FERTILITY TRENDS AND IMPLICATIONS

Hans-Peter Kohler

Department of Sociology and Population Studies Center, University of Pennsylvania, Philadelphia, PA 19104-6299, USA

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1. Introduction

Fertility decline and fertility change in both developing and developed countries is a social change of essential importance, encompassing human relations and conditions at almost any level of society. The divergence of mortality and fertility levels in the 2nd half of the 20th century has given rise to a rapid growth in the world population. More recently, below replacement fertility has spread from developed to developing countries, and in some developed countries, very low fertility has emerged as a prominent policy concern. In all contexts, fertility change and the associated alleged "population problems" of rapid population growth (in developing) and rapid population aging (in developed and some developing) countries have featured prominently in scientific and popular debates about fertility change and its demographic and socioeconomic implications. In these debates, fertility change is perceived as a central issue in a range of global and national concerns including economic growth, global resource distribution, the decline of families (or not) and intergenerational relations, well-being and health, sustainable development, and national and international political representation. At the same time, the fertility change underlying these problem has puzzled generations of researchers: alarmist perspectives, pessimism, optimism and revisionism have characterized the tides of the population debate in both developing and developed countries. Moreover, as the world populations have entered the 21st century, the new challenges presented by very low fertility and its implications for the family and population aging have reinvigorated research on fertility—but without necessarily resolving long-standing differences in the assessment of the causes, implications and policy responses to fertility change. These diverging assessments are in part due to the fact that considerable controversy exists among demographers, economists and sociologists over the causes of fertility change. New data and empirical analyses of both historical and contemporary fertility declines have weakened the standard theory of demographic transition, and the rise of low—and in particular, very low—fertility has challenged many theoretical frameworks that provided the workhorses of theorizing about fertility change during the 2nd half of the 20th century. Despite a plethora of new theories of fertility change, none has emerged as hegemonic or as an alternative guide to empirical research or population policy. Not surprisingly, the opinions about the long-term implications of fertility change and the need for policy intervention are inconclusive.

2. Fertility trends: past and present

Fertility transitions, including those still in process in the developing world, are frequently perceived as resulting from the economic and technological changes of the modern era that have led to economic development, mass communication, effective programs of public health, availability of contraceptive methods and related social changes. Yet demographic change is not merely a movement from ignorance to knowledge, from primitive to ever more effective forms of contraception. Modern fertility theories are based on the premise that the idea of fertility control was rarely absent, even in historical societies. However, the motivations to act on such ideas varied owing to exogenous and endogenous changes in the economic and social environment. For instance, the knowledge and concerns of the ancient Greeks with respect to progeny, fertility regulation and population size are well known. Plato (1942, 5.740), aware of the responsiveness of fertility to varying incentives, for example stated: "if too many children are being born, there are measures to check propagation; on the other hand, a high birth-rate can be encouraged and stimulated by conferring marks of distinction or disgrace".

Numerous anthropological studies have linked the need for long-term survival of the population, the environment and history of a society to specific practices of abstinence and breast-feeding, to marriage patterns and the use of birth control methods. The classic articles on "intermediate variables" (Davis and Blake 1956) and on "proximate determinants" (Bongaarts 1978) provide conceptual and analytical frameworks for the incorporation of these sociobiological factors in the fertility determination process. They fall short, however, of a predictive theory of demographic change. These conceptual frameworks neither explain the origins of the social and cultural factors that constrain fertility in traditional societies, nor do they provide guidance about the evolution of these norms and customs. This lack of a dynamic perspective is unfortunate, since even in pre-transitional populations the social context of fertility decisions has varied tremendously over time and space. It changed with trends in culture, religious and political influences; it was affected by technological progress; innovations or discoveries; and it evolved through social and cultural adaptation. Despite these variations, it is remarkable that population growth rates for most (surviving) societies were relatively modest over much of human history. Preceding the Neolithic Revolution (approximately 10,000 BC) the average long-run net reproduction rate was near unity, to within a few ten-thousandths. Between the Neolithic Revolution and 1750 AD the world population grew from 6 million to 771 million, which implies a very moderate average annual growth rate of 0.04%. Short-term fluctuations around this trend are well documented and undoubtedly existed. Yet, the low long-term growth rates, that prevailed despite large variations in reproductive environments and mortality conditions, strongly suggest the existence of an equilibrating mechanism between population size and available resources: population homeostasis.

This homeostatic theory was first devised by Malthus (1798) on the strength of three basic economic relationships he identified in pre-industrial England. On the one hand, when real wages fall below some subsistence level, mortality increases. On the other hand, when real wages increase, marriage is encouraged. In addition, agricultural production faces diminishing returns to labor. Given marital fertility control, increases in the duration of marital unions have a predictable positive effect on fertility levels. This results in a dual microeconomic relationship between population growth and the wage rate, operating through an economic-institutional marriage function and an economic-biological mortality function. When shocked from equilibrium, there is a tendency for wages to adjust in the opposite direction of population size. Over time society converges again to a "natural wage" at which population growth is either zero or equals a rate exogenously determined by productivity growth. Malthus assigned greater weight to the "positive check" operating through mortality as the long-run mechanism governing population growth. He believed in a "passion between the sexes" that prevents individuals from exercising "preventive checks", which could improve their well-being through a voluntary restriction of fertility. Demographic and economic evidence is largely consistent with the homeostatic theory for England from about 1250 to 1700 (Lee 1980). Wages are inversely related to population size. But even in preindustrial societies, the preventive check on population growth via fertility occupied a central place, while the positive check operated relatively independently of wage rates.

With the beginning of the Industrial Revolution in England, however, these relationships unmistakably altered: population growth accelerated, and wages nonetheless continued to increase. The homeostatic relationship between population and wages disintegrated. During the nineteenth century in Sweden, for instance, Schultz (1985) finds no more obvious relationship between increases in population and decreases in real wages. One interpretation of the evidence is that improvements in technology and non-labor factors of production started to grow more rapidly than did population, despite the acceleration in the population growth rate itself. In the late 19th and early 20th century, the mortality decline that was driving the population growth during the demographic transition in Europe was followed by fertility decline (Coale and Watkins 1986). During the first quarter of the twentieth century, the descent was so steep that by the 1920s more than half of Europe's population was living in a country exhibiting sub-replacement fertility (van Bavel 2009). This experience of European countries gave rise to a highly stylized description of the big demographic changes since the late 18th century that became known as the "Demographic Transition", which described the basic thread of the demographic changes as a shift from a population equilibrium with relatively high mortality and fertility to a new equilibrium with low mortality and fertility. After the transitional stage, fertility was expected to oscillate around the level of replacement and, consequently, birth rates were expected to converge towards death rates. However, this equilibrium of fertility and mortality rates remained—and continues to remain—elusive. In the interwar period in Europe, below replacement fertility became widespread as a new demographic pattern. Below-replacement fertility is defined here as a combination of fertility and mortality levels that leads to a negative population growth rate and a declining population size in a closed stable population, and it is generally not tied to a specific total fertility rate. Equivalent definitions of below-replacement fertility include: the number of deaths exceeds the number of births, the size of the birth cohort declines over time, the life-expectancy is below the inverse of the crude birth rate, and the net reproduction rate (*NRR*) is below one.

The below replacement fertility levels in the interwar period in Europe gave raising considerable concern about depopulation (Teitelbaum and Winter 1985). After WWII, the postwar baby boom reversed this period of sub-replacement *TFR* levels in Europe, and it reversed periods of relatively low fertility in the U.S. and elsewhere. Subsequent to the baby boom that has been discussed extensively elsewhere (e.g., Macunovich 2002), a renewed and very widespread decline of fertility was initiated in Western Europe, North America and other developed countries. Low fertility subsequently spread rapidly, and fertility levels often declined substantially below a level of 2.1, i.e., the *TFR* level that has de facto been accepted by demographers as the reflecting the fertility level required for long-term population replacement in contemporary contexts of low mortality and high life-expectancy. As a result, virtually all developed countries exhibit below-replacement fertility or close to replacement fertility in 2007–08 (Figure 1). Exceptions include, for example, Israel with substantially above-replacement fertility and the United States as the major developed country with a *TFR* near replacement-level fertility.

[Figure 1 about here.]

During the 2nd half of the 20th century, fertility trends—of what became known as the "global fertility transition"—followed a broadly similar pattern to that observed during the demographic transition in Europe, leading to a rapid decline across many countries and contexts. The extent of this global fertility transition has made population stabilization by the middle of the twenty-first century a reasonable forecast (Morgan 2003), and analyzing the 2000 UN forecasts, Morgan (2003) concludes that only 16 (of a total of 187) countries—with only about 3% of the global population—show not yet a clear evidence of a fertility transition in the early years of the 21st century. In contrast, there are 64 countries with fertility at replacement level or lower, and 23 countries (with 25% of global population) are listed as having made the transition to low fertility (*TFR* levels between 2.1–3). Of the 105 countries that are classified by Morgan as experiencing fertility transitions, 96%

have attained their lowest recorded fertility in the last year of observation, and only two countries have halted their transition at a fertility level that is substantially above replacement (at *TFR*s of 2.5 to 3.0).

Despite this widespread occurrence of fertility declines, and the widespread rise of low fertility, the patterns of fertility declines—and the associated socioeconomic and policy challenges—continue to be manifold. At one end of the spectrum, several developing countries have attained very low—and sometimes below-replacement—fertility levels, with total fertility declining within a few decades by three, four or more children per women. These fertility declines often occurred within short periods (UN World Population Prospects, 2008 Revision): in Bangladesh, the *TFR* declined from 6.7 to 2.8 during the early 1950s to 2000–05; in China, *TFR* dropped from 6.1 to 1.8 during this period; in Korea, the *TFR* fell from 5 to 1.2, and perhaps most strikingly, total fertility rates declined in Iran from about 7.0 in the early 1950s to replacement level in 2000–05. Moreover, because of the rapid pace of past fertility declines in these countries, population aging will occur relatively fast, and these countries will have to quickly adjust—often with more limited resources that developed countries—to a new demographic reality of near- or below-replacement fertility, high longevity and rapid population aging. While the combination of low fertility and low mortality may have given rise to a "demographic dividend", the longer-term consequences of rapid population aging as a result the swift transition from relatively high to relatively low fertility are likely to be significant.

[Figure 2 about here.]

