

# POPULATION AND DEVELOPMENT: WHAT DO WE REALLY KNOW?

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## ABSTRACT

Population and development generally refers to the study of the consequences of population trends on socioeconomic development, human welfare, and the natural environment. Although there is a long tradition of scholarship on the consequences of population trends, beginning with Malthus, contemporary research on population and development lacks a dominant paradigm and a cumulative research tradition. A major strain of the literature, which lies largely outside the corpus of modern demography, adopts a “doomsday scenario” which argues (or assumes) that population growth has highly adverse consequences on human welfare and the natural environment. Economic demographers and other researchers have questioned the logic and evidence offered by the population alarmist school. The revisionist perspective finds generally modest effects of population trends on economic growth in developing countries. I conclude that “middle range” research on tractable research questions might lead to a more productive and cumulative research literature.

## INTRODUCTION

One of the classic works on demography defined the scope of the field with the title “The Determinants and Consequences of Population Trends” (United Nations 1973). Yet, the field has reached the stature of a scientific discipline with a primary focus on the first part of this definition—the determinants of population trends. The study of the consequences of population trends on society—the subfield often identified with the label, “Population and Development” has been a much more elusive topic for systematic and cumulative research. More than two decades ago, Ronald Lee (1983a), observed that there had been a decrease over the preceding 30 years in the number of papers presented at international population conferences on the socioeconomic consequences of population change and there was relatively little progress in the ideas, theories, data, and methods used by researchers in this area. My impression is that there has been only modest progress in the two decades since Lee’s observation. As the incoming president of the Population Association of America, I chair the program committee which is planning for the program for the 2005 meetings. Based on the history of the last few years, we will be lucky to have 3 or 4 sessions (out of 160 or so) under the rubrics of population and development or population and environment.

At first glance, this lack of momentum in research on population and development seems perplexing. One of the historical taproots of demography is in the works of Thomas Malthus and other classical economists who speculated about the impact of continuing population growth on agricultural production, the persistence of poverty, and mortality. Many students and researchers are drawn to the field of population as a result of exposure to neo-Malthusian ideas expressed by Paul Ehrlich and others who blame rapid population growth for poverty, underdevelopment, the exhaustion of natural resources, the degradation of the environment, and many other social ills (e.g. Morgan 2003: 589). Much of the funding for population research and training from foundations and governments has been stimulated, at least in part, by the presumed policy implications of population trends (Preston 1987). With this historical tradition, the natural interests of researchers, and the lure of support for research, the relative invisibility of research on the consequences of population trends is all the more surprising. Indeed, many of the most famous books that have attracted popular attention to the “population question” from Ehrlich’s

*The Population Bomb* to Joel Cohen's *How Many People Can the Earth Support?* have been written by non demographers.

The scientific field of demography, as with all empirical sciences, is driven by good theory, high quality data, and most of all by tractable research questions that lead to cumulative research. The study of the determinants of population trends has all three. Demographic transition theory, which has almost as many variations as there are sects of Christianity, has proven to be a remarkably fertile source of hypotheses about the effects of social change and modernity on fertility, mortality, and migration. Demographers have branched out to many new topics, and have made seminal contributions to research on the family, social mobility, race and ethnic inequality, residential segregation, health, and gender roles (Hirschman and Tolnay 2005). This is not the case, however, with research on the effects of population variables on economic development and the environment. There have been important books published, National Academy of Sciences reports, and even PAA presidential addresses on these topics, but my impression is that the goal of a cumulative model of empirical research has not been realized. In this review, I attempt to explain why research on the consequences of population trends is much more complex and difficult than research on the causes of population trends. I also try to summarize the major lines of research on the effects of population trends on economic development and the natural environment.

