1805-1843 C 1873	1802-1848 C 1895	1807-1837 C 1875[t] 1831-1851 C 1898[g]	1831-1876 G 1734[n]	1826-1921 G 1774
Sweden II	1823-1888 C 1908	1693-1933 C 1941	1813-1908 C 1965[t] 1800-1850 C 1970[g]	1843-1893 C 1934[m]	1823-1848 G 1795 1848-1943 H 1757
Finland II	1753-1843 C 1896	1808-1938 C 1952	?	1798-1828 G 1734[mF] 1833-1878 G 1784[mF]	1808-1833 G 1801 1838-1873 G 1809
Norway II	1838-1868 D' 1860	1818-1923 C 1959	?	?	1818-1893 H 1758
Tuscany II	?	1822-1842 C 1865	1822-1857 C 1903[c]	?	1816-1861 G 179[2]
New Castile III	1820-1860 D' 1833	1640-1880 G 1595	1820-1850 G' 1834[c]	1840-1870 G' 1854[m]	1790-1896 G 1724[LR]
Later 1800s into 1900s:					
Spain III	1868-1942 C 1955	1859-1932 C 1966	1887-1950 C 1969[g]	1887-1940 C 1974[n]	1857-1920 E 1952
Germany III	1863-1927 C 1919	1877-1932 C 1929	1875-1939 C 1931[f] 1875-1939 C 1928[g]	1867-1910 G 1805[n]	1864-1910 E 1923
Switzerland	1873-1927 C 1912	1872-1937 C 1942	1878-1933 C 1934[f] 1860-1930 C 1940[g]	1860-1910 G 1807[n]	1880-1910 E 1934
Czechoslovakia	1907-1947 C 1941	1837-1937 C 1943	1880-1910 C 1930[gB]	1890-1930 G 1911[nB]	1851-1891 E 1945[BM]
Austria II	1883-1942 C 1927	1872-1912 C 1952	1890-1910 C 1935?[g]	1890-1910 G 1820[n]	1850-1880 E 1910 1880-1910 E 1934

England III	1848-1957	C	1933	1851-1933	C	1933	1881-1931	C	1928[g]	1891-1931	E	2015[n]	1861-1939	H	1794
Belgium III	1893-1932	C	1936	1872-1942	C	1941	1866-1910	C	1914[g]	1856-1890	G	1814[n]	1876-1910	H	1790
Netherlands III	1873-1932	C	1911	1878-1938	C	1950	1879-1930	C	1937[g]	1859-1899	G	1807[n]	1869-1899	H	1799
										1899-1930	G	1838[n]	1899-1947	H	1849
Denmark III	1893-1957	C	1934	1877-1937	C	1944	1880-1921	C	1934[g]	1870-1930	G	1804[n]	1850-1890	H	1775
													1890-1945	H	1833
Sweden III	1888-1957	C	1932	1693-1933	C	1941	1880-1930	C	1930[f]	1880-1930	G	1870[n]	1848-1943	H	1757
							1860-1900	C	1962[g]						
							1900-1930	C	1920[g]						
Norway III	1868-1912	C	1925	1818-1923	C	1959	1875-1930	C	1947[g]	1875-1920	G	1762[n]	1893-1948	H	1797
Hungary II	1853-1947	C	1956	1882-1937	C	1938	1880-1910	C	1968[g]	1880-1930	C	1981[n]	1880-1910	H	1811
Italy III	1863-1912	C	1927	1862-1942	C	1955	1881-1951	C	1959[g]	1864-1921	C	1986[n]	1861-1936	H	1755
France III	1858-1937	C	1933	1848-1912	C	1944	1871-1911	C	1927[g]	1876-1901	G	1759[n]	1826-1921	G	1774
Finland III	1843-1967	C	1935	1808-1938	C	1952	1900-1940	C	1945[g]	1880-1920	C	1955[n]	1873-1908	G	1860

Note: 9 other European populations offer only short data series of the "D" type in the late 1800s and early 1900s.

[ ] = contrasts with rest of group; [t] = total fertility; [f] = overall fertility (I_f); [g] = marital fertility (I_g); [c] = completed family; [m] = crude marriage rate; [n] = nuptuality (I_m); [mf] = mean fecundability; [nf] = natural fertility.

[AB] = Antwerp and Brabant; [EF] =East Flanders; [H] = Hofstee, 132; [K] = Knodel; [F] = Historical Statistics of Finland, 80; [L] = local evidence (see text); [W] = Württemberg; [BM] = Bohemia and Moravia; [B] = Bohemia; [LR] = Livi Bacci and Reher.

Sources: Figs. 4.1, 4.2, 4.3, 5.1a, 5.1b, 5.11, C.2, C.9; Tabs. 2.3a, 4.3, 5.1, 5.2, 5.9, 5.10, C.1, C.4, C.5.

Table C.9

Comparing Demonomic Trends in East Flanders and England

I. From the Early 1700s into the Early 1800s

A. Common Movements

East Flanders				England			
Real Rural Wage Day-L.	1747-1847	C	1857	Clark, SE & SW	1675-1805	C	1855
Weaver	1747-1847	C	1830	Clark, N & Midlands	1735-1775	C	1828
Real Urban Wage (Rye)	1738,1763	?C	1811	Phelps Brown-Hopkins	1731-1813	C	1839
(Wheat)	1738-1788	C	1819	Crafts-Mills, Cost Living	1750-1804	C	1849
Population Growth	1750-1831	E	1852	Wrigley-Schofield	1726-1806	E	1822
Urban Proportion	1750-1806	E	1864	De Vries	1750-1850	E	1853
				Lawton	1801-1821	E	1856*
Urban/Rural Wage DL(W)	1763-1838	E	1852	PB-H/Tsouhoulas	1715-1795	E	1851
Wvr(W)	1763-1838	E	1837	Clark (Agr.), N&M/SE&SW	1775-1815	E	1848
Crude Marriage Rate	1750-1848	C	1870	Wrigley-Schofield	1761-1841	C	1895
% Not Marrying	1725-1821	E	1854*	Wrigley-Schofield	1714-1774	C	1765*
				" "	1759-1814	G	1743*

B. Divergences

East Flanders				England			
Nuptuality (I_m)	1796-1856	C	1884*	Wilson-Woods	1758-1818	E	1860
Fem. Age 1st Marriage	1755-1805	E	1870	Wrigley-Schofield	1713-1813	C	1851
Per Capita Income	1725-1835	C	1851	p.c. GNP (Crafts)	1760-1860	E	1870
				p.c. Priv. Consumpt. (")	1760-1831	E	1880
Linen Pieces p.c.	1782-1845	C	1873				
Linen Value p.c.	1700-1845	C	1855	p.c Industry (Jackson)	1730-1810	E	1825
				Patents 5 Ind. (Sullivan)	1785-1835	E	1803
				All Patent Processes (")	1785-1845	E	1811
% Income from Agricult.	1725-1835	E	1866	% GNP from Agr. (Crafts)	1700-1840	C	1864
% Farms Small	1705-1790	E	1828	Workers/Farms (Kussmaul)	1765-1831	E	1838
				% Rem. L. Enclosed (Clark)	1750,1850	?E	1880
				Return on Consols (W & M)	1751-1796	E	1816
				Bank of Eng. Dividend (")	1732-1797	E	1848

Table C.9 (cont.)