Figure 2 depicts the past and future *TFR* trends across developed and less developed countries, including separately also sub-Saharan Africa. These forecasts reflect—consistent with broad consensus among demographers—that fertility declines that have been initiated will continue to progress, and that the remaining regions with relatively high fertility—which are concentrated in sub-Saharan Africa and often including the world's least developed countries—will experience fertility substantial fertility decline in the future. However, despite the projected declines in fertility (Figure 2), relatively high fertility and rapid population growth is likely to persist for several decades in the least developed countries. The pace of fertility declines in these countries thus has substantial effects for the long-term population size in the least developed countries, and the world more generally, and continued (or even renewed) attention to the determinants and consequences of, and possibly policy interventions targeted at, these relatively high levels of fertility may be warranted. Moreover, in sub-Saharan Africa, relatively high fertility co-exists with a severe HIV/AIDS epidemic that has resulted in increasing mortality rates and significantly depressed life expectancy levels. The HIV/AIDS epidemic may alter the prospects of future fertility declines, and rapid population growth is likely to continue in sub-Saharan Africa in the next decades despite the HIV/AIDS epidemic (Bongaarts 2009).

While there is a clear negative association in 2005 between the level of human development (as measured by the UNDP Human Development Index) and the level of the total fertility rate for all but the most developed countries (Figure 1), the heterogeneity of fertility rates at the various development stages is striking. On the one hand, a new phenomenon of recent years is that low fertility in 2005 is no longer restricted to the most developed countries: *TFR* levels of below 2.1

are achieved at 2005 *HDI* levels as low as .7, and *TFR* levels of below 3.0 are attained by countries at 2005 Human Development Index (*HDI*) levels of .55. Equally striking is the heterogeneity of fertility levels that are associated with all but the lowest levels of development. For example, countries with a 2005 *HDI* of .4–.6 exhibit *TFR* levels ranging from 3 to 7.1 (mean is 4.7), and *TFR* levels range from 1.2 to 5.9 among countries with a 2005 *HDI* of .6–.8 (mean *TFR* is 2.6).

The extensive studies that have investigated both the European and global fertility transition tend to highlight several key features of the fertility change during the demographic transition: its rapid pace and "period" character; its relatively "loose" temporal connection to many other measures of social, economic, and demographic change; its path-dependent character; and by all indications its inevitability in economically advanced societies (e.g., Bongaarts and Watkins 1996; Cleland 1985). First, once initiated, the fertility decline tends to be rapid and generally occurs across a broad age group and across many socioeconomic groups. Fertility change during this transition thus does not occur via a process of cohort replacement, but by relevant cohorts changing behavior relatively simultaneously. The second feature, loose temporal connections to other aspects of social change, manifests itself in the considerable heterogeneity of fertility levels at various stages of development (Figure 1), and this loose connection between fertility and other socioeconomic changes reflects the more cumulative basis for changes like increasing school enrollment or increased economic productivity. Finally, all evidence points toward the inevitability of low fertility in economically advanced societies. Specifically, once declines have begun they rarely pause until low levels have been reached, and no economically advanced society has high fertility. The earlier distinct fertility regimes, "developed" and "developing", have also increasingly disappeared in global comparisons of fertility levels as countries across a broad range of development stages have attained below-replacement fertility (Figure 1), and the majority of the world's population is likely to live in areas with *TFR* levels below 2.1 in 2010. Several aspects are particularly striking in this context. First, the spread of below-replacement fertility to formerly high fertility countries occurred at a remarkably rapid pace and implied a global convergence of fertility indicators that is quicker than the convergence of many other socioeconomic characteristics. Second, earlier notions that fertility levels may naturally stabilize close to replacement level have been shattered. In the early 1990s, for instance, Italy and Spain attained *lowest-low fertility levels* defined as a *TFR* below 1.3. At the end of the 1990s there were 14 lowest-low fertility countries in Southern, Central and Eastern Europe and several lowest-low candidates including Germany, Japan and S. Korea (Kohler et al. 2002a). Third, the focus on national-level *TFR* levels in the previous discussion, masks the considerable variation in fertility levels within populations, and the inter-individual diversity in fertility according to the parity distributions of women. For example, Shkolnikov et al. (2007) estimates that, for the 1960 cohort in (west) Germany, a country with one of the highest concentrations of childbearing in contemporary Europe, nearly a quarter of German women remain childless and about a quarter of German women have half of all children. Moreover, comparing 18 European countries and the US, the study also reveals a reversal in the long-term decline in the concentration of reproduction, and that institutional factors—including marriage patterns and labor market conditions—leave strong imprints on the extent to which fertility is concentrated in more recent cohorts. Fourth, there has been a remarkable divergence in the fertility levels of developed countries, ranging in the late 1990s from lowest-low fertility to *TFR* levels at or moderately below 2.1. For instance, the *TFR* in the United States has reversed from a trough of 1.74 in 1976 and reached levels above 2.05 in the late 1990s, where the *TFR* has been relatively stable since. Similarly, *TFR* levels in the Netherlands, Denmark, France and several other countries have recovered and stabilized at levels between 1.7 and 1.9. Fifth, in the first decade of the 21st century, there has been a widespread increase in total fertility rates in developed countries, including countries that experienced lowest-low fertility during the 1990s (Goldstein et al. 2009) and countries that with relatively high *TFR* levels for developed context (Myrskylä et al. 2009), thereby reversing some of the historically low levels of *TFR* that were observed in Europe towards the end of the 20th century. Early in the 21st century, Asian countries—in particular S. Korea and Japan and some Central and European Countries—exhibit some of the word-wide lowest *TFR* levels.

The combination of the above four patterns has resulted in a reversal in the well-established relationship between development and fertility in recent years. In particular, while development continues to promote fertility decline at low and medium levels of *HDI* (Bryant 2007), Myrskylä et al. (2009) suggest that at advanced *HDI* levels, further development may reverse the declining trend in fertility. The previously negative development–fertility relationship has become J-shaped in the early years of the 21st century (Figure 1), with *HDI* being positively associated with fertility in 2005 among highly developed countries. Despite these recent increases, however, fertility levels remain very low—and substantially below replacement level—in many European countries. Moreover, the divergence of fertility levels in developed countries has been accompanied by a disruption or even a reversal of many well-known associations between fertility and related behaviors. For instance, the cross-sectional correlations in European or OECD countries between the total fertility level on the one side, and the total first marriage rate, the proportion of extramarital births and the female labor force participation rate on the other side have reversed during the period from 1975 to 1999 (Billari and Kohler 2004; Brewster and Rindfuss 2000). At the end of the 1990s, there is also no longer evidence that divorce levels are negatively associated with fertility levels. Hence, there have been crucial changes in the relationship between traditional determinants of fertility—such as marriage, divorce, home-leaving and female labor force participation—and perhaps more importantly, there is a clear indication that a high prevalence of marriage and institutionalized long-term partnership commitments are no longer associated with higher fertility in cross-sectional comparisons among European countries. This reversal in cross-sectional associations between fertility and related behaviors is in part due to the different demographic factors driving fertility change. Initially, the decline towards low fertility has been importantly related to stopping behavior, that is, a reduction of higher parity births. More recently, the postponement of fertility—particularly for first births—has emerged as a crucial determinant of differences in fertility levels among developed countries (Sobotka 2004). For instance, during the period 1980 to 1999 the period mean age at first birth increased from 25.0 to 29.0 years in Spain, from 25.7 to 28.7 years in the Netherlands, whereas in the U.S. it has increased from 22.0 years in 1972 to 24.9 in 2000.

The implications of population aging, and the societal changes associated with the these recent fertility declines are going to be most pronounced in countries with very low fertility. These countries are likely to experience a dramatic transformation of their age pyramids, and the social and economic organization of individuals and families in these highly-aged societies is an unchartered territory in demographic history. The implications of this changes will reach across all aspects of society and individual lives. For example, the lowest-low fertility that have been observed in Europe during the 1990s, and continue to be observed in some Asian countries, are going to substantially alter the structure and age-composition of the labor force as well as of the young and old population, and female—and probably also male—labor supply patterns will change due to the combination of low and late fertility. Very low fertility will also transform a wide range of social relations, which are frequently taken for granted, due to the fact that low fertility, fewer siblings and increases in childlessness diminish the potential of family networks to provide social, psychological and economic support. The increased diversity in living arrangements and the changes in the timing of fertility have also important consequences for the income distribution, the well-fare of small children, and the life-chances across individuals and households.

In light of these trends for many European countries, it is important to ask "why are the United States so different in their fertility rates?" One might argue that the U.S. fertility trends simply trails behind Europe and Japan, and that the *TFR* in the U.S. will fall to historically low levels in future years, as occurred for so many wealthy countries in recent decades. However, the situation of the U.S. compared to most other high-income countries differs in at least two respects (Technical Panel on Assumptions and Methods 2003). On the one hand, the U.S. population composition favors a higher fertility level, since some of the largest immigrant and minority groups within the U.S. have fertility levels that lie above than the national average. However, and particularly surprising in light of the relatively weak government support for children, fertility in the U.S. is relatively high for the population as a whole. Notably, the *TFR* of non-Hispanic White women, falling in a range from 1.77 to 1.87 during 1990–2001, exceeds the national average for most other high-income countries. While the heterogeneity of the U.S. population is therefore one factor that contributes to the relatively high level of fertility in the United States, it does not constitute the primary explanation. Instead, it appears that an overriding factor is their greater ability to combine work and childbearing, thanks to a variety of institutional factors (Morgan 2003). The importance of this situation is reflected in the positive relationship between measures of women's labor force activities and levels of fertility across wealthy countries that has been mentioned above, and as a result, despite a lack of a generous public financial support for families with children, it appears that the flexibility offered to individuals through the market in the U.S. facilitates integration of work and traditional family life. The way to reconcile this interpretation with the leading theoretical frameworks for explaining fertility, however, is not immediately obvious: traditionally, female labor force participation has been associated with lower fertility, and increases in female education and human capital—which often underlies the high rates of female labor force participation—is usually thought as one of the primary driving forces leading to reduced fertility.

3. Theoretical frameworks

As illustrated in the above discussion, theoretical frameworks explaining fertility change and variation face a substantial challenge in explaining the considerable variation in fertility levels over time and with development, the substantial cross-sectional variation in *TFR* levels across both developed and developing countries, and the considerable heterogeneity of fertility levels within countries by socioeconomic, ethnic/racial or religious groups. In addition, the theoretical frameworks for explaining fertility are increasingly confronted with more sophisticated micro-data that captures not only the socioeconomic and lifecourse contexts of individuals and couples in greater detail, but increasingly also extends beyond the domain of socioeconomic data and integrates aspects of biology and genetics. In this section we therefore review some of the existing theoretical frameworks for fertility research, starting with the basic concept of fertility decline as formalized in the Demographic Transition Theory and then covering economic, evolutionary and sociological theories, and ending with a new integrative framework for fertility research. Related reviews and discussions, on which the presentation in this chapter partially builds, include for example Bulatao and Casterline (2001), Caldwell and Schindlmayr (2003), Hirschman (1994), Johnson-Hanks et al. (2009), Lee (2003), Mason (1997) and Morgan and Taylor (2006).