#### THE LACK OF A PARADIGM FOR POPULATION AND DEVELOPMENT

Research on fertility and mortality is largely driven by theories in the field of demography, and demographic transition theory, in particular. In addition to variations in theoretical formulations of the demographic transition, there is a world of data from the past and present to be explored and analyzed. With somewhat different findings from different empirical studies, the research literature is full of debate over methods and theoretical nuance that stimulates novices and experienced researchers. For example, Jack Caldwell has proposed the intergenerational transfers of wealth as a key determinant of fertility behavior, and Richard Easterlin has formulated a model of the supply and demand of births to explain why there is a lag in the fertility response (and sometimes even a rise) during the course of socioeconomic development (Caldwell 1976, Easterlin 1975). Another branch of demographic research, with more of a European flavor has

emphasized the role of ideas and culture in shaping fertility trends (Lesthaeghe 1883, Cleland and Wilson 1987, Watkins 1991). There are even several articles that attempt to reconcile all of the other contending perspectives within a broader theoretical tent (Hirschman 1994, Mason 1997).

Rising slightly above these debates, one sees a more or less common paradigm for research on the determinants of population trends. All researchers who seek to advance research on these topics read from and contribute to the same body of literature. Every demographer can instantly expound on the basic logic and standard criticisms of demographic transition theory, discuss the theoretical insights of Caldwell and Easterlin, and note the methodological problems that confront empirical research. The differences in theoretical nuance and analytical approaches create many exciting debates in the literature, but do not split the field into separate research communities.

This characterization of the field of modern demography does not extend to research on the consequences of population trends. The simplest explanation for this lack of unity is that the center of gravity for research on economic development (to take one example) does not lie in demography or even in the journals that are most likely to be read by demographers. There is not one school of research or paradigm on economic development, but many. Within the discipline of economics, there is not a consensus on a paradigm for research on economic growth, but rather there are multiple research exemplars. There are different theoretical and analytical approaches for micro and macro economists, the new growth theorists, and those who espouse a more institutional perspective. Economic historians, whose work is primarily focused on growth, operate as almost a separate discipline. Within the sociology of development, researchers are balkanized into mutually exclusive schools of modernization, dependency, world systems and neoMarxian approaches that seem to be driven as much by ideology as cumulative empirical research. Similar divides exist in geography and political science. For example, at my university, there are economists who study problems of economic development and change, but who reside in different departments and seem largely unaware and uninterested in each other.

Needless to say, there is no unified theory of economic development or even analytical models that are shared across different theoretical schools. This absence of a common perspective or paradigm makes it difficult for demographers (or any researcher) to make empirical or theoretical contributions. Without a cumulative research tradition, every researcher (or school of researchers) goes in their own direction with little motivation to speak to other research schools and to provide critical empirical tests of rival hypotheses (Hirschman 1981). The same problem exists for many other important issues, such as political development, ethnic violence, natural resources, environmental degradation, and many other topics on which there is considerable interest in the impact of population size and growth.

Schools of cumulative research develop when it is possible to test competing hypotheses, and all (or most) researchers acknowledge that their favored hypotheses (or variables) might be proven wrong, or at least less generalizable or parsimonious than competing hypotheses. My reading of the current state of the social sciences is that there are few broadly based paradigms that could provide an intellectual and institutional home for research on the impact of population attributes on societal outcomes.

The other fundamental problem is that research on the consequences of population trends usually means that societies (or other aggregates) over medium to long historical time periods are the units of analysis. Although there is a long tradition of aggregate and historical population analysis in demography, much of this work tends to be descriptive rather than of the hypothesis testing genre. With few observations for multivariate analysis, it is difficult to “prove” the determining impact of one factor on economic growth (and other aspects of social change) relative to other competing explanations.

#### CLASSICAL MODELS OF POPULATION AND ECONOMIES

There are multiple “conventional wisdoms” of the impact of population size and growth on the economy. Throughout most of history, and even to some modern eyes, a large and growing population was considered to be a sign of prosperity. This view was most forcefully challenged by Thomas Malthus, who wrote seven editions of his *An Essay on the Principle of Population*, first published in 1798 (Malthus 1960). Malthus invented the theory of the declining rate of

return for each additional unit of labor in an agricultural economy with constant technology. In an overpopulated rural economy with no reserve of cultivatable land, population growth leads to underemployment and an increasing fraction of the population is pushed into abject poverty. “Agricultural involution,” in Clifford Geertz’s memorable phrase, describes the condition where elaborate efforts are made to avoid the loss of even a single grain of rice and a culture of shared poverty characterizes village life.