II. Across the 1800s

East Flanders				England			
Population Growth	1811-1866	G	1778	Wrigley-Schofield	1816-1861	H	1758
" " (Belgium)	1815-1866	H	1717		1861-1939	H	1794
" " (")	1876-1910	H	1790				
Urban Proportion (Ghent)	1815-1855	G	1797	Lawton	1821-1901	H	1742
Marital Fertility (I_g)	1846-1880	G	1803*	Wilson-Woods	1748-1873		flat
	1846-1930	G'	1860*	Coale-Treadway	1861-1931	G'	1874
% Not Marrying (age 25)	1771-1841	G	1732	Wrigley-Schofield	1814-1839	G	1801*
Crude Marriage Rate	1848-1863	E	1888	Wrigley-Schofield	1831-1871	G	1788
" " "	1883-1913	E	1939				
Nuptuality (I_m)	1866-1910	E	1944*	Coale-Treadway	1851-1871	G	1780
CBR (Belgium)	1847-1872	E	1922	Wrigley-Schofield	1812-1846	D	1779
CDR (Belgium)	1815-1922	C	1935	Wrigley-Schofield	1831-1923	C	1936
Real Rural Wage D-L	1847-1892	E	1893	Clark, SE & SW	1815-1865	G	1786
				Clark, N & Midlands	1805-1865	G	1792
Real Urban Wage (Wheat)	1813-1863	E	1928	Phelps Brown-Hopkins	1809-1869	G	1808
" " " (Silver)	1838-1888	E	1890	Crafts-Mills, Cost Living	1800-1864	G	1795
				" " , Own Product	1830-1866	G	1788
Urban/Rural Wage	some E indicated			PB-H/Tsouhoulas	1805-1835	G	1789
				Clark (Agr.), N&M/SE&SW	1805-1865	G	1755
				GNP p.c. (Crafts)	1840-1910	H	1790
				% GNP Manuf/Cons (Crafts)	1800-1890	G	1820
% M Work Ind. (Lge&Hain)	1846-1910	H	1822*	% M Work Manuf/C (")	1800-1870	G	1780
" " " " (E&W Flan)	1846-1910	H	1854*	" " " " " (G-W)	1856-1913	G	1775
" " " " (Ant&Brab)	1846-1910	H	1881*				
% M Work in Agr. & Weav.	1846-1890	C	1916*				
% Land Owned by Cultiv.	1856-1895	C	1945*				

Table C.9 (concl.)

III. From the 1600s into the Early 1700s

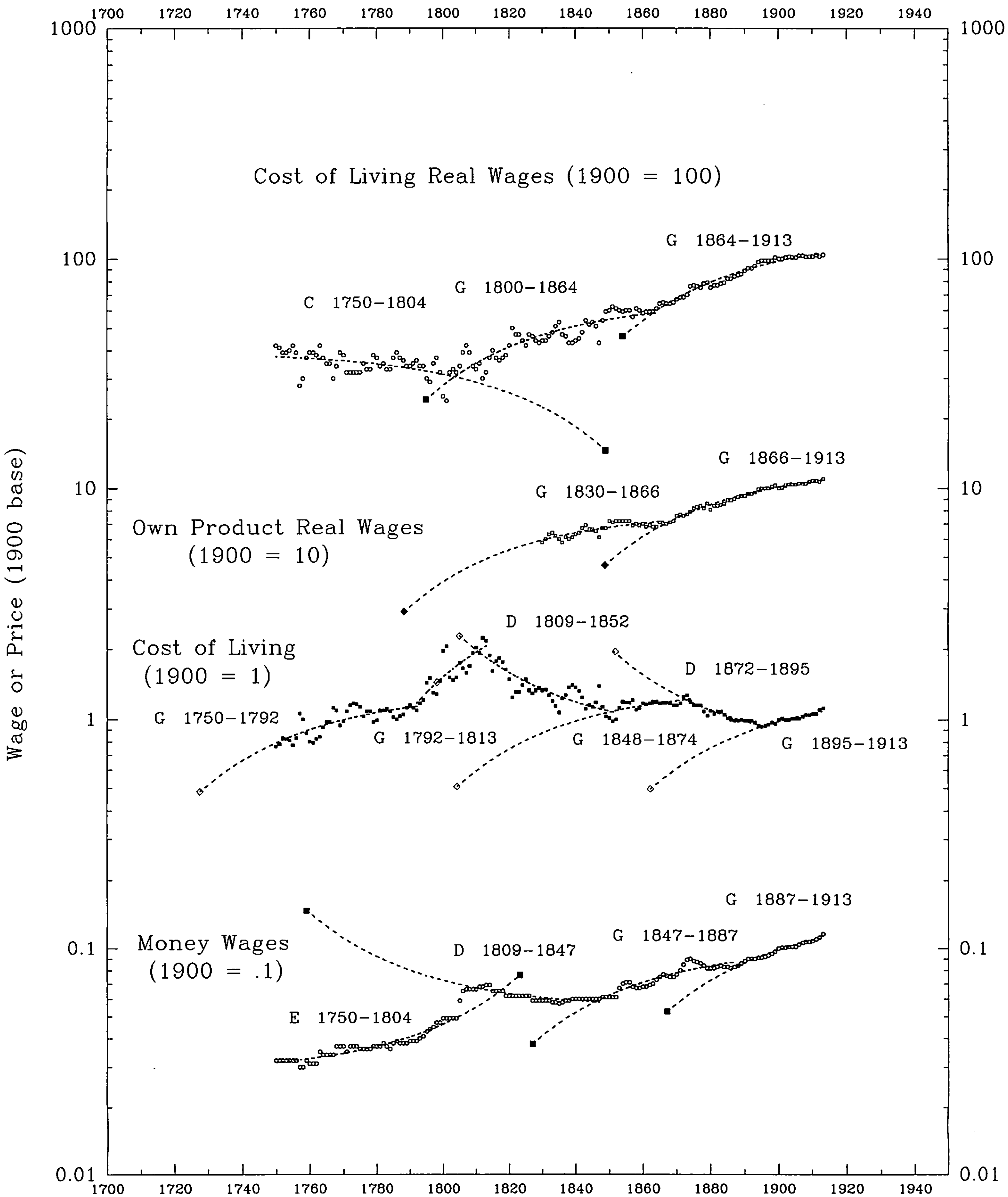
East Flanders				England			
Population Growth	1665,1700	drop		Wrigley-Schofield	1656-1686	D	1587
	1700-1806	H	1581		1686-1726	H	1492
	1700-1750	?E	1778*				
Urban Proportion	1650,1700	?G	1579	Wrigley	1670-1750	H	1556
" " (Ghent)	1660-1710	G	1602				
" "	1700,1750	?D	1675				
" " (Ghent)	1710-1780	D	1697				
Marriage Age (Elvesele)	1625-1725	E	1784*	Wrigley-Schofield	1663-1713	flat	
" " (Adegem)	1685-1730	E	1793*				
" " (Vieuxbourg)	1690-1780	E	1786*				
% Not Marrying	?			Wrigley-Schofield	1664-1714	C	1717*
Crude Marrage Rate	1685-1750	C	1773	Wrigley-Schofield	1661-1756	G	1606
Nuptuality (I_m)	?			Wilson-Woods	1663-1763	G	1618
Births/Marriages (Vieux)	1710-1770	E	1815	I_g (Wilson-Woods)	1543-1748	flat	
" " (S&I soil)	1710-1770	E	1812				
Young Men Die (Vieuxbg)	1730-1788	C	1820*	Crude Death Rate (W-S)	1681-1701	D	1664
Young Women Die (")	1710-1788	C	1827*		1701-1731	E	1756
Young Men Die (Elvesele)	1675-1773	C	1790*				
Young Women Die (")	1675-1773	C	1810*				
Av. Age Death M (Vieux)	1710-1750	G	1640*				
" " " F (")	1710-1750	?G	1630*				
				Extramar. Fert. (I_h, W-W)	1653-1758	H	1640
Real Rural Wage Day-L.	1642-1747	G	1632	Tsouhoulas	1615-1725	G	1550
Weaver	1662-1757	G	1665	"	1595-1735	E	1789
Real Urban Wage (Rye)	1663-1738	G	1634	Phelps Brown-Hopkins	1693-1731	G	1676
	1688-1738	E	1792				
(Wheat)	1688-1738	E	1781				
(Silver)	1613-1713	C	1769				
Urban/Rural Wage DL(Rye)	1663-1738	D	1638	PB-H/Tsouhoulas	1695-1725	G	1653
Wvr(")	1663-1763	D	1659	Clark (Agr.), N&M/SE&SW	1675-1755	E	1805
DL(Wh)	1713-1763	D	1657				
Wvr(")	1688-1788	D	1662				
				Nat. Income p.c. (Mayhew)	1600-1700	E	1740
				People in Agr. (Wrigley)	1670-1750	D	1606
				Patents for Ag. (Sullivan)	1625-1755	D	1617
				All Patent Processes (")	1665-1755	H	1563
				% Rural Pop. Not Agr. (Wr)	1670-1800	H	1540
				Rural People Not Agr. (")	1700,1750	?H	1575
				Workers/Farms (Kussmaul)	1599-1793	H	1554
				% Ag. Workers Laborers (")	1599-1705	H	1637

* Estimated by template.