3.3. Demographic Transition Theory

The occurrence of rapid demographic change—including substantial declines in both mortality and fertility levels—during the process of socioeconomic modernization during the 19th and early 20th century led to the formalization of the demographic transition theory. The basic idea is that socioeconomic development first induces a mortality decline and, with some lag, a decrease in fertility. The easiest way to summarize this theory is to quote from one of its formulators:

> [Premodern birthrates in Europe] . . . were high by present standards. Indeed, they had to be high [in face of the inevitably high mortality]. . . . Peasant societies in Europe, and almost universally throughout the world, are organized in ways that bring strong pressures on their members to reproduce. The economic organization of relatively self-sufficient agrarian communities turns almost wholly about the family, and the perpetuation of the family is the main guarantee of support and elemental security. . . . In such societies, moreover, there is scant opportunity for women to achieve either economic support or personal prestige outside the roles of wife and mother, and women's economic functions are organized in ways that are compatible with continuous childbearing.
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> These arrangements, which stood the test of experience through-out the centuries of high mortality, are strongly supported by popular beliefs, formalized in religious doctrine, and enforced by community sanctions. They are deeply woven into the social fabric and are slow to change. Mortality dropped rather promptly in response to external changes because mankind had always coveted health. The decline of fertility, however, awaited the gradual obsolescence of age-old social and economic institutions and the emergence of a new ideal in matters of family size.
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> The new ideal of the small family arose typically in the urban industrial society. . . . Urban life stripped the family of many functions in production, consumption, recreation, and education. In factory employment the individual stood on his own accomplishments. The new mobility of young people and the anonymity of city life reduced

> the pressures toward traditional behavior exerted by the family and community. ... Education and a rational point of view became increasingly important. As a consequence the cost of child-rearing grew and the possibilities for economic contributions by children declined. Falling death-rates at once increased the size of the family to be supported and lowered the inducements to have many births. Women, moreover, found new independence from household obligations and new economic roles less compatible with childbearing. ... Under these multiple pressures old ideals and beliefs began to weaken, and the new ideal of a small number of children gained strength. (Notestein 1953, pp. 16-17)

The corpus of this theory is very broad. It entails the central role of norms and their erosion, the emergence of rational fertility decisions, and the changing socioeconomic environment. The demographic transition theory has room for almost any variable. As a descriptive tool, the theory provides a framework to "rationalize" demographic change. The question is, how well the theory performs as a predictive tool that allows the analysis of fertility behavior in a positive sense, and that establishes a firm link between modernization and demographic change.

Over the past few decades, intensive research on fertility change in historical and contemporary societies, and in developed as well as developing countries, has revealed complex patterns that do not fit neatly into this theoretical schema. The transition theory neglected the subtleties and variability of the process, and it became increasingly perceived as overdetermined. The lack of theoretical understanding of this process is disconcerting. First, a large number of fertility transitions in developing countries—including, especially, sub-Saharan Africa countries—are still in process, and in some areas a substantial decline in birth and population growth rates is yet to occur before fertility rates reach or fall below replacement levels. Second, only fertility theories that can explain both the fertility declines during the demographic transition and the variation and trends of fertility within and across developed countries are serious contenders for providing a satisfactory framework for fertility change.

One of the central challenges to the notion of fertility change as formulated in the demographic transition theory is due to Coale (1973, p. 65), who concluded, based on analyses of fertility decline in Europe, that "[t]he diversity of circumstances under which marital fertility has declined, and the consequent difficulties of formulating a well-defined threshold, may originate in the existence of more than one broad precondition for a decline". Coale thus identified three preconditions for a major fall in marital fertility: (*i*) fertility must be within the calculus of conscious choice; (*ii*) reduced fertility must be advantageous; (*iii*) effective techniques of fertility control must be available. These conditions are not so much a predictive tool as an integrative device for discussing the approaches of different behavioral schools. Demand theories, such as the demographic transition theory and economic approaches to fertility, have traditionally taken the first and third condition as granted, and analyzed fertility behavior as an adaptation to changing environmental conditions. Ideational and diffusion approaches, on the other hand, emphasize the first and third factor. They interpret conscious fertility control within marriage as an innovation and focus on the diffusion or acceptance of this behavior. Supply theories emphasize the role of the third factor, the availability of methods to control fertility and the biological context of reproduction. These theories are broader than the individual-centered economic approaches, but more detailed than the macro-theories of the demographic transition.

3.3. Economic approaches to fertility

The economic approach to fertility is usually associated with the "new home economics" initiated by Gary Becker (e.g., Becker 1991). The scope of the new economic approach to household behavior reaches far beyond fertility. At the same time, the demand for children and its interaction with related household decisions constitutes a central concern throughout the new home economics literature, and is an important question that continues to stimulate further empirical and theoretical developments. As currently employed, most household models for the demand for children share certain features (Schultz 1997). First, the traditional money income budget constraint is replaced by a time budget constraint, and considerable attention is devoted to the allocation of time between market labor supply and non-market activities, especially for women. Second, demographic and economic behaviors depend on the household stocks of human and physical capital, and differences across individuals in their relative advantages of engaging in specific market or non-market activities are an important determinant of a household's time allocation. Third, many models for the demand for children incorporate an explicit life-cycle perspective. Choices of individuals about human capital accumulation, marriage, saving, etc., are therefore considered as interrelated decisions that need to be investigated jointly.

In a simple and commonly used framework of the demand for children, parents are assumed to maximize lifetime utility, which depends for example on the number of children (child quantity), the education and health of the children, (often referred to as the child quality), the leisure activities of the husband and wife, and other consumption goods. Each input into the utility function can be thought of as being produced within the home by combining both non-market time of the household members and market goods according to a constant returns to scale production function. Except for the integrated supply-demand framework by Easterlin and Crimmins (1985), the production function for children in the classic new home-economics models does not include limitations to the "supply" of children due to fecundity, mortality and child survival. The allocation of each individual's time is usually mutually exclusive and subject to an overall time budget constraint. Market income is equal to lifetime wage rate, received by each member of the family, times their market labor supply (plus additional non-labor income). The shadow prices of the above commodities are then defined as the opportunity costs of market goods and the household member's time inputs used to produce one unit of the commodity.

The optimal choice of children, consumption, as well as the optimal allocation of time and market goods to the various activities results in the above framework from utility maximization within the time and money income budget constraint and given prices and wages faced by the individuals in the household. Moreover, the framework assumes that the family can be approximated as a unified optimizing consumer without detailed attention to the decision-making processes within the household. For example, one of the strong empirical relationships in developing countries that has received considerable attention from this perspective of how opportunity costs shape fertility outcomes, is a negative association between mother's education and children ever born (Caldwell 1980; Kravdal 2002; Schultz 1997). Using aggregate data in developing countries, for example, Schultz (1997) finds—consistent with the implications of the new home economics—that male education and income from non-human-capital sources are associated with higher fertility. Kravdal

(2002) also suggests that education effects on fertility exist not only at the individual-level, but also at the community level net of urbanization and her own education. Rosenzweig (1990) and Rosenzweig and Wolpin (1980) provide evidence for the quality-quantity trade-off in developing countries by utilizing exogenous variations in the wage of children to infer child-costs and the incentives for child-quality versus quantity, or using twin births as a natural experiment. Evidence for this trade-off is also found in the US by Hanushek (1992), using scholastic performance as an indicator for child-quality, although some newer studies using gender composition for the first-born children as instruments for overall fertility, have found negligible quality-quantity trade-offs in some developed countries (Black et al. 2005). Kravdal and Rindfuss (2008) also provide evidence that the negative relationship between fertility and education has been weakened: drawing on the Norwegian population registers for cohorts born 1940 to 1964, for example, the relationship between completed fertility and educational level attained at age 39 has become substantially less negative for women, and for higher order birth rates, the negative effect of education on birth rates—net of the impact of later motherhood—has disappeared.

Relatively few dynamic models exist that investigate explicitly the spacing of children over the life-cycle in a utility maximizing framework with sequential decisions. Exceptions are for instance Cigno (1991, ch. 8) and Gustafsson (2001) who derive the optimal spacing or timing of children over the life-cycle. The nature of the problem makes it almost unavoidable to consider explicitly uncertainty and learning from experience. For instance, individual learning about fecundity has been shown as an important factor in the determination of fertility (Rosenzweig and Schultz 1985), and uncertainty about socioeconomic conditions during early adulthood has been shown to be an important motivation to delay childbearing (Bernardi et al. 2008; Johnson-Hanks 2006). However, within economic life-cycle models, the formal complications make the theoretical results on the timing and spacing of children during the lifecourse only tractable with considerable simplifying assumptions.

Overlapping generations models are an alternative tool for dynamic fertility theories. In this approach the focus shifts from an individual's life-cycle to intergenerational considerations. Parents exhibit intergenerational altruism and are concerned about the well-being of their children. This leads to a dynastic utility function (Becker and Barro 1988; Galor and Weil 1996). The utility of the parents depends on the utility of its immediate offspring, and recursively on all future generations. The head of a dynastic family acts as if he maximizes the dynastic utility subject to a budget constraint that depends on the wealth inherited by the head, the cost of rearing children, and earnings in all future generations. Maximization of the resulting dynastic utility usually implies an arbitrage condition for consumption over generations, and it has important implications for intergenerational relations. According to this model, fertility, but not the growth of consumption per descendant, responds to variations in interest rates and the degree of altruism. More generally, fertility is also related to the growth in net costs between generations, and transfers to children depend on the taxes and production opportunities faced by children in the future (an interpretation that has been questioned in more recent studies; e.g. Lee and Kramer 2002). Using overlapping generations models, for example, Galor and Weil (1996) suggests that technological progress leads to reduced fertility because it increased the ratio of women's to men's wages, thereby increasing the opportunity costs of children and increasing the motivations to invest in child quality. Manuelli and Seshadri (2009) argue in a recent study based on an overlapping generations model that cross-country differences in productivity and taxes go a long way toward explaining the observed differences in fertility across contemporary developed countries, and Greenwood et al. (2005) point to the importance of relentless rise in real wages during the last 200 years in contributing to increased the opportunity cost of having children, while at the same time, arguing that baby boom during the 1950–60s is explained by an atypical burst of technological progress in the household sector that occurred in the middle of the last century that lowered the cost of having children.