If we can ignore the politics of Malthus (he was not an advocate of public relief for the poor) and the fact that he did not foresee the technological changes and demographic responses of the 19<sup>th</sup> and 20<sup>th</sup> centuries, his account was a fairly accurate portrayal of the demographic cycles of boom and bust that characterized much of premodern Europe and many other agrarian societies (Grigg 1980, Wrigley 1969). Without technological and organizational change, there were population ceilings for human communities within any bounded ecological niche. Mortality crises and population implosions were common events in many agrarian societies as a result of warfare, climatic change, and spread of epidemic disease, but they were more common in societies that were already weakened with populations that exceeded local food supplies.

There is a counter hypothesis to Malthus’s pessimistic account, namely Ester Boserup’s (1981) thesis that densely settled populations provide the motivation and resources necessary for technological breakthroughs. The pressures of growing populations have probably stimulated large scale migration around the globe, the origins and spread of agriculture, the shortening of the fallow, irrigation, and most other developments that we associate with civilization in traditional preindustrial societies.

If Malthus and Boserup point to opposite predictions of the impact of population on the economy of agrarian societies, who is right? It seems that both are (Lee 1986). There were probably many traditional societies that suffered from overpopulation and a few that were able to “move to the next level” as a result of population pressure. The few historical societies that did move to higher levels of agricultural productivity were the ones that were able to expand their populations and dominion, primarily through conquest, and laid the foundations of our modern world. Growth and expansion did not necessarily mean better lives for the people in such societies. Boserup and

other researchers have noted that peasants and workers in more developed agrarian societies probably worked longer hours, consumed fewer calories, were exposed to more infectious diseases, and suffered from more despotic rulers than people in less developed societies that practiced swidden agriculture and even hunting and gathering populations. Classical agrarian empires have left architectural and cultural legacies that modern societies romanticize, but the lives of their inhabitants were not ones that most of us would envy.

## MODERN THEORIES OF POPULATION AND ECONOMIC GROWTH

The primary focus of Malthus and Boserup was on premodern agrarian societies and with a time frame that spanned many decades if not centuries. What relevance do these perspectives hold for contemporary developing countries and for policy makers who are trying to weigh policies in slowing population growth (such as family planning programs) relative to other much needed investments in building roads, schools, and health programs? There are contemporary advocates of neo Malthusian beliefs, though contrary to Malthus, who believed nothing much could be done to lower high fertility, many contemporary neo Malthusians believe that public policies, even regressive and coercive policies should be used to lower fertility as quickly as possible. There is a broad range of neo Malthusians, ranging from the primarily polemical (such as the Paul Ehrlich of *The Population Bomb*) to demographers (Davis 1967) who believe the current world population is unsustainable.

There is also a small number of scholars and policy advocates who assume, following Boserup's arguments, that large populations will stimulate technological change and productivity. The most famous advocate of this position is the late Julian Simon, whose book, *The Ultimate Resource* (1981) argued that each person was a potential source of ingenuity and creativity. Societies with larger populations would be more likely to develop because of their larger number of potential scientists, inventors, and creative minds. Although there is intellectual merit in both the neo Malthusian and the Boserupian arguments, there is relatively little evidence offered by advocates on either side. The general style of argument is one of illustrative examples and extrapolation. There is, however, a small group of researchers, mostly economists and economic demographers who have made serious efforts to measure or simulate the impact of demographic factors on

economic development. These results have been mixed, and there is not a consensus of views among experts or policy makers.

The most primitive models simply posit a horse race between economic growth and population growth. If population growth is about 2 percent per year (very common in many developing countries in the post World War II era), then per-capita income will not rise (and may fall) unless the economy grows at a faster rate. Although population growth may be a drag on rising living standards, many developing countries in East Asia were able to make rapid progress over the last few decades by having economic growth rates of 6 to 8 percent per annum. The cross-sectional correlation between population growth and economic growth is close to zero (Kuznets 1967, Lee 1983b, National Academy of Sciences 1986).