Sources: East Flanders from Figures 6.2, 6.3, 6.4, and 6.5 and Tables 6.3, 6.4, and 6.5. See text for page numbers and other particulars concerning England.

Figure D.1

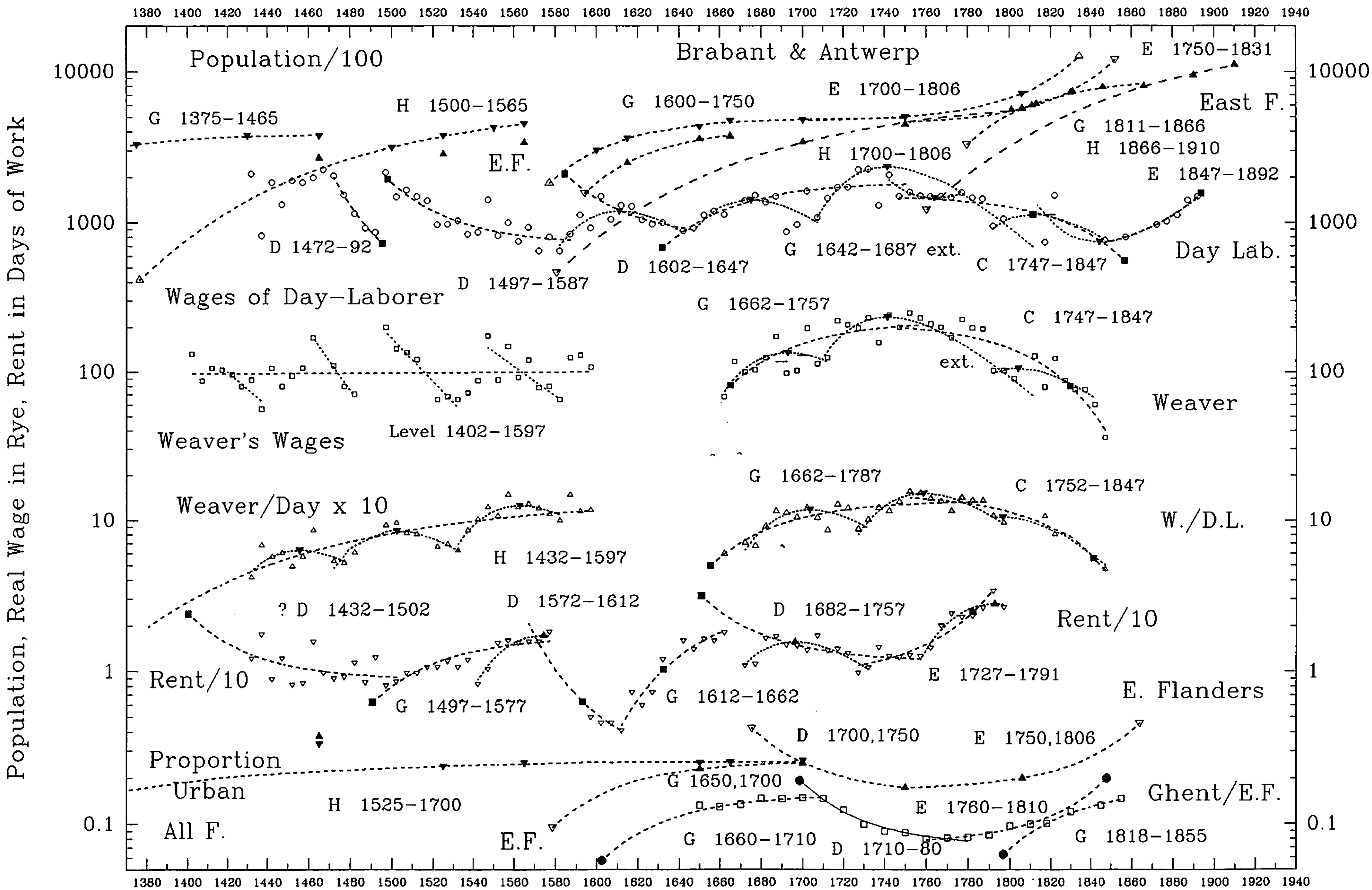
Wages and Cost of Living 1750–1913, Crafts and Mills



Source: Crafts and Mills 1994, 179–82.

Figure D.2

Long– and Short–Term Trends of Population, Real Wages, and Land Rent in East Flanders and Adjoining Regions from the 1400s to the 1900s



Sources: Klep 1991, 505, 498; Vandenbroeke 1984, 922, 924, 916.

Figure D.3

National and Per Caput Income, Production, and Consumption in England 1470–1910

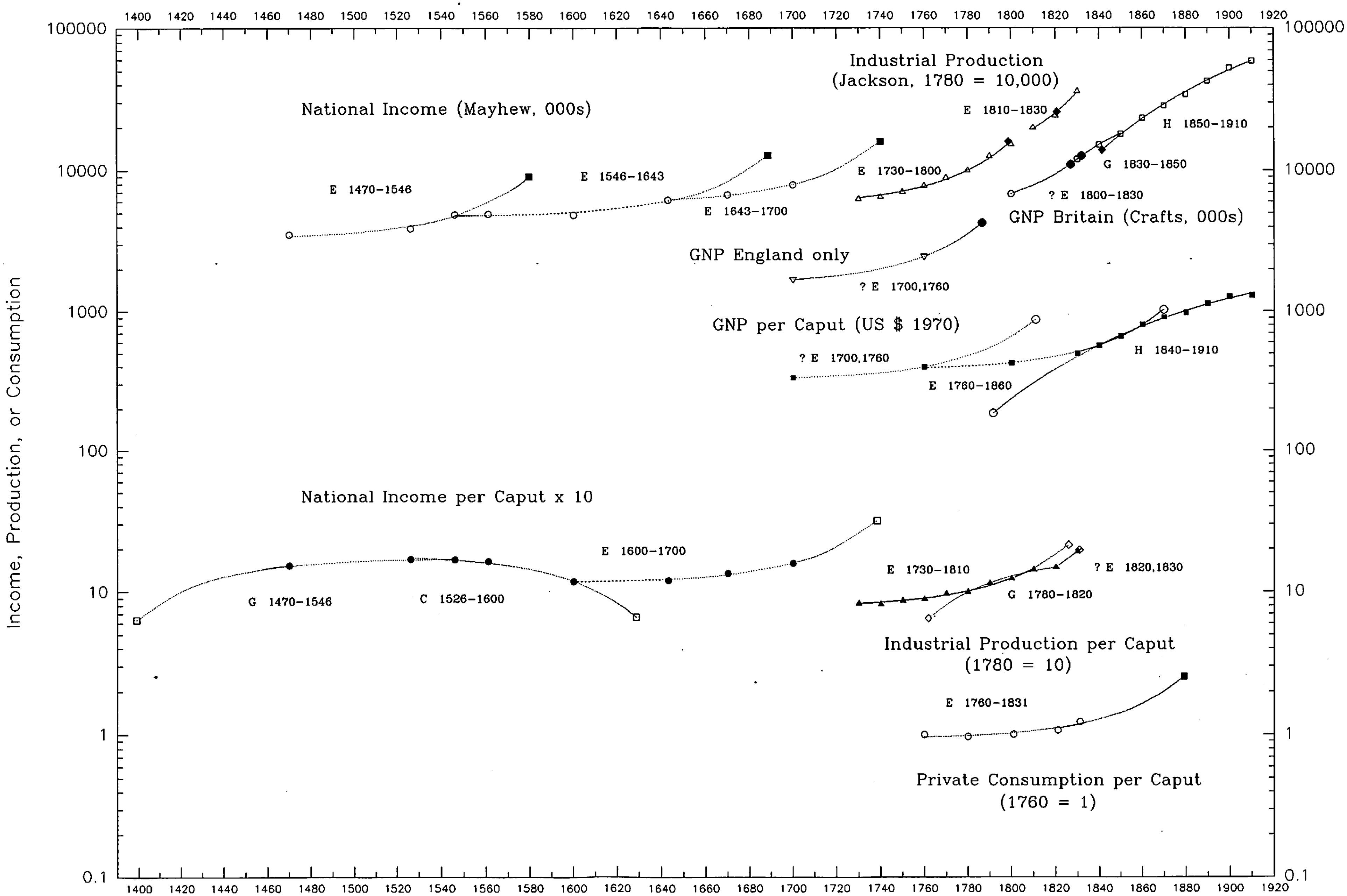


Figure D.4

Innovations in English Agriculture and Industry 1525–1895

a. Patents and Their Applications for Industry and Agriculture, and Agricultural Books