In addition to intergenerational relations, recent economic theories have also developed more explicitly the decision processes within households about fertility and related behaviors. For example, the above models concentrate on a single decision-maker and disregard the fact that household decisions usually involve more than one person who may not agree about the respective factor allocations. Various assumptions, such as Becker's (1974) "Rotten Kid Theorem", establish circumstances under which households act as if they were governed by a single, utility maximizing decision-maker. Empirical evidence, however, tends to contradict this assumption (Haddad and Hoddinott 1994; Schultz 1990), and bargaining theories (Bergstrom 1997; Lundberg and Pollak 1996) provide a sophisticated framework for analyzing this process for fertility and other household decisions. Bargaining between partners (or spouses) can have complex implications for fertility decisions because, among other factors, the ability to dissolve unions, the well-being outside marriage, or the withhold care or services within a relationship are important determinants of bargaining power in these models. For example, England and Folbre (2002) argue that primary care givers (usually mothers) usually have less bargaining power than parents whose contributions simply take the form of financial support, and that this weakness in the bargaining process may not be fully compensated by the less tangible, non-pecuniary resources that result from greater physical proximity and stronger emotional connection to the child. Within this view, less gender specialization in the form of parental involvement could lead to improved outcomes for children not only by improving mothers' economic position but also by strengthening emotional connections between fathers and children. Using similar views about gender asymmetries in decision-making processes within and outside the family/household, McDonald (2000) argues that an increase in gender equity—and thus more gender-equal bargaining power within families—is a precondition of a rise in fertility from very low levels in developed countries, while at the same time, increased female bargaining power is a necessary condition for achieving lower fertility.

It is well-known that the individual decision-making processes that are emphasized in the economic frameworks of fertility do not necessarily result in optimal or, for that matter, replacement level fertility. For example, it is an old observation that individuals' fertility decisions may deviate from the socially perceived optimum level of procreation. Polybius (1927, 36.17.5–7) in the second century BC, for instance, lamented about a decreasing population and a decline of cities because "men had fallen into such a state of pretentiousness, avarice, and indolence that they did not wish to marry, or if they married to rear children born to them, or at most as a rule one or two of them, so as to leave these in affluence". Instead of this concern for underpopulation, recent writers about the divergence between individually and socially desired population growth were primarily concerned with overpopulation. The reasons for this divergence are twofold: the first is that the relative prices of goods and services that households face may simply be "wrong" due to market failure. The second is provided by the ubiquitous phenomenon of externalities. The externalities underlying this divergence of private and social incentives for low fertility are mainly found in three areas. In Malthus' model that emphasizes diminishing returns and the finiteness of space as limits to population increase, the externality is pecuniary and relates to the negative effect of an additional worker on the wage level. Alternative externalities can arise due to public goods or natural resources. An early modern formulation of the "tragedy of the common" is provided by Hardin (1968). Motivated by this existence of common resources, Demeny (1986) described the population problem as a prisoner's dilemma, in which each couple, acting in their self-interest, induces suboptimal collective outcomes. The existence of a prisoner's dilemma has been used to advocate population policy and public intervention in individuals' fertility decisions. Yet even if one accepts the relevance of negative externalities, little is known about their magnitude. A study by Lee and Miller (1991) is one of the few attempts to estimate them in the context of developing countries. Contrary to the expectation, "[f]or some countries widely viewed as having serious population problems, the net total of these quantifiable externalities was close to zero" (p. 295). In developed countries where concerns about low fertility are prominent, however, the externalities to childbearing are substantial. Instead of the negative spillovers that dominate the concerns of excessive population growth, these arguments focus primarily on the positive externalities to childbearing resulting from the existence of public transfer and related systems that—in their net effects—transfer resources from the younger to older generations. In this context, children tend to be associated with positive externalities, resulting in lower than socially optimal fertility levels, because the discounted contributions of children to these systems exceed the discounted benefits they receive. For example, Lee and Miller (1997) estimated a positive externality of $170,000, about six times the per capita GDP for the mid-1990 reference year, using long-term projections of taxes and benefits received by a newborn during the course of his/her life. In addition to contributing to the reasons of low and very low fertility in developed countries, these externalities are important because they emphasize the concerns over the appropriate distribution of the costs of children. For example, England and Folbre (1999) argue that, because the production of children's capabilities creates a public good that cannot be priced in the market and because individuals can thus free ride on the efforts of parents in general and mothers in particular, developed societies need to redesign the social contract in ways that encourage more sustainable forms of intergenerational altruism and reciprocity.

In addition to the above focus on economic externalities, recent fertility models that include social interaction and social learning have emphasized possibly positive externalities—or spillovers—that arise because the adoption of low fertility by some parents contributes to the erosion of traditional norms or pressures to conform (e.g., Kohler 2001). Other forms of social interactions are possible, including also the returns to education or feedbacks affecting the marriage market. For example, these externalities occur because the diffusion of information is a path-dependent process and the choices of early adopters influence the availability of information for later decision-makers (Kohler 1997). Externalities exist in health behavior due to threshold phenomena in the spread of contagious diseases. Alternatively, they emerge in economic development because the return to human capital depends on the average level of education in a community. Or, as Goldin and Katz (2002) argue, during the introduction of the pill that altered women's career decisions in the United States through two pathways: a direct pathway that through better fertility control facilitated women to invest in expensive long-duration training without the price of abstinence or a high risk of unwanted fertility, and an indirect pathway in which the resulting delay of marriage increased the size of the "marriage pool" at older ages, thereby reducing the "costs" of delaying marriage in terms of the probability of finding an appropriate mate.

In all of these examples, the "local" environment for fertility decisions is not an exogenously given entity, but it is rather determined interdependently with the aggregate behavior of the population and with the historical evolution of social institutions. Its changes therefore reflect past conditions, altering incentives for individual behavior, and processes of social interactions. Social interaction can also endogenously transform social institutions and social norms, and it can create feedback loops between changes in the aggregate fertility level and individual incentives for reproductive behavior. As emphasized by Nobel Prize-winner Kenneth Arrow in his foreword to Arthur (1994), these social interaction processes can give rise to *path dependent* social changes, and this notion of path-dependent developments is particularly pertinent to situations where foresight is imperfect, or expectations are based on limited information. Many fertility related decisions are inherently subject to such uncertainty and imperfect foresight, and fertility decisions almost always incorporate expectations that are based on limited information because many aspects of future conditions are unknown. Newer approaches to understanding fertility behaviors, which are discussed in more detail below, therefore recognize the importance of path-dependency. The notion of path dependency draws on the work of sociologists and economists that have used the notion of path-dependence to explain how global processes—such as de-industrialization and globalization—and the unfolding of the human life-course have resulted—despite similar environmental conditions at the onset—in very different and individually and/or nationally varying patterns of schooling, labor force participation and other life-course dimensions. With respect to fertility-related behaviors, for example, Billari and Kohler (2004) point to the apparent lack of convergence between Northern and Southern European countries during recent decades with respect to important life-course patterns such as the sequencing of first birth and first marriage or the prevalence of cohabitation in early adulthood. In similar vein, Reher (1998) emphasizes enduring differences in family systems within Europe, contrasting the patterns in Southern Europe characterized by strong family ties with patterns in North-Western Europe, where weak ties have been typical of family relations for several centuries.

3.3. Institutionalist and ideational perspectives

While demand theories emphasize how the costs and benefits of children depend on the institutional contexts—the development stage, the legal and policy context, gender relations, etc.—these aspects are often considered as exogenous to the theoretical framework, and moreover, institutional differences or often only represented in rudimentary fashion. For example, according to Lesthaeghe (1980, p. 539), the puzzle of the European demographic transition is not so much the fact that geographical dispersion patterns are detectable or that the fertility transition followed linguistic and cultural boundaries, but rather that the timing and format of marital fertility decline "were closely associated with the development of differential and sometimes compartmentalized ideological codes". In the ideational theories discussed in more detail below, differences in religious beliefs, individualism and secularism explain variations in fertility level. According to this reasoning, fertility in traditional societies is largely socially controlled. One criticism of these ideational approaches is that the mechanisms leading to these alterations remain largely unexplained. It is also unclear whether culture identifies causal relations relevant for fertility decline, or whether it is merely a residual of otherwise unexplained observations. Moreover, there is a potential circularity in the logic as behavior is explained because of cultural or ideational preferences for this behavior. To avoid this fault, culture needs to be defined in terms of structural conditions or historical experiences. Institutionalists (e.g., McNicoll 1980, 2009) adopt this perspective and emphasize the structure within which fertility decisions occur. Elements of this structure are family systems, social classes, lineage groups, political and administrative structure, etc. McNicoll (1980) for instance relates the continuing high fertility in Bangladesh, parts of China, and Bali to social characteristics that either encourage high levels of childbearing or imply a social control of fertility. These characteristics range from a net economic value of children, to the absence of insurance and old-age security markets, to a lack of social and political cohesion within communities. McDonald (2000) argues that gender equity can be in high fertility contexts by increasing the likelihood that women's fertility intentions will be consequential and by increasing alternative avenues to satisfaction, status, and prestige; in low fertility settings, however, gender equity can be pronatalist because women bear fewer of the time, energy, and financial costs of rearing children (greater equity has spread these costs more broadly than in settings with stronger familial patriarchy). In light of these heterogeneous effects of institutions, McNicoll (2009) therefore argues that each country-level fertility transition takes place in a unique historical and geopolitical environment with often idiosyncratic elements. In a broad-brush typology of modern transitions, McNicoll for example identifies several variants: a Latin American model, in which fertility decline is accompanied by urban-led, capitalist development of the kind envisaged by the theorists of demographic transition; an East Asian model, where fertility decline was in part facilitated by an intrusive but competent development administration that, as part of a broader development agenda, pressed for smaller families; and a South Asian model in which, at least for several decades, slow progress on both fertility and development resulted from a "soft state" and an ever-present risks of downward mobility. While McNicoll (2009) attributes important roles of population policies in each of these declines, he also emphasizes that inherited institutional and cultural designs and practices sometimes facilitated relatively easy fertility transitions, while in other contexts, the institutional context caused a slower pace of decline, and sometimes even a stalling of the fertility reduction. This relevance of institutional contexts for explaining fertility variation continues even once fertility has declined, and for example, Esping-Andersen (1999) points to the importance of Western welfare state regimes, where fertility behaviors may substantially differ between, say, a social democratic regime (e.g., Norway) and a conservative regime (e.g., Italy) owing to the balance of the family, state, and market in managing social risks.