The more sophisticated model of the relationship between population and economic growth focuses on the impact of age structure on savings. The most important research exemplar in this tradition was the 1958 book *Population Growth and Economic Development in Low Income Countries* by Ansley Coale and Edgar Hoover. High levels of fertility create a very youthful age structure with a high ratio of children to working age adults. Coale and Hoover coined the term “dependency ratio” to characterize this aspect of the age structure. If fertility were to be reduced, the change in the dependency ratio would allow for a substantial diversion of economic resources from the care and maintenance of children to productive economic investment. The greater economic savings would occur at the household level as families with fewer children could afford to invest in more education, and at the societal level with more state revenues becoming more available for investment in productive capital (infrastructure, factories, and research). The empirical evidence in support of Coale and Hoover were formal models or simulations that made assumptions about how different scenarios for declining fertility in India and Mexico lead to greater savings and higher economic growth. According to the assumptions, declining fertility would lead to more rapid economic growth.

The primary flaw in the dependency ratio thesis is the assumption that the proportional reduction in consumption with fewer children will be invested productively. It is quite possible that parents with three children instead of six children will simply change their consumption patterns rather

than save and invest the funds that were not spent on the three additional children. The distinction between consumption and investment is fuzzy at the household level because many poor parents may consider additional children to be an investment. At the societal level, any reduction in aggregate expenditures necessary to maintain a youthful population could simply be diverted to the military budget or extravagant state expenditures rather than making investments in roads, irrigation facilities, and higher quality education. The dependency ratio thesis also failed to gather empirical support from research conducted in the 1970s and 1980s that examined the relationship between family size and household savings and between national fertility levels and national savings rates (for a comprehensive review of the literature, see Kelley 1988).

By the late 1980s, the alarmist tone of much population policy discussion had begun to shift to a revisionist view that the effects of population growth on the economy were likely to be small (Kelley 2001). The revisionist view was exemplified by the 1986 National Academy of Sciences report which stated that “On balance, we reach the qualitative conclusion that slower population growth would be beneficial to the economic development of most developing countries” (National Academy of Sciences 1986:90). This is a very weak and qualified observation that led to a reduction in the political and policy priority on lowering population growth in order to boost economic growth in developing countries. The famous 1994 Cairo Population and Development Conference emphasized the priority of women’s reproductive health and gender equality as the most important policy goals, not lowering world population growth.

In the 1990s, there has been a shift back to the orthodox position that population growth has a negative impact on economic growth. This is exemplified by the 2001 collection of essays and empirical analyses in *Population Matters* (Birdsall, Kelley, and Sinding, 2001; in particular, see the introduction by Birdsall and Sinding). In their chapter in this volume Kelley and Schmidt (2001: 92) offer their assessment that changes in fertility and mortality from 1960 to 1995 have accounted for about 21 percent of the rise of approximately 1.5 percent per capita annual output for this period. This more positive interpretation of the significance of the salience of demography has been buttressed by several studies, which conclude that the East Asian economic miracle has been due in large part to the rapid growth of the labor force (relative to the

dependent population), which was caused by the rapid demographic transitions in these countries (Bloom and Williamson 1998; Lee Mason and Miller 2001).

These frequent oscillations in the prevailing scientific wisdom of the impact of demographic factors on economic development reflect the complexity of the problem as well as the larger debate over the causes of economic growth. Population growth creates more mouths to feed, but also more workers to produce. Larger populations, when weighed relative to fixed resources and capital, lead to lower per-capita welfare, but larger populations also create more demand and increased economies of scale. The negative and positive effects of population on the economy could cancel each other out. Moreover, there are numerous feedback loops between demographic variables and economic change. Households and firms may respond in anticipation of population pressures (or increased economic demand). The standard cross sectional research design of much empirical research may also be inadequate to capture historical processes in different times and contexts. It is remarkable that there is any agreement among researchers on the complex relationships between demographic factors and economic growth and development.

## POPULATION AND NATURAL RESOURCES AND THE ENVIRONMENT

There has also been a huge debate over the demands of population size and growth on the availability of food supplies, the exhaustion of natural resources, and negative externalities on the environment. Even more than the debate on the impact of population and the economy, the research literature and public discussion of the sustainability of the earth to support human populations of various sizes occurs beyond the boundaries of demography. Demographers have expertise in their own field—population dynamics and factors that influence population trends, but when the dependent variable shifts to topics in other sciences, such as soil erosion, future water supplies, or the carbon cycle, demographers have relatively little comparative advantage over other specialists. The one topic that demographers may know a bit more about than others is history. Current history (the last century or two) notwithstanding, human populations have always fluctuated with unpredictable events (wars, epidemics, etc.). This knowledge may make demographers a bit more cautious in making projections more than a generation ahead.