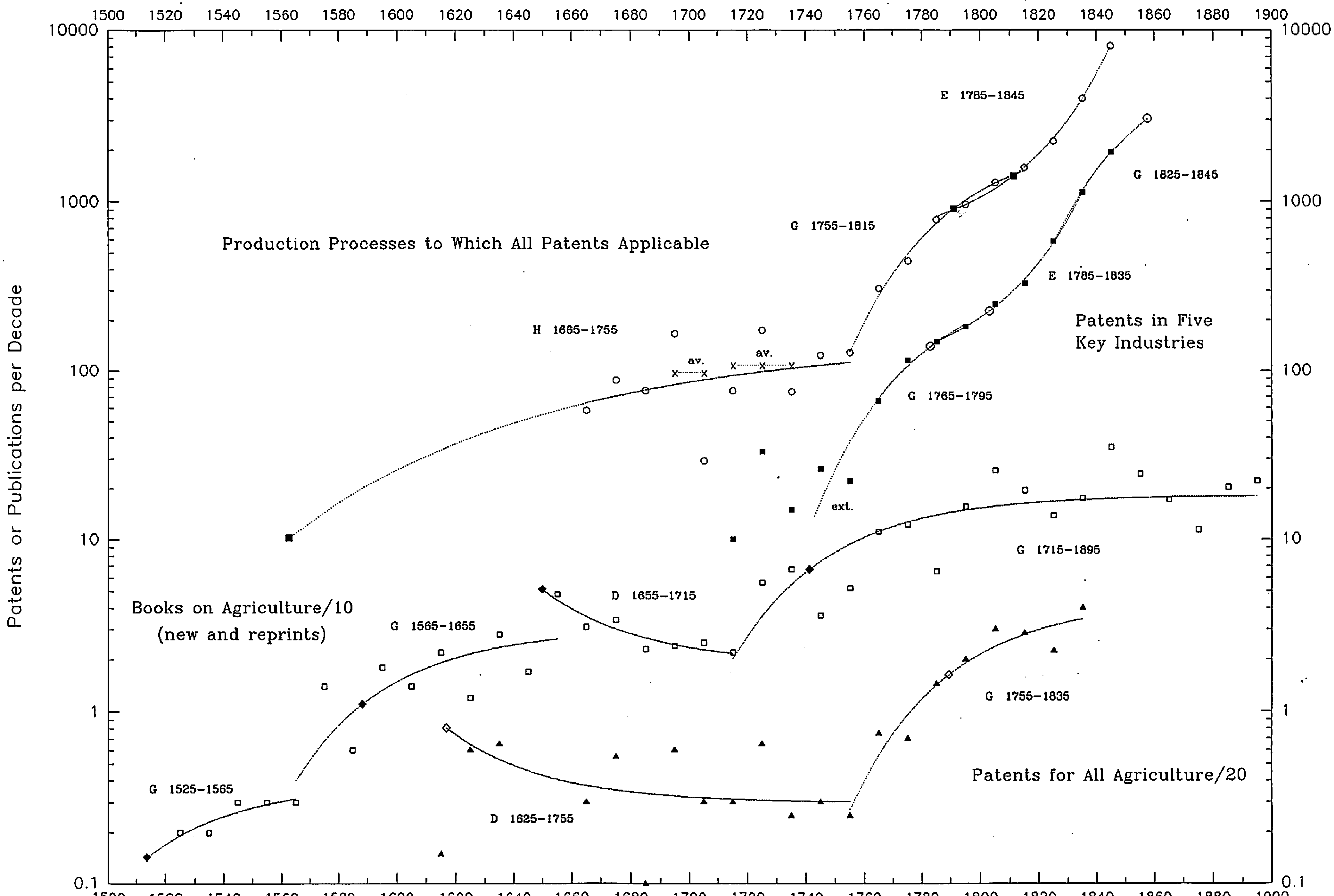


Figure D.5

Trends of Structural Change, Rates of Growth, and Investment in the Economy of Britain 1700–1913

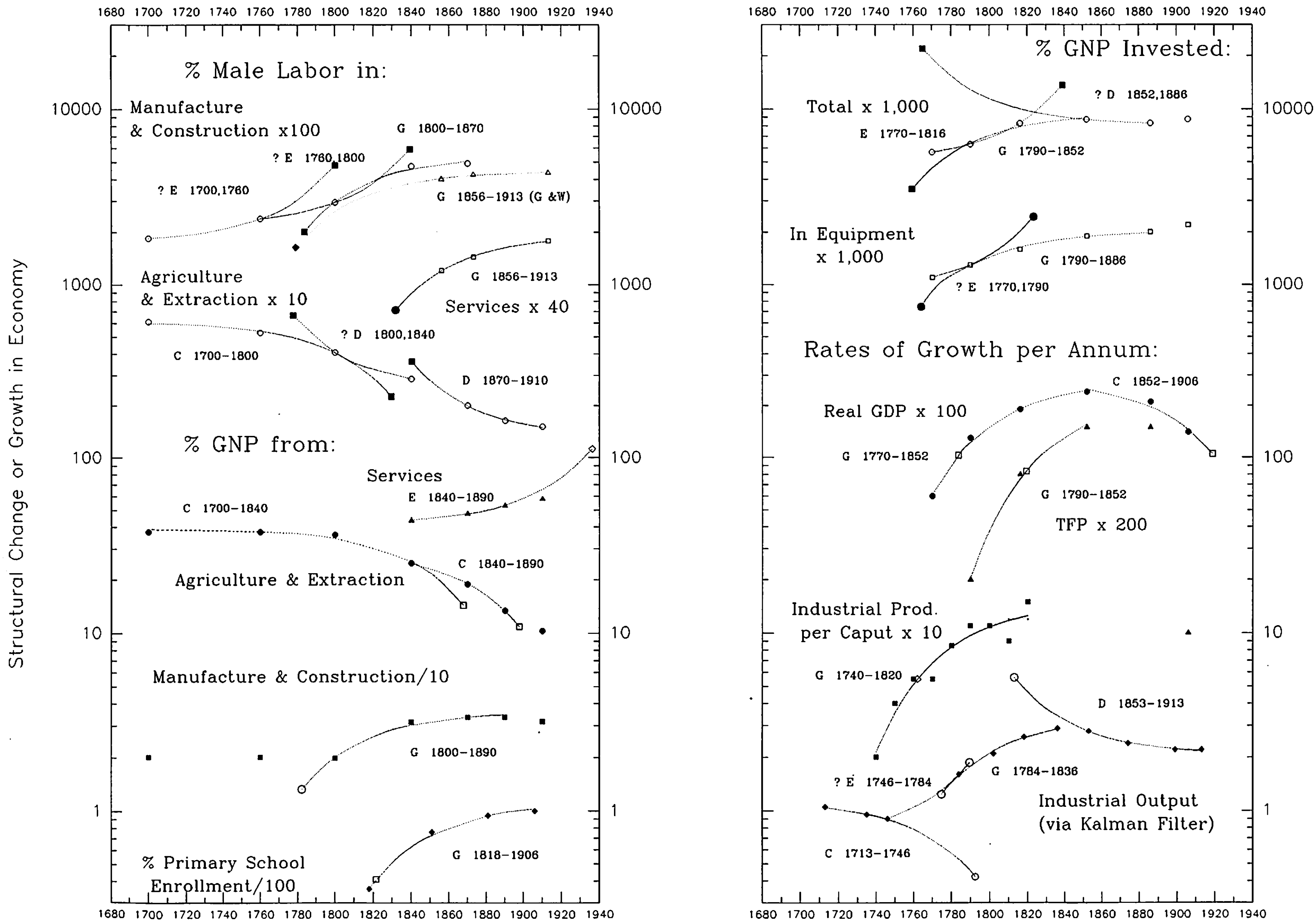


Figure D.6

Population Growth, Urbanization, and Agricultural Productivity in England from 1550