Despite acknowledging this heterogeneity in institutional contexts and the interactions between policy and institutions, the rapid speed and the pervasiveness of early fertility decline (or fertility change more generally) that often does not coincide closely with socioeconomic characteristics or structural changes of traditional institutions, continues to be challenging to explain for both demand and institutionalist perspectives about fertility. In the 1980s, this alleged failure of demand theories to explain demographic change in Europe or developing countries (Cleland and Wilson 1987; Montgomery and Casterline 1993) has given an impetus to alternative explanations. Cleland suggests the interpretation of "fertility control as an innovation", and argues that the diffusion of this innovation is the basis of fertility decline. The emphasis on diffusion reduces the importance of the incentives that are central in demand theories, and it provides an explanation for the rapid adoption of contraceptive behavior. Diffusion is the process by which an innovation—new technologies or new ideas—are communicated through certain channels of a social system. Early innovators adopt a new technology or idea, and subsequently the innovation percolates through the social system by communication. A characteristic *S*-shape of adoption over time is frequently associated with diffusion processes. During the take-off period, where the *S*-curve exhibits an increasing slope, the innovation spreads rapidly from the initial adopters to a majority of the population.

The idea of diffusion is consistent with the pervasiveness of fertility decline in Europe during the demographic transition in Europe, and in many developing countries during the latter half of the 20th century. Moreover, the role of communication in this diffusion process provides an explanation for the divergence of demographic behavior in different linguistic, cultural or geographic groups, both during the European demographic transition and contemporary declines. The strongest support for the diffusion hypothesis is derived from the direct study of social interaction and fertility or related behaviors (for a recent review, see Behrman et al. 2009). For instance, Rogers and Kincaid (1981) study the adoption of fertility control in rural Korean villages between 1964 and 1973 using social network analysis. Socially isolated individuals have significantly lower rates of contraceptive use, and a woman is found to be more likely to adopt family planning if more of the individuals in her personal network have adopted it previously. Motivated by these suggestions of associations between social interactions and fertility behavior, several new data collection projects have improved the empirical micro-evidence in favor of social interactions. Reports from KAP studies in many developing countries in the 1960s and 1970s indicate that substantial proportions of respondents heard about modern methods of fertility control from informal sources such as friends rather than from family planning clinics. Analyses of qualitative data from Thailand and Kenya have provided evidence that women chat with each other about family size and family planning (Entwisle et al. 1996; Watkins 2000). Entwisle et al. (1996, p. 1), for example, state the general point nicely in an empirical study on contraceptive choice: "we find unmistakable 'footprints' of a different type of community variable ... evidence for the importance of the social community, bound together by social interaction."

Several related studies have taken the next step and attempted to estimate causal models to evaluate whether social interaction matters for demographic attitudes and behavior (Behrman et al. 2002; Entwisle et al. 1996; Kohler et al. 2001; Munshi and Myaux 2006). Behrman et al. (2002), for instance, conclude that social networks have significant and substantial effects even after controlling for unobserved factors that may determine the nature of the social networks. Moreover, these network effects generally are nonlinear and asymmetric. They are relatively large for individuals who have at least one network partner who is perceived to be using contraceptives, and they are relevant only for interactions with family planning users and not for interactions with non-users.

The mechanisms by which social networks affect the diffusion process can be summarized under the headings "social learning", "joint evaluation", and "social influence" (Bongaarts and Watkins 1996; Montgomery and Casterline 1996). At early stages, potential adopters need to be informed about the existence of new methods of fertility control, their availability, costs and benefits, and possible side effects. Social learning is defined as the process by which individuals (*a*) learn about the existence and technical details of new contraceptive techniques, and (*b*) reduce the uncertainties associated with the adoption of these methods by drawing in the experience of network partners. The spread of information about modern contraceptives is always accompanied by the spread of new ideas about the social role of women and families or new trends concerning the desired number of children. Joint evaluation refers to the fact that social networks facilitate the transformation of these new ideas into terms that are meaningful in the local context, and assist in the evaluation of the respective social changes. A woman's decision to adopt a modern form of contraception, however, rests not only on information, conviction, and discursive evaluation, but also on the normative pressures of dominant groups or actors. Social influence defines the process by which an individual's preferences and attitudes are influenced by the prevailing norms and values of the social environment. The direction of this social influence can differ in different stages of fertility decline. In the early stages, social influence may constrain the adoption of contraception that demographers may interpret as being in a woman's best interest, because deliberate control of fertility is still considered deviant. Once a noticeable fertility decline has set in, however, the direction of social influence can shift. As low fertility becomes commonplace, the interaction among women or couples is likely to encourage a decline in the demand for children and behaviors that lead to a limiting of fertility. Kohler et al. (2001) argue that these mechanisms can be distinguished because the structure of social network modifies the impact of the content of the network interaction. The study finds that social influence is important in contexts where market activity is low, whereas in contexts where market activity is high, social learning dominates. The notion that higher market activities favor social learning is plausible. After all, the spread of information is an important aspect of markets, and market participants may focus more strongly on the information provided by their personal contacts than on the social acceptance regarding their family planning behavior.

The ongoing research on social networks and fertility is in part stimulated by the fact that the dynamic implications of fertility models that include social interactions seem to be more consistent with the empirical evidence on fertility transitions than individualistic models. However, specific theoretical analyses of social interactions and fertility decisions are required as further support for this conclusion. Early formal models treat the diffusion of low fertility similar in a manner to the way the way the spread of contagious diseases is treated in epidemiological models. More recent developments have used stochastic processes or simulation, and they explicitly consider the interplay between social networks, women's fertility decisions, and economic incentives on a micro-economic level (Kohler 2001). The main consequence of interactions in social networks is that fertility decisions of women or couples in a population become interdependent and exert mutual influences on each other. The implications of this interdependence can be illustrated in a simple nonlinear model of social interaction. In particular, assume that the probability that a woman ever adopts modern contraception is given by $\Pr(\text{woman adopts modern contraception } | x, \bar{y}) = F(\alpha \cdot (\bar{y} - .5) + \beta x + \gamma)$, where α and β are positive parameters, γ represents individual characteristics, x is the level of family planning effort, F is the cumulative logistic function, and $\bar{y}$ is the proportion of women in the population who use modern contraception in the reference period. Hence, the social utility term $\alpha \cdot (\bar{y} - .5)$ captures the dependence of a woman's contraceptive choice on the fertility behavior in her network, where we assume for the sake of simplicity that this network includes all members of the population. The model implies that social effects are absent in a population in which half of the members use modern contraception and the other half do not. If the proportion of contraceptive users exceeds (is below) .5, then the social network increases (decreases) the probability of using contraception. This simple model already reveals that the aggregate properties of fertility dynamics in the presence of social interaction are distinct from the fertility dynamics in a purely individualistic model. In particular, the relevance of social interaction arises from two factors (for further discussion, see Kohler 2001): First, social interaction implies the presence of multiplier effects which change how the fertility level adjusts to changes in family planning programs. An increase in family planning effort x, for instance, increases the probability of choosing modern contraception in two distinct ways. The direct effect reflects the increase in the propensity to choose modern contraception while holding the population prevalence $\bar{y}$ constant. However, because the increased level of x affects all community members, the prevalence of modern contraception in the population tends to increase as well. This change in the community has a feedback or social multiplier effect on individual behavior in future periods via the social utility term. This means that the total change in the prevalence of family planning exceeds the direct effect. The interaction in social networks thus enhances the changes in contraceptive behavior that follow changes in family planning efforts or other socioeconomic changes. Second, in contract to many formal fertility models assume that there is only one aggregate fertility level—denoted as "equilibrium"—associated with any given level of socioeconomic conditions, models with social interactions allow for the possibility that when the interdependence of fertility decisions in social networks is sufficiently strong, multiple equilibria can emerge. This possibility of there being multiple equilibria is relevant because in this case a population can be "stuck" at a low level of contraceptive use, even though a second equilibrium exists with a higher level of contraceptive use and higher individual utility levels. In this case, increases in the policy level x (or other socioeconomic changes) can induce a transition from the low contraceptive use to the high contraceptive use equilibrium. These transitions between equilibria are often thought to occur at a rapid pace, resulting in significant changes in fertility behavior within a relatively short space of time. Moreover, both the high and low contraceptive use equilibria are stable, so that a transitory increase in the family planning effort can yield sustainable long-term changes in fertility levels.

The role of social interactions on fertility is not restricted to the fertility transition or contraceptive use. The Second Demographic Transition Theory (Lesthaeghe and van de Kaa 1986; van de Kaa 1987), a prominent framework explaining the spread of low fertility since the 1970s, includes as a central component cultural shifts in the cultural schema related to fertility and the transition to adulthood that diffuse through the population through social interaction processes. In this theory, therefore, the emergence of sustained low fertility and associated increases in rates of cohabitation and divorce, were motivated by the spread of individualism, including a less normative life-course, the concept that having children is optional and that parenthood should contribute to individual self-realization. In a similar fashion, Kohler et al. (2002a) integrate socioeconomic changes and feedback effects mediated through social interactions to explain the rapid delay of childbearing that has been a characteristic of fertility trends in many developed societies. On the one hand, the socioeconomic reasons for the rapid delay of childbearing in many developed countries include increased incentives to invest in higher education and labor market experience, uncertainty in early adulthood (for instance, due to high youth unemployment up to 40 percent for females in Southern European countries during the 1990s), general economic uncertainty in Central and Eastern European transition countries, and inefficient housing markets leading to high costs of establishing or expanding independent households. Kohler et al. (2002a), however, argue that these incentives are not sufficient to understand the dynamics of fertility postponement. In addition, social interaction effects are likely to reinforce individual's desire to delay childbearing in response to socioeconomic changes. These interaction effects occur due to social learning and social influence in the decision processes about the timing of fertility, and they can also be caused by feedbacks in the labor and marriage market that make late fertility individually more rational the later the population age-pattern of fertility is. As a consequence of these interaction effects, the delay of childbearing follows a postponement transition that shares many characteristics with the fertility transition in Europe or contemporary developing countries: it occurs across a wide range of socioeconomic conditions; once initiated, it results in a rapid and persistent delay in the timing of childbearing; and it is likely to continue even if the socioeconomic changes that initiated the transition are reversed. In this context, social interaction constitutes not only an important element that helps to explain the rapid delay of childbearing in many low fertility contexts, but the approaching of the end of the postponement transition and the resulting decline in the pace of fertility postponement seems to partially underlie the recent rise in fertility rates in many developed countries (Goldstein et al. 2009).