The natural limits to population size and growth has been a topic of recurrent interest to scientists and layman alike. At first glance the question seems to be a straightforward projection exercise. Since most natural resources are finite, and human population growth is not, the logical task is to compute how long it will take until (or what population size is reached before) natural resources are exhausted. Even for resources that may be considered renewable, such as cultivatable land, forests, and water supplies can also be exhausted under extreme population pressure (Hardin 1968). For example, annual cropping can lead to the exhaustion of soil fertility, excess cutting of young trees can lead to permanent deforestation, and the draining of wetlands and aquifers can create arid lands. The impact of human settlement has probably expanded natural deserts to lands that were formerly forested or grasslands in Africa and West Asia.

Generalizing from the past, even if formalized with mathematical projections and computer simulations, may not predict the future. There are feedback loops in any system, including human societies and economies. If a commodity or resource is in short supply, its value increases, promoting decreased consumption and the search for substitutes. For example, the switch from swidden agriculture to irrigated fields is probably prompted by the awareness that land and water must be conserved in order to increase production in areas where land is scarce. The beautiful terraced rice fields down the sides of steep hills in Java and Luzon are examples of peasant engineering to prevent soil erosion. The natural conservation methods of peasants around the world were incorporated into local cultures, presumably by trial and error by prehistoric peoples. Of course, there are many counter examples of when successive trials led to more and more human errors with disastrous consequences for the natural environment, mega fauna, and human populations.

Modern populations have some advantages and some disadvantages over their ancestors in managing their natural environments and resources. The major advantage is the accumulation of modern science and technology that allows for the creation of less expensive substitutes for resources in short supply. Knowledge of the past should also help human populations to avoid prior errors and to weigh short term gains against long term considerations. One major disadvantage is that the size and consumption demands of modern populations mean the time scale for trial and error has been dramatically shortened. In all likelihood, fossil fuels which

currently power the planet will be exhausted within a century or two. There is much more dependence on the wisdom of organizational and technological responses of a few societies at present than in the past when thousands of human societies lived in geographically isolated ecosystems.

Until the last decade, the literature on the effects of population on natural resources could be divided into two communities that had little contact with each other. Those who were primarily concerned about the exhaustion of natural resources—let’s call them the “pessimists”—could model the limits of sustainability and predict a doomsday scenario when the world’s resources would be exhausted. On the other side were the economists and historians—let’s call them the “optimists”—who would report that new sources of energy or resources would be discovered or invented. Since the exhaustion of wood for fuel was replaced by charcoal, and in turn, coal was discovered as a substitute for charcoal, followed by oil, natural gas and presumably by atomic and/or solar power, doomsday will never arrive.

There was actually a brief meeting of the pessimists and optimists when Paul Ehrlich accepted a bet with Julian Simon in 1980 over the future prices of natural resources ten years later (Tierney, 1990). Simon claimed that resources were infinite and Ehrlich claimed the exhaustion was likely. According to the terms of the bet, Ehrlich was able to choose any five metals, and the winner would be based on whether the inflation adjusted prices of the metals in 1990 were above or below their 1980 prices. Ehrlich chose copper, chrome, tin, nickel, and tungsten. The price of each metal in 1990 was below its nominal 1980 price and Ehrlich had to pay Simon \$576.00. Score one for the optimists. Although most people might be skeptical that a public wager between zealots is an appropriate test of alternative hypotheses, the academic debate has been only slightly more enlightening.

The field changed, however, with the publication *How Many People Can the Earth Support* by Joel Cohen in 1995. Cohen is a mathematician and biologist, and judging by the sentiments expressed in the concluding chapter of the book, his heart is with the natural scientists who fear that human population numbers are harming nature. His book, however, is pure logic, though tempered with an ability to entertain and educate the reader in the process. Cohen subjects the

many claims of authors who have attempted to address the question in the title in his book, to an in-depth analysis of their reasoning, assumptions, and methods. His sample of claims about the potential size of the human population begins with Leeuwenhoek in 1679 and covers almost 70 more projections and conjectures by scientists and national commissions, most of them from the late twentieth century.