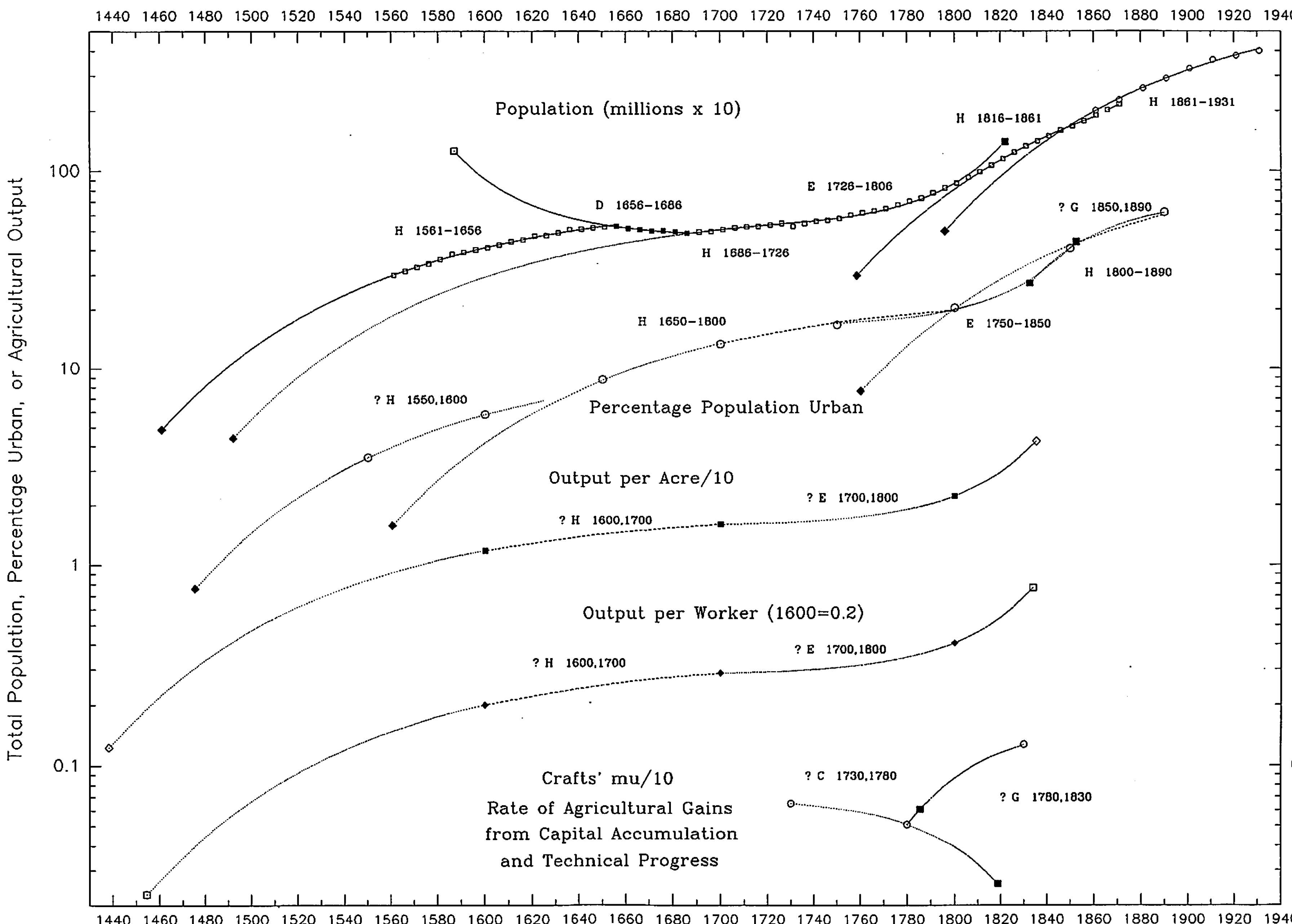


Figure D.7

Some Health and Food Conditions for English Workers during Industrialization

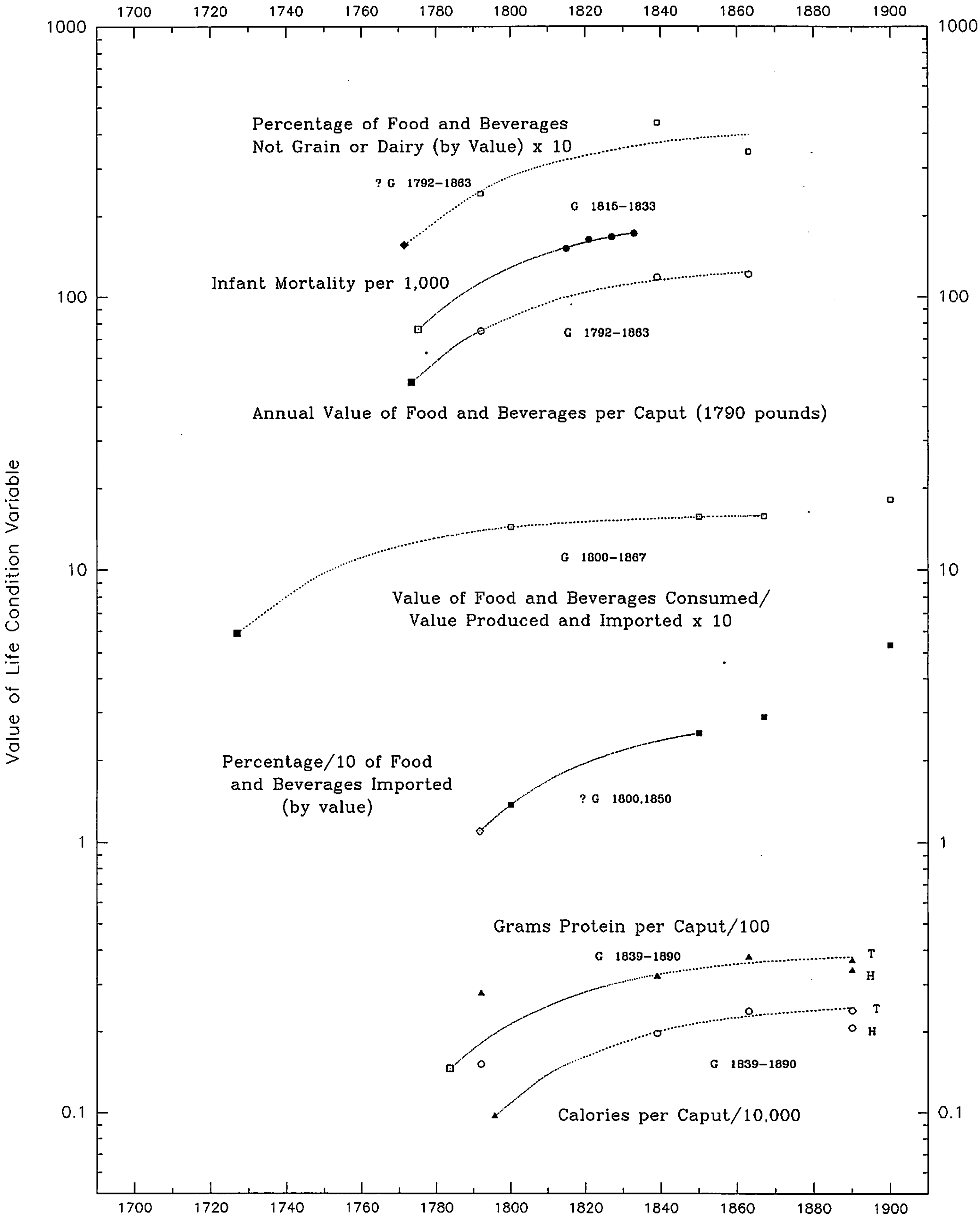


Table D.1

Estimated Trends in Crude Birth Rates from Reducing Fertility in Certain Ways

A. Pre-Transition

Base	0-30	G' 16			30-100	level
C	15-55	E 100			60-100	D 7
Shift	15-50	G' 28			50-100	level
D'	0-35	G -23			40-100	D 5
D	15-40	E 91			45-85	D -2
O to Y	15-45	C 46	50-75	C 110	50-100	D 11
Y to O	15-35	C 30	30-65	C 97	35-100	D -2

B. Madagascar 1966

Base	0-40	G -50			40-100	level
C	15-55	E 100			60-100	D 15
Shift	15-35	G' 35	35-65	D -2	65-100	level
D'	0-30	E 59			40-100	D 10
D	0-30	E 68			45-100	D -5
O to Y	25-45	C 49	50-75	C 117	55-100	D 15
Y to O	15-35	C 38	35-65	C 101	35-100	D -1

C. Mexico 1966

Base	5-25	G' 12			25-100	level
C	0-55	E 101			60-100	D 10
Shift	15-35	G' 35			35-85	D -1
D'	0-35	E 62			40-100	D 8
D	0-35	E 74			45-100	D 2
O to Y	15-40	C 44			20-100	D 6
Y to O	20-50	D' 48			50-100	D 12

D. Italy 1980

Base	15-65	D -16			65-100	level
C	15-45	D' 34	50-70	D' 71	70-100	D 47
Shift	15-55	C 58			25-90	D 20
D'	15-60	C 80			40-100	E' 84
D	15-45	D -15			45-100	D 34
O to Y	15-40	C 23	40-70	C 76	55-100	D 44
Y to O					20-100	D 35

APPENDIX D

Some Relevant Economic Trends

[Figure D.1]

[Figure D.2]

[Figure D.3]

Sources: Mayhew 1995, 244; Jackson 1992, 19; Crafts 1984, 440; Crafts 1983, 198.