3.3. Biodemographic perspectives on fertility

The above theories primary emphasize social and economic determinants of fertility change. It is important to emphasize that the focus traditional demographic research on socioeconomic factors, is not inconsistent with biological theories. To the contrary, recent evolutionary approaches to demographic change frequently incorporate transformations in the socioeconomic context of fertility that lead to adjustments in the optimal (i.e., fitness-maximizing) fertility strategies (Kaplan and Lancaster 2003), and the *biodemography of fertility* has recently emerged as an important subfield (e.g., see Wachter and Bulatao 2003) that investigates human fertility and family formation by combining sociological/economic theories with approaches from behavioral genetics, molecular genetics, neuro-endocrinology, and cross-species life history analysis, and evolutionary theory. For example, Kaplan and Lancaster (2003) jointly consider the evolutionary and ecological analysis of human fertility, mating patterns, and parental investment, focusing on three broad themes: first, the timing of life events, including development, reproduction, and aging; second, the regulation of reproductive rates and their relationship to parental investment; and third, sexual dimorphism and its relationship to mating systems and changes in mating systems across human evolution and across different societies. Within this evolutionary framework traits (and the genes that code for them) increase in frequency relative to other traits when their average effects on the individuals possessing those traits act to maximize their long-term production of descendants through time. Fertility is an important topic in this context as it is the most direct contributor to an organism's fitness (i.e., the number of descendants it produces). However, fertility behavior within evolutionary models is characterized by important trade-offs. First, there is a trade-off between present and future reproduction, and humans substantially invest into growth and development before reproduction. Second, there is a trade-off between the quantity and quality of offspring, similar to economic framework. However, where in the economic models quantity and quality are weighted with the aim to maximize utility, the quality-quantity trade-off pertains to fitness maximization. Different reproductive strategies are optimal in different contexts, and for different species. During millennia of evolutionary change, a life-course evolved for humans that is characterized by (1) a very long life span, (2) an extended period of young-age dependence, resulting in families with multiple dependent children of different ages, (3) multigenerational resource flows and support of reproduction by older postreproductive individuals, and (4) male support of reproduction through the provisioning of females and their offspring.

In addition to using evolutionary framework to better understand fertility patterns over the long term, biodemographic ideas are increasingly utilized for understanding aspects of contemporary fertility trends, and the interplay between genetics, environment and fertility has recently received considerable emphasis as one important aspect of understanding human reproduction from a biodemographic perspective. For example, in exploring why individuals and couples continue to have children in the 21st century where the net economic costs of children are clearly substantial, Morgan and King (2001) reviews the interaction of biological predispositions, environment (social coercion) and rational choice in the motivation to have children, and explores the argument evolution has produced sets of genes that predispose persons to childbearing by making sex and parenthood pleasurable, and thus, that very low fertility is not an inevitable consequence of economic development. Consistent with such a broad evolutionary framework, differential genetic dispositions can exert influences on fertility and related behavior through at least three distinct pathways: First, biological dispositions can affect fertility relatively directly through genetically-mediated variation in physiological characteristics affecting fertility outcomes. Genetic influences on fecundity are an obvious example (Christensen et al. 2003). Second, biological dispositions can affect fertility through deliberate fertility decisions and a broad range of fertility-related behaviors that are subject to substantial volitional control. Within this category of influences, we can further distinguish between two different pathways. On the one hand, some biological dispositions exert their effect on behavior through conscious decision making and life-course planning. On the other hand, biological dispositions may also operate subconsciously on fertility-related decision processes. Examples for the former are individuals' knowledge about their fecundity or knowledge about their returns to schooling and delaying fertility. Examples of the latter, subconscious influences are variations in evolved preferences for nurturing (e.g., Foster 2000; Miller and Rodgers 2001), or differences in endowments that affect preferences and the "happiness" derived from having children (Kohler et al. 2005), or influences on emotions, personality characteristics and cognitive abilities. Considering these aspects jointly suggests an interplay between social change and genetic influences on within-population variation in human traits and behaviors. For example, Instead of testing "nature *versus* nurture", Kohler et al. (1999, 2002b) therefore pursue a socially contextualized analysis of the shifting contributions of both nature *and* nurture to variation in human fertility behavior over time. This consideration therefore accommodates the recent argument proposed by sociologists and other social scientists that the extensive social theorizing about human fertility that has occurred over the past several decades by psychologists, sociologists, demographers, economists, and public health experts is incomplete unless those social models are also informed by biological/genetic components as well (e.g., Udry 1996). Using Danish monozytogitic (MZ) and dizygotic (DZ or fraternal) twin pairs born between 1953 and 1959, Rodgers et al. (2001b) for example show that slightly more than a quarter of the variance in completed fertility is attributable to genetic influence. In addition, multivariate behavior genetic models suggest that one of the contributing sources of genetic influence to the total number of children is the age at which individuals first attempt to get pregnant, and that the age at first attempt to get pregnant itself has a major genetic component—higher than that for completed fertility, and higher for females than for males. Rodgers et al. (2001b) argue that this finding suggests a theoretical approach to fertility in which, in addition to operating through fecundity, genetic influences on fertility outcomes appear to operate at least partially through volitional fertility motivation and desires. However, a static that roughly a quarter of the variance in completed fertility is attributable to genetic influences, is cautioned by Kohler et al.'s (1999; 2002b) historical analyses showing that genetic influences on fertility may be strongly contingent on the socioeconomic and demographic context. In particular, periods of changing fertility norms—like those that occur at the onset of demographic transition at the end of the 19th century or during the Second Demographic Transition after 1965—appear to be the ones in which genetic influences are allowed to express themselves. This finding is consistent with an earlier prediction by Udry (1996, p. 335) that this interaction between the importance of biological factors and the societal context argued that low-fertility societies are better suited for studying biological factors: "Low-fertility societies provide wide behavior choice. Where behavior choice is broad and opportunities are egalitarian, biological variables, reflecting natural differences in behavioral dispositions, explain increasing variations in behavior. Applications of this principle to demographic research suggests that, increasingly, gendered behavior, fertility, contraception, abortion, nuptiality, occupational choice and other behaviors of interest to demographers will be influenced by biological choice."

The above findings for various fertility outcomes are consistent with the existing behavioral-genetic evidence on fertility precursors. For instance, several studies have documented genetic influences on the onset of puberty, sexual behavior, dating and marriage, on the desire for children and the desired age at first birth, as well as on motivational traits that are associated with fertility behavior (Rodgers et al. 2001a). In addition to these behavioral genetic studies, there are some molecular-genetic studies that point to a potentially important role of genetic influences on fertility outcomes. For instance, Miller et al. (1999) found that several dopamine receptor alleles were significantly associated with age at first sexual intercourse, especially in males. MacMurray et al. (2002) examined the association between alleles at the dopamine D2 receptor gene (DRD2) TaqI site in a sample of 293 adult males from Catacamas, Honduras, and found that carriers of the A1 allele had an earlier age at birth of their first child (p=.024) and increased total fertility (p=.007). A similar finding is reported by Gerdes et al. (1996), who investigate the relationship between APO-E gene and fertility and find that, on average, men with the ε-3 ε-3 genotype (n = 212) had 1.93 children, men with the ε-3 ε-4 or ε-4 ε-4 genotype (n = 105) had 1.50, and men with the ε-3 ε-2 or ε-2 ε-2 genotypes (n = 53) had 1.66 children. Of the men in the three groups, 6%, 26% and 19%, respectively, reported being childless. Similar effects of the APO-E gene have also been documented by Corbo et al. (2004) in a pre-modern population as well as in healthy subjects of postreproctive age in developed societies, suggesting that different total cholesterol levels associated with APOE genotypes could have an effect on steroidogenesis and determine as a consequence the observed differential fertility. Reijo et al. (1995) have also detected deletions of portions of the Y chromosome long arm in men with azoospermia (no sperm in semen), while no Y deletions were detected in their male relatives or in 90 other fertile males. These deletions overlap and defining a region likely to contain one or more genes required for spermatogenesis (the Azoospermia Factor, AZF). Very recently, Stefansson et al. (2004) have also identified a region in the human genome that appears to promote fertility. In some Icelanders, Stefansson et al. (2004) found, the DNA section runs in the standard direction but in others it is flipped. Women carrying the flipped or inverted section tend to have slightly more children. The link between the inversion and fertility, however, remains unclear at this point.

3.3. Understanding fertility change and variation: structure, conjuncture and action:

In concluding this review of fertility theories, it is important to point out that despite several decades of research on the determinants of fertility, there are very few theoretical frameworks that bridge across the different approaches emphasized above and provide an integrated theoretical framework. Moreover, Morgan and Kohler (2009) argue that, despite the profound changes in fertility levels and the detail with which these changes have been documented, the role of fertility decline in assessing general theories of societal change and/or behavioral differences has been modest. To address this niche in the literature, Morgan and Kohler (2009) build on recent development of a *Theory of Conjunctural Action* (TCA) (Johnson-Hanks et al. 2009) that is by the duality of structure argument, and show that the large body of theories, methods, facts, and understandings regarding fertility change and variation reviewed above can be usefully integrated within the

TCA framework proposed by (Johnson-Hanks et al. 2009). While a full review of this integrative framework is beyond the scope of this chapter, an introduction to the essential elements of this framework can illustrate how this model can be used better understand contemporary fertility patterns within a multidisciplinary perspective.

The most basic premise of TCA is that all stimuli and experience are filtered by an individual's brain on the basis of stored (but modifiable) mental "maps," "frames," or "schemas" (hereafter schemas). The second premise of the TCA is that society is organized materially as well as schematically. Any material form or reserve of value that has an existence outside of the schemas it manifests we call a "material," or material structure. The product of the interaction of schemas and materials over time is called "structures." For example, TCA argues that the structure of the "nuclear family" would not exist without both examples of such families in the world and the ability of individuals to learn schemas about such families, store them, and use them to motivate or evaluate their own and others' family behaviors. Finally, within TCA—similar to some of the theories emphasizing social interactions—the circumstances or situations in which individuals find themselves embedded are central to all human behaviors: action never occurs in the abstract but rather in concrete configurations of context. The situational context of of individuals' and couples' behavior—denoted "conjunctures" within TCA—are therefore key foci of both theory and empirical research, and it is the construal of key conjectures that shapes fertility and family behavior within the TCA framework.