The range of estimates of the “carrying capacity” (maximum population) of humans on Earth range from less than one billion to more than 1,000 billion people, with the majority of estimates around 8 to 64 billion. Interestingly, there is no trend in the magnitude of the estimates over time, and indeed there is much greater variability in the estimates in recent years—from incredibly high to well below the present world population (about 6 billion). There is no trend toward consensus among the experts.

Many of the estimates of the Earth’s carrying capacity are quite ingenious, with careful accounting for the quality of soils in different regions, the availability of water, and the demands of different types of crops. There is also great variability in the amount of food (and other resources) demanded by populations, depending on the type of diet, including the consumption of meat. However, there are many examples which illustrate how almost all of the estimates were heavily dependent on initial assumptions. In 1954, Harrison Brown reported that the world could support a population of 50 billion, but three years later, he estimated that the world could only support a population of 7.7 billion (Cohen 1995: 234). For the higher estimate, Brown assumed that algae farms could produce food, in the latter estimate he did not. Colin Clark, one of the most frequently cited authorities on the topic of sustainability, also offered two estimates of the maximum world population—the first of 28 billion and the second of 157 billion (Cohen 1995: 190-193). The differences were due to assumptions about cultivable land, productivity, and minimum living standards.

Perhaps the most celebrated case which Cohen investigates is the “system models” developed by Jay Forrester at MIT in the 1950s. These models were given wide publicity by the book *The Limits of Growth*, published in 1972 by a group of MIT researchers who were financed by the Club of Rome, an influential business and government group (Cohen 1995: 120-128). The book,

which sold 9 million copies and was translated into 29 languages, predicted a collision course between population growth and natural resources, which would lead to “overshoot and collapse” (also see Catton 1980). The complex system models that underpinned their simulations of population growth, resources, and industrial societies were built on very simplistic assumptions that were buried in appendices and computer code. Indeed, the birth rate projections were “made up’ and any undergraduate with one course in demography would have questioned their empirical validity.

The old joke about computers, GIGO (garbage in, garbage out) describes many of the large scale simulation models that attempt to model economic-demographic relationships. In a classic article, Arthur and McNicoll (1975) showed that the economic-demographic models used to persuade leaders of developing countries to adopt population control in the 1960s and 1970s were entirely determined by input assumptions. The complexity of the models was merely a smoke screen designed to obscure this central element.

Cohen does not answer the title question in his book, indeed, he concludes that it is impossible to answer the question because there are too many unknowns (however, see Holling 1994). He says that human choices about the quality of human life, the uses of technology, the nature of economic organization, and many other features of human societies may be more critical determinants of the size of future population size than physical or natural resources. Cohen makes a number of suggestions for the improvement of the human condition in his final chapter and calls for more realistic research on the relationships between population, culture, economics, and the environment.

## CONCLUSIONS

The field of population and development is at an impasse. There are probably important relationships between the size and characteristics of human populations and economic, political, and social features of societies. But, these relationships are very hard to pin down because population factors are intertwined with so many other macro level features that are part of complex structures and processes (Johnson and Lee 1987). Moreover, the standard multivariate research design that works so well with large samples of individual persons seems ill suited to

sort out historical patterns among small samples of countries that include contingences, porous boundaries among societies, and numerous feedback loops. These features, which are similar to those encountered in other macro level fields, raise important questions about the appropriate research design.

An additional problem has been that ideology, often under the cover of science, has had a disproportionate influence on the study of population and socioeconomic development and on the relationship between population and the natural environment. This problem is hardly unique. The fields of criminology, international relations, and many others have received considerable attention and additional resources because of their connection to public policy. In most cases, there are self correcting features built into the nature of scientific debate and empirical research. In spite of the popular neo Malthusian assumptions of some research sponsors, most demographers and the field as a whole remain agnostic on the impact of population on economic development. However, Kelley (2001:48-50) documents the strange case of the 1971 National Academy of Sciences report on Rapid Population Growth. The anonymous author of the first volume largely ignores the detailed analytical research in the second volume and makes a one sided case for the adverse effects of population growth.