[Figure D.4]

Sources: Sullivan 1984, 274; 1989 448-49.

[Figure D.5]

Sources: Crafts 1984, 450; Crafts 1983, 198; Gemmell and Wardley 1990, 301; Crafts 1995, 754; Crafts et al. 1990, 460-61; Jackson 1992, 19.

[Figure D.6]

Sources: Wrigley and Schofield 1981, 528-29; de Vries 1984, 39, 45; Allen 1991, 487; Clark 1991, 447-48; Crafts 1980, 167.

[Figure D.7]

Source: Clark et al. 1995, 220.

Appendix E

Fertility-Related Particulars Beyond Europe

Differing Patterns of Increase in the Spacing of Births

What distinguishes G from E gains in spacing? One hint comes from patterns of change among Utah women who married at different ages (Anderton and Bean 1985, 179). Among those wed before they were 21, spacing for females married around 1868, 1883, 1898, and 1913 (birth cohorts of 1845, 1860, 1875, and 1890) enlarged for parities 2, 3, 4, 7, and possibly 5 and 6 in E shape. For those married over the age of 25, *G-type* gains in spacing were the norm instead for parities 2 through 6, while among females married from 21 to 25--the intermediate group--for parities 2 through 7 the increase was generally *log-linear*: it neither accelerated nor decelerated. The net amount of proportional change over 45 years, meanwhile, tended to be about the same for the three categories of women by age of marriage. They just arrived there via different paths. What do these findings suggest, and how might such patterns come about?

Over the period studied by Anderton and Bean (1985, 176), on the other hand, for women who in the end had only 4 children ever born, spacing increased significantly at parities 2, 3, and 4 from those wed around 1868 to those married around 1913 (in G manner at $p = 2$, but not at $p = 3$ or 4). For those ever bearing 6 children, obvious extension occurred only at $p = 5$ and $p = 6$. At earlier parities for those eventually having 6 births, at parities 2 through 6 for those giving birth to 8, and at parities 2 through 8 for those producing 10 children, the tendency for all or most of the time examined was instead for birth intervals to *contract*, and mostly to do so in approximate C fashion.

Components of Change in the Duration of Reproduction within the Female Life Cycle

The patterning of fertile span is simplest for Sturbridge (Osterud and Fulton 1976, 489, 485). For marriages between 1745 (1730-1759) and 1830 (1820-1839) the average age of mothers at last birth rose slightly to about 1770 then fell off thereafter in C fashion for a net contraction of 2.9 years while mean age at first marriage for females increased quite steadily by 6.0 years in G manner (indicates background graphing). As a result, the span of years over which women were making children shrank from 19.1 to 10.2 years, or 47 percent; and it did so via C with target year at 1844 (Fig. 6.7a). This trend closely resembles the 40 percent decline in the number of children ever born in the completed families of Sturbridge (ibid., 483), which took place from the marriages of 1770 through those of 1819 in C form with t_0 around 1847 (Tab. 6.1) . It should be noted that 67 percent of the contraction in duration of the productive span was due to delayed marriage across a period in which this relatively new farming community matured. Women may have ceased to bear as many in the later stages of their fertile lives (part B of Tab. 6.4); but increased age for first being ‘at risk’ for pregnancy still, in this 1745-to-1830 era of transition, was a more important determinant for fertility reduction. Nonetheless, the women of Sturbridge were in fact also beginning to trim back how late in life they bore children.

Patterning the evidence for Deerfield (Temkin-Greener and Swedlund 1978, 35) is complicated by the way in which between women married around 1753 (estimated from women born 1721-1740, etc.) and those wed around 1773 the span of child-bearing lengthened markedly before assuming for the next 40 years the kind of C path noted in Sturbridge. This initial rise on the record occurred as the mean age of last birth expanded 3.5 years while the average age at marriage climbed only 0.2 years. Together these changes generated a G' surge in the number of children ever born for these women that peaked in the marriage cohorts around 1763 (Tab. 6.1) compared with a maximum at 1771 for the kind of G' trend that is tentatively fitted to the data for childbearing span in marriages between 1753 and 1793 in Figure 6.7a. Part B of Table 7.4 has shown how it was G' surges in the fertility of cohorts of women 30 through 49 that put this shape of imprint upon the number of children ever born at this early time, while younger females already by the 1750s were experiencing C-shape contraction in their rates of reproduction. Comparably, the intervals between penultimate and final births, 4th and 5th, and 2nd and 4th all on average shortened in 1/G' fashion with bottom years in the early 1760s, though the gap between 1st and 2nd births for marriages made between 1753 and 1813 adhered to a steady upward G trend throughout. There is a tendency, furthermore, for the bounce back to longer spacing beyond the 1st to 2nd interval to take G' shape from 1773 through 1813 with top of the surge in the 1790s. What might have made reproduction in later fertile years behave this way in Deerfield?

From 1773 forward, then, mean age at marriage in Deerfield rose 4.0 years into the early 1800s while the average age of women at last birth declined 2.3 years. These movements followed, respectively, the G and C patterns previously encountered in Sturbridge. Between the cohorts of 1773 and 1813, 37 percent of the reduction that occurred in reproductive span seems to have derived from curtailing the average age of women at their last birth--just slightly more than the 33 percent role that this source of shortening played in Sturbridge.

For the women of Nantucket, too, among those married between 1715 and 1745 the span of reproduction first stretched in G' manner then took up C-type contraction into the early 1800s. Here, however, the G' surge was appreciably earlier--peaking around 1727 rather than 1771. Unlike the dynamics in Deerfield, moreover, a dip of 1.2 years in age of marriage from the 1720s into the 1730s significantly supplemented an increase of 3.2 years in age of last birth from around 1695 into the 1720s to generate the bulge in the span of child-making (Byers 1982, 21, 29). The net G' here did not depend quite so much upon later years of reproduction.

In unions of the 1740s forward, increase in age of marriage in Nantucket followed a leveling out G track with base year about 20 years earlier than similar movement in Deerfield and Sturbridge while age at last birth came down in an accelerating C pattern that more closely paralleled the comparable trends in those two other towns. The result between the 1740s and the 1810s was a 4.7 year or 32 percent shrinkage in the span of reproduction for completed families in the whaling community. That change compares with 28 percent fewer children ever born in completed families between 1737 and 1812 (Logue 1983, 436; Byers gives no such information). Of this cut in the average duration of reproduction, as much as 4.2 years came from later marriage while only 0.5 years or just 11 percent of the total contraction derived from an earlier point in their life cycle at which women ceased to bear children. This mix of movements, as identified from Byers, may contribute to how Logue found no significant *m* value in Nantucket, though she herself separately demonstrated curtailment of age at final birth for women married under 20, from 20 through 24, and also 25 through 29 between 1737 and 1812 (1983, 438). In aggregate, the Nantucket population seems to have responded to challenge through delayed marriage, not fertility control within marriage, while in Deerfield and Sturbridge an earlier end to childbearing contributed a third or more of the abbreviation of the reproductive span rather than just one ninth (though of course the early years are most important in determining total fertility).