In applying TCA to fertility change and variation, Morgan and Kohler (2009) consider the life-course an interrelated set of path-dependent processes—education and career, relationships and marriage, childbearing, and so on—and focus particularly on the fertility related situations—or conjunctures—in which one or more of these processes becomes particularly salient or important—such as graduation from college, the formation of a new partnership, a divorce, or a new job. In explaining the variation and change of fertility, Morgan and Kohler (2009) then emphasize in particular the *schemas*, *materials* and the *interaction between materials and schemas*. First, the concept of *schemas* integrates the notion that ideational factors, mental maps and schemas are central for fertility change, and TCA thus integrates concepts such as Coale's (1973) classic precondition for fertility change, van de Walle's (1992) that numeracy about children—that is, the perception of a particular family size as a goal in the long-term strategy of couples—is a prerequisite of deliberate fertility control, van de Kaa and Lesthaeghe's Second Demographic Transition Theory (Lesthaeghe and van de Kaa 1986; van de Kaa 1987), the ideational factors emphasized by ideational theories and diffusion theories of fertility change reviewed above, and the shifting schemas central to Thornton's (2005) framework of "developmental idealism" that associates the modernization process with predictable family changes through a package of "ideas" such as that the modern (i.e., conjugal or Western) family is good and attainable and that the modern family is a cause as well as an effect of modern society. Second, the emphasis on *materials* in TCA on the one hand reflects that rational choice theories of fertility, which emphasize the trade-off between child quality and child quantity, the attention to the opportunity costs of mothers' time, and attention to the life-cycle implications of fertility behaviors, and the notion that fertility is being determined by couples who attempt to allocate limited resources—importantly including time and money—have become widely accepted as a useful framework for understanding fertility change and variation. However, TCA also recognizes that many key/critical factors determining fertility choices are missing in these frameworks, such as the legal institution determining the structure of labor markets or family policies, routinized social practices, and forms of built space that so compellingly organize our daily lives. While McNicoll (1980) argued a quarter-century ago that institutional context matters, as we have argued above, few rational choice theories have incorporated a broader notion of context that extends beyond the resources—such as time and money—that are controlled by individuals, and allows for an endogenous evolution of the institutions and environmental conditions affecting behaviors. In contrast to this emphasis on the allocation of scarce resources within rational choice theory, TCA takes a broader approach and defines the material components of structure as the artifacts, rituals, and institutions that both embody schemas and also have a concrete existence that does not wholly depend on schemas. The material structures in TCA thus include not only economic resources or economic development; instead, Morgan and Kohler (2009) argue that institutions and conventionalized practices are as important as budget constraints in explaining fertility behaviors and its changes over time and contexts behavior. Perhaps the most important innovative aspect of the TCA theory in this context is that material structure affects behaviors not only through its direct effect (by facilitating or inhibiting a particular action) but also through its indirect effect on the schemas individuals are likely to invoke.

Third and finally, a key axiom of TCA in Morgan and Kohler (2009) and Johnson-Hanks et al. (2009) is that schematic and material structure are mutually constructed. For example, life-course schemas not only specify that "marriage" (or a stable union) should precede a birth, but they incorporate the rationale for this ordering—care for the child is more secure when provisioned by two adults with a long term commitment. Materials in the world reinforce that this ordering is appropriate, normal, and moral. An example for this interaction of schema and material is Caldwell (1982) analysis positing universal schooling as a key factor stimulating the onset of fertility decline that blends schematic and resource changes in a two-fold argument: on the one hand, that schooling raises the cost of children due to the direct costs of tuition, books, and clothes required for attendance and because of the indirect effects on children's reduced availability for work; and on the other hand, increased levels of schooling reinforce the effect of these direct costs by introducing a "new way of thinking" about children in which increased longevity and higher returns to human capital make "investments" in children more attractive and increasingly normative, thereby reinforcing—in a similar fashion as the social multiplier effects previously discussed in the context of social interaction models—the changes in fertility that result from education.

In a different context, but consistent with the TCA framework, Bernardi et al. (2008) use an interaction between schema and resources to explain the "puzzle" that East German women continue to have their children earlier than their West German counterparts, and fertility occurs more often outside marriage and within cohabitation (thus producing higher levels of single parenthood), despite higher levels of unemployment and greater economic uncertainty, the cumulative fertility rates of young East Germans exceed that of young West German cohorts. In particular, Bernardi et al. (2008) argue that, while job security is crucial to the western Germans' idea of achievement and as a foundation for family formation in a sequential pattern, in eastern Germany job security is only one of the parallel paths in one's life course and thus investments in the job and private life are conducted in parallel. The western German couples in the study thus tend to hold a schema of "the integrated life", which is "connected with a straight career path, [...] with a lack of discontinuity between the stages of the life cycle, and in which perceptions of family are centered on a male breadwinner model. East German respondents, on the other hand, expressed a schema of parenthood that is better classified as a diversified portfolio of priorities in which competing goals need to be "balanced" without strictly sequencing their achievements. More generally, Morgan and Kohler (2009) argue that low fertility countries emerges as a result of schema that continue to imply a considerable importance of childbearing with schema that emphasize individuals' pursuit of a meaningful and satisfying life, and the rewards to "hard work" and persistence in planning and attaining one's goals. These schema interact with a material context that can differ widely across or within countries, and both the schema and the material contexts continue to be transformed by changes such as globalization, economic development, progress in communication and other technologies.

4. Looking forward: the future of low fertility

We conclude this chapter by a brief outlook on the future of low fertility, which—similar to the earlier focus on fertility decline during the first and second demographic transition—is likely to be a defining theme for fertility research in the next decades. Several questions seem to be of central importance in assessing the of future below-replacement fertility. First, due to a socioeconomic and institutional context that favors low fertility, it is difficult to foresee a widespread increase in fertility levels in Europe or other developed countries to levels persistently above replacement levels (a TFR of 2.1). Many additional countries—and particularly also developing countries—are likely to experience below-replacement fertility in the near future, and *TFR* levels of 2.1 do not constitute a natural endpoint to the fertility decline. The experience of below-replacement fertility level in developing countries is a relatively unchartered demographic terrain, and while the past experience with fertility transitions suggests that these levels of low fertility are likely to be persistent, relatively few studies have analyzed low fertility in these contexts and the relationship between low (ie, below-replacement) fertility among developed and developing countries is only poorly understood.

In light of the widespread rise of fertility rates that are below—and often substantially below—replacement levels, the U.S. experience of a *TFR* above two during recent years is indeed remarkable and deserves close investigation, as does the recent increase in *TFR* rates across many developed countries (Goldstein et al. 2009; Myrskylä et al. 2009). Second, and mostly relevant for developed countries where childbearing has been postponed to relatively late ages, a review of the medical literature in Billari et al. (2007) suggests a general skepticism about the feasibility of widespread and sufficiently reliable childbearing above age 35, especially for first children. While in vitro fertilization, intra uterine insemination and oocyte donation, may partially overcome some of these age-related problems, evidence about the extent to which these developments can facilitate widespread very late fertility on the population level is still scarce. At the same time, analyses of country-level data on the mean age at birth and parity-specific childbearing intensities do not necessarily suggest that—while the pace may decline—the postponement will come to a halt in the near future. Further increases are particularly likely in countries that only recently attained below-replacement fertility, or in Central and Eastern European transition countries with still relatively young age-patterns of first-birth fertility.

Finally, there also exist mechanisms that could potentially lead to a reversal of below-replacement and in particular lowest-low fertility patterns. On the one hand, this can partially occur due to a diminishing role of tempo and compositional distortions in period fertility measures, as seems to be the case in some of the recent fertility increases in developed countries. On the other hand, fertility levels could stabilize or recover due to a wide range of factors that affect the quantum and desired level of fertility, such as improvements in the economic situation (especially for young adults or in transition countries) and more generous social policies that provide increased incentives for having children through improved child-care provision, better access to labor markets for women with children, increased transfers to families with children, etc. Moreover, there could also emerge homeostatic forces that increase the quantum of fertility because rapid fertility declines lead to substantially reduced relative cohort sizes. When these small cohorts begin higher education, or begin to enter the labor and housing markets, they are likely to face substantially more favorable conditions than their older predecessors in large cohorts, and this effect potentially leads to an earlier timing and higher level of fertility.

The policy responses to low fertility are likely to differ significantly depending on the demographic and socioeconomic contexts. In countries that have only recently achieved below-replacement levels after a fairly rapid large decline in fertility, policies are likely to focus on the accommodation of the resulting substantial age-structure changes and possibly on preventing a decline of fertility to very low levels. In European and some other countries where low and very low levels of fertility have prevailed for several decades and population aging has already considerably progressed, policies aimed at reversing the pattern of very low fertility are increasingly discussed and or implemented. Some caution, however, is necessary with respect to possible effects of policy interventions on fertility behavior in low fertility contexts. The existing empirical evidence generally provides mixed conclusions as to the effects of various policies on fertility behavior in developed countries (e.g., Gauthier 2002; Grant et al. 2004; Neyer and Andersson 2008; Sleebos 2003). On balance, that the evidence supports a weak positive relation between reproductive behavior and a variety of policies, but policy measures which may potentially affect reproductive behavior will manifest their influence only in the long-term. Policy measures that aim to make women's participation in the formal labor force compatible with childrearing are in our opinion among the most promising alternatives. For example, Del Boca (2002) finds a positive relationship between availability of part-time jobs and fertility rates in Italy, and Adsera (2004) finds that a large share of public employment, by providing employment stability, and generous maternity benefits linked to previous employment, such as those in Scandinavia, boost fertility of the 25–34 year old women. Some recent studies have also documented a strong positive—and possibly causal—relationship between total fertility rates and formal childcare availability (e.g., Rindfuss et al. 2007). In addition, utilizing a "natural experiment" provided by the introduction of a policy in Spain that provides working mothers with a monthly childcare benefit amounting to one hundred Euros for each small child, Sánchez-Mangas and Sánchez-Marcos (2004) show that the introduction of this policy resulted in an increase in the labor participation of mothers with small children. For low and medium educated women, for which the policy seems to be most effective, more than 40% of the 3.5 percentage point increase in female labor force participation during 2002–03 can be attributed to the policy change.

The effectiveness of such measures, however, is likely to be limited due to a negative population momentum that results from decades of below-replacement fertility in many parts of Europe since the 1960s and 1970s (Lutz et al. 2006). Even if policies are effective in raising women's or couple's fertility, and even if levels of immigration into Europe increase, a loss of demographic weight within the global population, a decline in the population size during the coming decades and a substantial aging of the population are therefore safe predictions for the Europe of the twenty-first century (Demeny 2003). It is clear that current social and economic institutions are not sustainable in light of these trends, and individual's life-courses already have been—and will continue to be—transformed in response to reductions in fertility and increases in longevity. Adjusting to the demographic reality of the 21st century will therefore constitute a major challenge for policy makers and companies on the one, and for individuals and families on the other side. Whether the adjustment to these trends can be successful, and whether these trends lead to a reduced well-being of individuals if appropriate policies are implemented, is still an open question.