Joel Cohen's tour de force has had an important corrective impact on popular (and much academic) thinking, which assumes that population growth is the single most important factor affecting the human survival. Population trends are very important factors shaping human societies, but the impact of population is generally intertwined with many other societal and economic factors, such as taxation levels, trade, government policies, and technological change. This does not make population factors any less significant, but just more difficult to investigate.

Perhaps, the conclusive research on population and development will be done by demographic historians with the added perspective that temporal distance (and additional data) permits. Since many effects do not occur immediately, the opportunity to examine historical trajectories provides an important corrective to the standard cross-sectional research design. For example, the rapid declines in fertility in developing countries that began in the 1970s and 1980s were not immediately apparent to researchers at the time. Research on the pace of contemporary fertility

transitions and the span of years before reaching replacement level fertility must await their completion. Although scholarly attention may wane, the scientific task remains. Just as economic and social historians are still working on the causes and consequences of the industrial revolution, perhaps demographic historians will be the final judges of the impact of population trends on the course of social change in the twentieth century.

One of the most useful paradigms for research on the determinants of population trends has been accounting frameworks, such as the population balancing formula ( $P_2 = P_1 + B - D$ ), and Bongaarts decomposition of the changes in fertility into components representing changes in marriage, breastfeeding, contraceptive use, contraceptive efficacy, and abortion (Bongaarts 1978). Using a similar logic of decomposition, Bongaarts (1992) estimated the effect of population growth on global warming with a formula that included changes in per-capita income, energy consumption, and carbon emissions from fossil fuels. A similar logic is illustrated in the IPAT accounting framework, in which the environmental impact (I) is a function of population (P), affluence (A) and technology (T) (Pebley 1998, York et al. 2003).

The development of “middle range” hypotheses in the field of population and aging may be an instructive example. The implications of changes in age structure for human societies has become one of the most vibrant and productive branches of demography and related social sciences. When the field first captured popular and policy attention several decades ago, there was really no paradigm for demographic research on population aging. Many studies would simply project the absolute and relative size of the elderly population for future years and offer speculations on the implications for medical care, social security, and other age-dependent phenomena. Although such research filled an informational need, the field lacked big ideas and a framework for cumulative research.

Over time, demographers in the field of aging were able to identify key problems that linked aging research with mainstream disciplinary questions. For many social demographers, the study of aging was encompassed within the field of family research and the study of living arrangements. For example, do the elderly remain in their own homes after the death of their spouse, or do they move in with their adult children? Who is institutionalized and for how long?

What sort of exchanges and intergenerational support occur among non co-resident elderly and their adult children? Since household structure and family support represent costs to be born by individuals or by society at large, there are enormous policy implications. Moreover, the study of intergenerational resource flows is an important window to study the structural and cultural features of modern families in different societies and cultures—a topic of great interest for basic research on the family.

Many economic demographers have emphasized the process of retirement as a key element of research on aging. The questions of how couples coordinate the timing of joint or separate retirement, the impact of pensions, social security and other financial considerations on retirement, and the impact of retirement on health and happiness are the sorts of empirical questions that stimulate research. Research on these questions speak to policy issues and also relate to important theoretical questions in micro economics.

The development of a paradigm(s) in population and aging research was not immediate or automatic. By linking the aging field to research topics for which there are interesting hypotheses, good data, important policy considerations, and disciplinary insights, cumulative research traditions and paradigms begin to emerge.

The transformation of the field of population and aging from a “problem” into a research paradigm offers an instructive lesson for the field of population and development. There are many middle range hypotheses that could be pursued with micro level data that speak to some of the broader questions of socioeconomic development. One possibility might be studies of migration and employment. Development creates uneven spatial patterns of new opportunities that induce people to move from one area to another and from one sector to another. In the population and environment field, research on exposure to toxic substances and the subsequent health outcomes would be an ideal topic for which there is tremendous policy interest as well as emerging research paradigms. Perhaps it may be possible to create a more cumulative traditions of research on population and development.

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