Overall, Figure 7.7a shows, the range of years across which women conceived and bore children contracted between the middle 1700s and the early 1800s in very similar C trends in a whaling port, an old frontier town up the Connecticut Valley, and a later farm settlement of the 18th century Massachusetts interior. The women of Nantucket, however, appear to have been distinctive for making the overwhelming majority of this change via delayed marriage while in Deerfield and Sturbridge cuts in late births were beginning to make a more significant contribution. Unfortunately their has been no *m* calculation for these communities for comparison with Nantucket.

In all, Utah women who were approaching what turned out to be the limit of their reproduction tended to expand spacing between the last two pairs of children whether their final number was 4, 6, 8, or 10. Before that point, however--in ultimate families of 6, 8, and 10 children--intervals between births actually *shortened*. Only in families of 4 eventual children did increased spacing between the 1st and 2nd child already occur. From marriages made in the 1860s to those of the time of World War I, the women of Utah who produced only relatively small families increased spacing between their births from their earliest reproductive years forward. Others actually saw children come along faster before the number approached their eventual level. Shortened spacing like this across the earlier parities in eventually large families would have been influenced by the apparent rise of fecundability among Utah women. This increase from 0.18 to 0.27, by half, between women of age to marry around 1863 and those probably wed in the vicinity of 1903 took G shape with zero year around 1816. The investigators attribute such change to healthier living conditions as settlement matured (Bean et al. 1990, 189-90). Post-partum infecundability, meanwhile, from marriages around 1868 through those around 1918 mostly hovered around 9 months, in spite of a rise between 1863 and 1886--which had a G pattern with t_0 around 1815, like the longer lasting gain in overall fecundability. Then--in the end--mothers of large families, too, stretched out the spacing among their last three births.

Variations in Reproductive Span

For individual communities within a region, length of reproductive span--like various measures of fertility--displays significant variation in the timing of its C-shape trends during the late 1700s and early 1800s (Fig. 6.7a; Tab. 6.1). Likewise, the G’ surge of reproductive duration identified in Figure 6.7a for Nantucket presages better than such movement for Deerfield--later in overall span of births as in completed family size--how a G’ pattern might fit the 1675 and 1725 data points for geographically mixed New England family records from Wahl.

Among her genealogies, meanwhile, levels differed by region, with C movements coming down from maxima of 14.8 years in New England, 16.0 years in the Mid-Atlantic region, and 17.6 in both the South and the Midwest in trends evident before the 1840s in Figure 6.7b, which all had their target years in the 1850s. The second possible C path in the Midwest, then, declined as if it had started from a maximum of 15.1, the contemporary 1843-1887 trend in the West from a model level of 21.1 years. In all these movements the most *years* of curtailment came from reduction in the age of women at last birth. In four regions (the South cannot effectively be plotted), this average contracted about 6 years in C manner. The curves by year of mother's birth for 1725 to 1818 in New England and 1675 to 1818 in the Mid-Atlantic paralleled each other with zero years in the vicinity of 1870. A C pattern for the later, wholly 19th-century movements, in the Midwest or the West would have t_0 around 1908. The age at birth of the first child, on the other hand, rose in E fashion for mothers born between 1775 and 1843 in both New England and the Mid-Atlantic with target year in the 1890s, producing average reductions of just over 3 years in the reproductive span from the early, most fertile years. In the Midwest and the West, in contrast, age at first birth fell via C--more markedly in the West (2.7 years vs. 1.0)--before gaining back two-thirds of that change between 1856 and 1887 (for an overall net of just 0.8 years between 1831 and 1887). In all, shortening how late in life children were born, though less effective per year, composed an important component of fertility reduction in America during the 1700s and 1800s.

Singleness, Childlessness, and Family Structure

For one thing, the lack of children on the whole evolved quite differently in white households than it did in nonwhite ones, as the top portion of the left panel of Figure 7.8b indicates. From 1910 through 1980 childless couples increased as a proportion of all white households in G manner, approximating 25 percent by 1980 in contrast to the 11 percent of

1880. In nonwhite households, meanwhile, of which also about 11 percent did not have children in 1880, childlessness expanded to about 20 percent of the total as of the 1930s but fell back to 11 percent again by 1980. This trend from 1910 through 1980 took G' shape. A comparable G' trend is suggested, at least from 1910 through 1960, for the proportion of childless pairs among all nonwhite *couples*, the middle of the left panel shows. From 1940 through 1980, however, the lack of children among nonwhite couples declined in C fashion. For some reason, this was just the opposite of movement among white couples, whose percentage without children rose in E shape with t_0 at 2010 compared with the 2004 for C decrease among nonwhite couples. From 1910 through 1960, furthermore, the trend for whites had been G rather than the G' of nonwhites. G followed by E, finally, was the sequence of patterns among white households also for estimating overall childlessness (the bottom of the left panel of Figure 7.8b). This assessment combines households composed only of primary individuals with childless couples in the numerator. For nonwhites, on the other hand, from 1910 all the way through 1980 the percentage of households composed of either childless couples or primary individuals kept expanding in decelerating G shape parallel with the trend seen among whites between 1880 and 1940. This movement yields some 36 percent current absence of children among nonwhites as of 1980 contrasted to 51 percent among whites thanks to the upwardly accelerating E trend that took over the trajectory of such increase for the latter group by 1940.

What elements of economic opportunity, migration, family custom, and the like might have generated these divergent patterns? It is easy to conceive, for instance, a particularly marked impact of the Depression and the great 20th-century northward migration that would generate a crest in the 1930s for childlessness among nonwhites (compare Harris 2003, 48). Postwar, post-pill, post-1960s cultural change away from traditional family formation for reasons other than hardship, on the other hand, can readily be imagined to have had more impact among whites than among nonwhites, thrusting childlessness upwards among the former markedly more than the latter.

This hypothesis of different dynamics for white and nonwhites garners support from the much stronger gain of units containing just primary individuals, without spouses or children, among white households than among nonwhite ones. Up to about World War I, the first phase of E-shape increase was apparently even a little steeper for nonwhites than for whites, the right panel of Figure 7.8b shows. Between there and 1940 and then from 1940 to 1980, however, proportional increase in E form was stronger for whites, so that as of this last date 26.5 percent of households held only primary individuals, slightly more than among nonwhites (25.0), whereas at 1910 about twice as many nonwhite households were constituted this way (11.5 vs. 6.2 percent). And among whites these accelerating gains for households of just primary individuals combined with E-type increase in childlessness among couples to give total childlessness in white households a steeper E surge in the left panel of Figure 7.8b than for couples alone.

A certain percentage of childlessness among couples in populations derives from biological limitations of one partner or the other. Among the German villagers of the 18th and 19th centuries studied by Knodel, for example--for whom not having children was unlikely to have been a modern choice of lifestyle--permanent childlessness ran at 11 percent across the later 1700s but rose to 14 percent for the period 1800 to 1825 before receding back to 10 percent for the quarter-centuries around 1862 and 1887. In Figure 5.10 the C shape of decline from 1812 through 1862 has been trended. From 1787 through 1812, however, a G' surge with crest at about 14 percent around 1810 also fits the data. Did the Napoleonic Wars spread disease--venereal or perhaps that scourge of the early 19th century, tuberculosis--across the German countryside, which temporarily elevated the natural distribution of sterility and poor health? Was accentuation of disease then also a significant factor for nonwhites of the United States in the years between World War I and World War II that did not have the same impact upon white fertility? The levels for both whites and nonwhites in Figure 7.8b are higher than those for German villagers in Figure 5.10 in large part just because they include temporary as well as permanent childlessness.

Though their level remained somewhat higher (8.6 vs. 7.0 percent), meanwhile, *single parents* and their children declined as a percentages of all households between 1880 and 1940 more among nonwhites than among whites--and more strongly at first because of D rather than C shape. The stereotype of single, black, welfare mothers can draw only upon the steeper surge after 1960 for nonwhites than for whites: from 9.3 to 17.9 percent of all households vs. from 5.1 to 7.0 percent. If these trends were temporary shocks rather than more durable shifts in level, thay may have taken the G' shapes suggested in the right hand panel of Figure 7.8b. Data for 2000 should make very interesting material for an important social debate. Have the surges started to recede?