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Bibliographical Sketch

Hans-Peter Kohler received a M.A. in demography (1994) and a Ph.D. in economics (1997) from the University of California at Berkeley, and is currently a Professor of Sociology and a Research Associate at Population Studies Center at the University of Pennsylvania. His primary research focuses on fertility and health-related behaviors in developing and developed countries. A key characteristic of this research is the attempt to integrate demographic, economic, sociological and biological approaches in empirical and theoretical models of demographic behavior. For example, Kohler has been investigating aspects of the bio-social determinants of fertility, the determinants of low- and lowest-low fertility in Southern and Eastern Europe, the causal effects of education on health, the interrelations between marriage and sexual relations in developing countries, and the role of social interaction processes for fertility and AIDS-related behaviors. He is author of a recent book on fertility and social interaction, has co-edited a book ok on the biodemography of human reproduction and fertility, and has widely published on topics related to fertility, health, social and sexual networks, HIV/AIDS, biodemography and well-being in leading journals. Kohler has been awarded the Clifford C. Clogg Award for Early Career Achievement by the Population Association of America, has been a recent fellow at the Center for Advanced Studies at the Norwegian Academy of Science, and he currently serves as the president of the Society of Biodemography and Social Biology.

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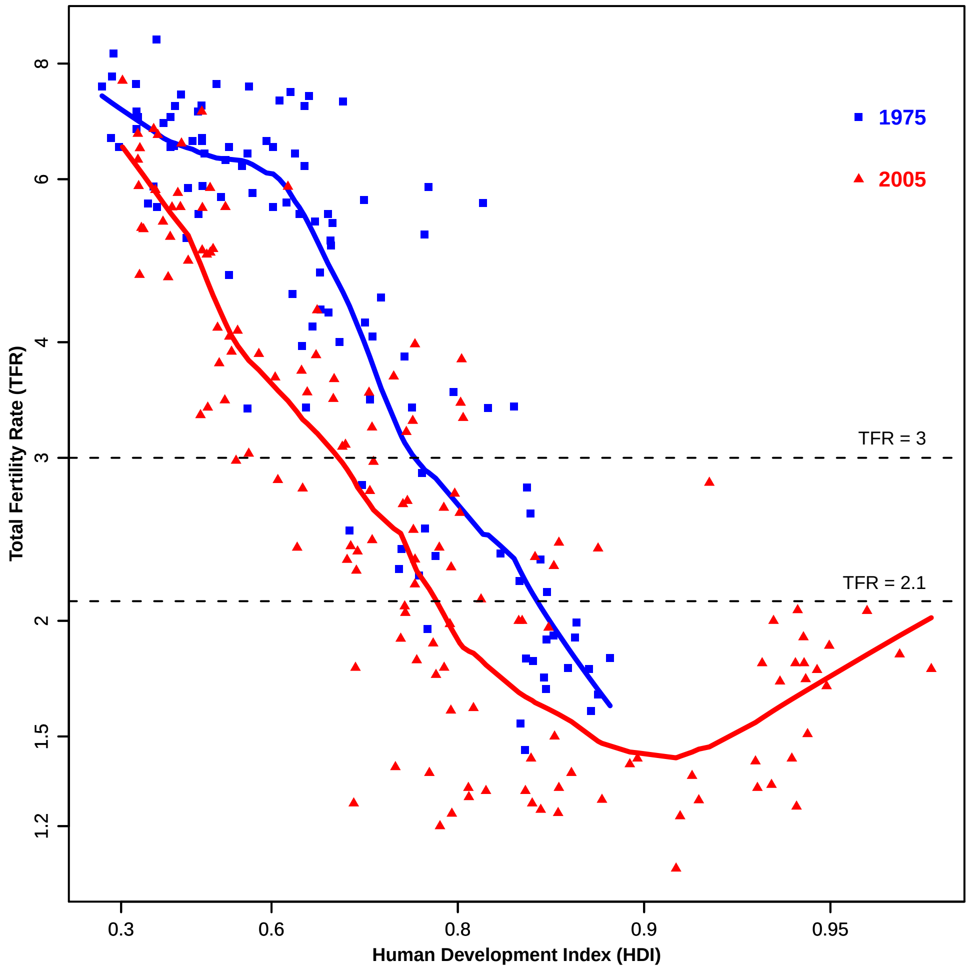

Figure 1: Cross-sectional relationship between the total fertility rate (*TFR*) and the human development index (*HDI*) in 1975 and 2005

The *HDI* is the primary index used by the United Nations Development Programme (UNDP) to monitor and evaluate broadly-defined human development, combining with equal weight indicators of a country's health conditions, living standard and human capital. For example, a *HDI* of 0.9 roughly corresponds to 75 years of life expectancy, a GDP per capita of US$25,000 in year 2000 purchasing power parity, and a 0.95 education index (a weighted sum of literacy rate and primary, secondary and tertiary level gross enrolment ratios). 1975 data include 107 countries, with 1975 *HDI* levels ranging from 0.25 to 0.887, and 1975 *TFR* levels ranging from 1.45 to 8.5; the 2005 data include 140 countries, with 2005 *HDI* levels ranging from 0.3 to 0.966, and 2005 *TFR* levels ranging from 1.08 to 7.7. The city states of Hong Kong, Macao, Monaco and Singapore are excluded. Selected countries, with their corresponding 2005 *HDI* and *TFR* values in parentheses, include: ***HDI below .4:*** Niger (0.304; 7.67); Mozambique (0.356; 5.3); Malawi (0.384; 5.84). ***HDI .4–.6:*** Tanzania (0.417; 5.2); Zimbabwe (0.479; 3.34); Uganda (0.482; 7.1); Kenya (0.491; 4.98); Yemen (0.497; 5.87); Sudan (0.511; 4.15); Nepal (0.524; 3.46); Ghana (0.532; 4.06); Bangladesh (0.544; 2.98); Botswana (0.565; 3.03). ***HDI .6–.8:*** India (0.609; 2.84); South Africa (0.644; 2.78); Honduras (0.682; 3.47); Nicaragua (0.693; 3.08); Egypt (0.696; 3.1); Moldova (0.705; 1.27); Vietnam (0.707; 1.78); Indonesia (0.708; 2.27); Syria (0.725; 3.24); Algeria (0.725; 2.44); Georgia (0.748; 1.39); Ecuador (0.755; 2.67); Iran (0.756; 2.07); Philippines (0.758; 3.2); Turkey (0.765; 2.19); China (0.767; 1.81); Colombia (0.786; 2.4); Ukraine (0.786; 1.2); Albania (0.79; 1.78); Brazil (0.795; 2.29); Malaysia (0.798; 2.74). ***HDI above .8:*** Saudi Arabia (0.803; 3.83); Russia (0.808; 1.29); Mexico (0.817; 2.11); Uruguay (0.843; 2); Croatia (0.848; 1.42); Bahrain (0.85; 2.34); Slovak Republic (0.853; 1.25); Argentina (0.86; 2.29); Hungary (0.863; 1.32); Czech Republic (0.883; 1.28); Portugal (0.895; 1.4); S. Korea (0.911; 1.08); Germany (0.916; 1.36); Israel (0.922; 2.82); Italy (0.934; 1.32); United Kingdom (0.936; 1.8); Spain (0.938; 1.33); New Zealand (0.938; 2); Japan (0.943; 1.26); USA (0.944; 2.05); France (0.945; 1.92); Canada (0.946; 1.51); Sweden (0.947; 1.77); Norway (0.961; 1.84); Australia (0.966; 1.77). Source: adapted from Myrskylä et al. (2009).

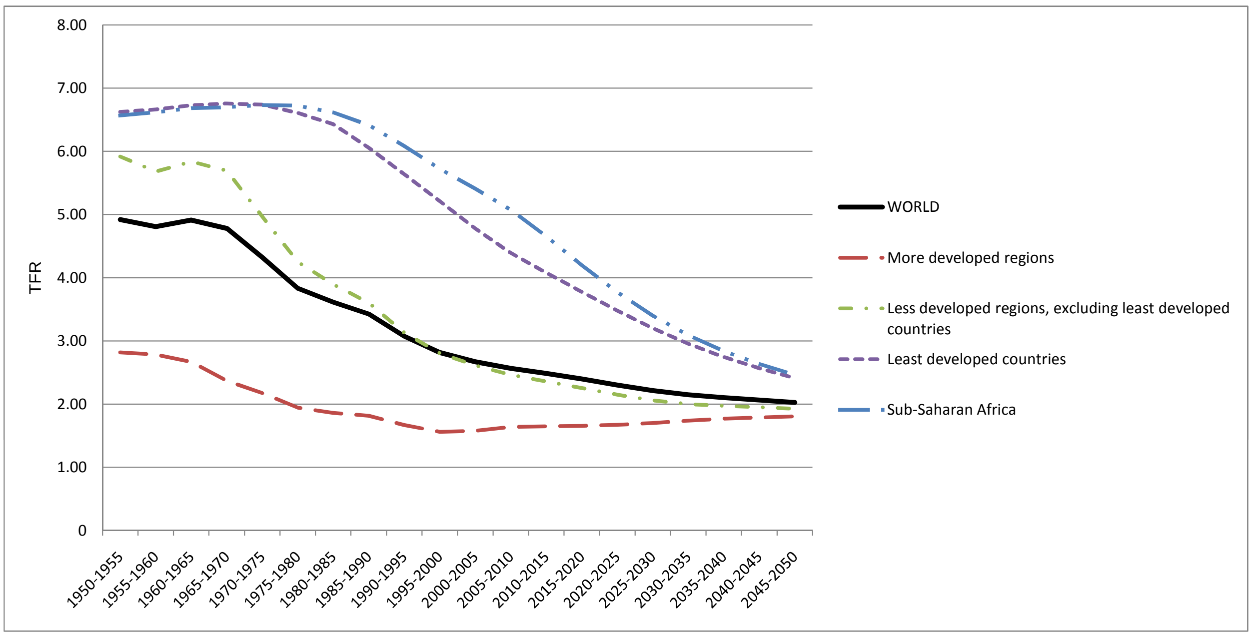

Figure 2: Past and project *TFR* trends by major regions (UN World Prospects, 2008 Revision, medium variant)