Recent analysis of Public Use Microdata Samples by Van Hook and others (2004, 659) indicates that among children of both natives and immigrants in the United States from 1970 through 2000 the proportion who had single parents did indeed climb in G' form, with estimated crests around 2006 and 2003 respectively. Simultaneously, the data of McLanahan (2004, 612)--also from PUMS--suggest G' trends in single parenthood from 1960 through 2000 that peak around 2001 and 2003 for the lowest quartile and for the middle two quartiles of women by education (with projected maxima around 47 and 25 percent). Only for the remaining 25 percent of women with most education is no G' pattern evident for the whole period, though from 1970 through 1990 change may have followed G' form with about 9 percent near 1987. The G' projections for whites and nonwhites at just 1960 and 1980 in Figure 7.8b, though they were scarcely definitive, have pointed in the right direction as to what later-running, more frequent data are likely to show.

Meanwhile the proportion of single households headed by women (whether or not they had children) within the total for these and for households headed by couples expanded among U.S. women of all races aged 30 through 39 in the Current Population Surveys between 1972 and 2002 in a G' trajectory aimed to crest at about 38 percent in 2006. Separately, for nonwhites a G' crest of some 64 percent is indicated near 1998, for whites (1977 to 2002) about 31 percent around 2005 (Musick and Mare 2004, 632). This is the kind of movement shown for singleness in Figure 7.8a for Massachusetts women 25 through 54 who married between 1873 and 1943.

Both eschewing or postponing marriage and willingly or unwillingly engaging in single parenthood have evolved in a context where more women work, of necessity or by choice. From 1960 to 2000 the proportion of U.S. mothers in the upper quartile of educational experience who were employed for a significant fraction of their time climbed from 12 to as much as 64 percent (McLanahan 2004, 613). Between 1970 and 2000 this increase took G' shape with a projected top of 66 percent around 2013. Yet these women with the most education were least likely to be single parents, never reaching 10 percent during the period studied. Among the *least* educated women, the bottom quartile, between 1960 and 2000 the percentage of mothers who were employed rose the least, from 8 to 30 percent. For them, support from the extended family and welfare can be thought to have been most significant. From 1960 to 1980, the increase from 8 to 15 percent took G' shape with estimated projected maximum around 16 percent in the vicinity of 1992. Then, however, new gain from 18 to 30 percent appeared between 1990 and 2000. Undoubtedly the fundamental shift in welfare policy that took place in the 1990s drove some of this renewed expansion of employment among the least educated mothers. If it followed G' form, and continues, a crest of about 45 percent around 2027 is projected.

Of the middle half of U.S. mothers according to level of education (the 2nd and 3rd quartiles), by 2000 some 58 percent were employed rather than the 10 percent of 1960. That almost matched the proportion for the most educated women. Their participation in the labor force outside the home, however, had increased in a distinctive manner--via the slowly decelerating H curve with zero year targeted around 2014. Shifts of urbanization and migration that involve or imply fundamental and durable changes in employment have been identified as taking this H trajectory in many historical contexts: 19th-century migration to industrial or industrializing countries such as the United States, Britain, Belgium, and the Netherlands (Harris 2003, 32, 34, 36), sometimes collating component movements of G' shape from particular sources into an overall H trend; the total Atlantic slave trade from the middle of the 1600s to the middle of the 1700s (ibid. 96-97); the growth of London within the population of England between 1562 and 1737 (ibid., 187-88); the urbanization of Sweden, Ireland, the United States, and the Old Northwest in the 19th century and the early 20th (ibid., 209-16) and of England, France, and the Netherlands from the 1500s into the 1800s along with growth in non-agricultural rural population and the effectiveness of farming (ibid. 224-47); and the evolution of urban systems in many countries, especially across Europe, over substantial periods of time between 1500 and 1980, including accompanying industrial employment, GNP per capita, and agricultural productivity (ibid., 251-300). It seems appropriate to hypothesize that the recent shift of average U.S. women, including mothers, into the workforce outside the home has been another such fundamental, long-term change of economy and society that has been taking H form.

Meanwhile, put together with European evidence that has previously been encountered, the U.S. findings indicate that G' trends in proportion marrying or not marrying have been a familiar feature in human population history. The G' impacts, though, can go either way. In England, for example, *celibacy* took two G' surges, first between 1587 and 1637 then from 1662 to 1712 (Figure 5.1b). Inversely, on the other hand, the crude *marriage rate* in Flanders bulged in G' fashion during the periods 1700-1750 and 1805-1848 while *nuptuality* followed such a trajectory between 1856 and 1890 (Figure 6.1 and Table 6.1a).[1] I_m in Ireland, Scotland, England, Belgium, the Netherlands, Luxemburg, Iceland, Denmark, Norway, Sweden, Finland, and Austria took G' shape in 'marriage booms' that followed World War II while in Poland and Russia the combination of inter-war opportunity and wartime horror generated rather earlier G' up-and-down movements in nuptuality. From 1910 to 1950, in contrast, I_m in Switzerland took 1/G' form as somehow marriage temporarily became more difficult rather than easier (Figures 4.2a through 4.2f). And, between the middle 1800s and the 1930s, several European countries experienced G' or 1/G' movements in the percentage of *young* women currently married--a crucial determinant of overall fertility (Table 4.6). Both when the impulse was an expansion of life chances and when some shock cut back opportunity instead, trends for the frequency of marriage readily acquired G’ or 1/G’ shape.

Another key element of social change in American society has involved the extended family--the role of grandparents, aunts and uncles, half- or whole brothers and sisters in households, particularly those in which children are raised. Following slight increase up to about World War I, the proportion of these declined among both whites and nonwhites, Figure 7.8b shows from the data of Ruggles (1994, 107). Though C-shape alternatives are possible, in each case the best fit seems to be a G’ trend. For whites, between 1910 and 1980 the curve came down from a crest at 1916. For nonwhites, the G’ maximum was appreciably later, at 1931. Study by Van Hook and others (2004, 659) now shows later movements of G’ shape, too, for native-born U.S. women and probably also immigrants. It is estimated that the proportion of children of natives who lived in extended households (many of whom would seem to have been nonwhite) peaked at about 19 percent in the vicinity of 1984, and that segment of the children of immigrants at approximately 33 percent around 2000. This compares with 21 percent extended among all white U.S. households at 1916 and 27 percent at 1931 for nonwhite ones (via Ruggles in Figure 7.8b). At each stage of social and economic change across the 20th century, the group undergoing the greater strain and novelty of environment at the time not surprisingly relied more upon extended family for support. In each case, however, the swing in that direction took G’ shape.

Accompanying G’ movements for childlessness among nonwhite couples, this patterning further strengthens the picture of stress on nonwhite families that peaked in the Depression. The suggestion of Figure 7.8a has been that a similar period of tension drove up childlessness and inability to marry (or stay married) among the women of Massachusetts to a crest in the 1890s--in large part, it is hypothesized, immigrant women. Such women today, though they come from different places than the southern and eastern Europeans of the early 1900s, once again most count on their extended family for support, while less often forging ahead as single-parent heads of households than native females.

Notes

1. Though for East Flanders alone G and E patterns are evident in CMR and percentage not married (Table 6.10).

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Chapter 6

{Please note that Figure 9.3 has two iterations. This is the second one, which seems to belong into Chapter M. The text of Chapters 9 and M, respectively, provides some guidance—MSW 31 July 2015}

{Please note that the following Figure 9.6z seems provisionally labeled. Harris had collected the data but was not able to transform all of the data into the graphs he had planned—MSW 31 July 2015}

{Please note that the some of the "lettered" Figures referenced in Chapters 10 and 11and the Conclusion are in Appendix A, B, C, and D. The Figues for Chapters L and M are not included because almost none of them were in the printed-out notes. Harris produced the manuscript of his *History of Human Populations* on PCs, using word processing and graphing programs that were no longer available or supported when I attempted to retrieve them from the hard drives of his PCs or from the diskettes on which he meticulously backed up his work. As a consequence, I could not produce those Figures that he had already prepared but not printed out. MSW 31 July 2015}

Appendix A

Appendix C

Appendix D

Miscellaneous Figures

{Please note that this Figure belongs in Chapter M and is included there at the end of the text (notes). MSW 31 July 2015}

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Chapter 6

{Please note that Kiana Thomas prepared this list. I thank her here formally for her assistance in my efforts to organize the various parts of P.M.G. Harris's History of Human Populations in the summer of 2013.
When Ms. Thomas did her work, the order of Chapters 10 and 11, the Conclusion, and Chapters L and M was not determined, which makes her "interleafing" of Figures and Tables past Chapter 10 not match. MSW 31 July 2015}

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