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Fertility and the economy*

Gary S. Becker

University of Chicago, Departments of Economics and Sociology, 1126 East 59th Street, Chicago, IL 60637, USA

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Abstract. I relate the demand for children to parental incomes and the cost of rearing children – especially to the value of the time spent on child care and to public policies that change the cost of children. This paper also links the demand for children to investments in their human capital and other dimensions of the so-called quality of children. Fertility is shown to depend too on child and adult mortality, uncertainty about the sex of children – if there is a preference for boys, girls, or for variety – uncertainty about how long it takes to produce a conception, and other variables.

Since biological necessity dictates that succeeding generations overlap, it is not surprising that fertility in one generation influences the fertility of succeeding generations. The overlapping generations approach provides a useful framework for relating fertility choices to population growth and macroeconomic changes.

The modern approach to fertility leads to very different interactions between population growth and economic growth than is implied either by Malthusian or the usual neo-classical growth models. In particular, it provides a framework for analyzing how societies escape a Malthusian-like stagnating equilibrium and embark on the journey toward becoming modern economies, where per capita incomes, human capital, and physical capital all continue to grow, fertility declines to rather low levels, and married women participate extensively in the labor force.

1. Introduction

Malthus's famous essay on population is subtitled "With Remarks on the Speculations of Mr. Godwin, M. Condorcet, and Other Writers". It begins with

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an objection to their claim that the well-being of mankind will continue to improve over time, and develops a theory of population change to rebut their arguments. According to Malthus, population grows more slowly when average incomes decline because the typical person then marries later and has fewer children – the preventive check – and because deaths increase when families are poorer – the pessimistic positive check. These fertility and mortality responses raise future incomes through diminishing returns to the size of the labor force.

The modern economic analysis of fertility is a development of Malthus's pioneering work. The modern approach is a very delayed reaction to the failure of the Malthusian analysis to explain the bahavior of fertility in the nineteenth and twentieth centuries in Europe, the United States, Japan, and other developed countries. The crucial problem is that fertility fell rather than rose as per capita incomes advanced in these countries.

This essay will discuss the analysis of fertility mainly in the context of the Malthusian question: what are the links between family choices – in particular, fertility behavior – and long-term economic growth? Due to this emphasis, I pay less attention to some significant advances that are more oriented to understanding microlevel differences in fertility behavior.

Let me immediately confess that I will not attempt to provide a comprehensive statement of all the determinants and effects of fertility choices, even when limited to "economic" variables or to the relevance of variables to issues like economic growth. The emphasis is heavily biased toward those aspects I have worked on, or have followed reasonably closely. Some important topics are omitted entirely and others receive less attention than they deserve. But I do believe that the issues treated are crucial to appreciating the progress during the past several decades in the economic analysis of fertility. At the same time, it should become clear that very much remains to be done.

2. Income and price effects

The spirit of the Malthusian approach to fertility can be stated in a very simple way. Assume the typical family maximizes its utility with respect to children and other goods:

$$\left.\begin{aligned} &U = v(x)+b(n),\ v', b'>0\ , \\ &v''<0, b''<0\ , \end{aligned}\right\} \tag{1}$$

where n is the number of children, x are goods, and utility increases at a decreasing rate in both x and n. Malthus claimed that the number of children is determined by "the passion between the sexes . . . that will reman nearly in its present state" (p. 8). This assumption about "passion" explains why Malthus did not try, until very late editions, to explain changes in fertility over time by shifts in tastes.

Rather, he relied on changes in income since each family is constrained by a budget equation

$$p_x x+p_n n = I\ , \tag{2}$$

where I is income, and p_x and p_n are the unit prices of x and n, respectively. Clearly, the assumption of a concave utility function implies that

$$\frac{dn}{dI} > 0 \ , \tag{3}$$

so that fertility rises and falls with increases and decreases in income.

As *I* already indicated, this prediction did badly during the two centuries following publication of his essay; even Malthus himself eventually tried to patch up his analysis to accommodate the fall in fertility by assuming that tastes shifted against children over time. A simple way to modify his conclusions without changing the framework very much is to recognize that price of children also affects the demand for children. The basic result of demand theory implies that

$$\frac{dn}{dp_n} < 0 \ . \tag{4}$$

This holds in the present setup not only when real income is held constant, but also in the Slutsky sense since the demand for children has a positive income effect.

The price of children is the net cost of rearing them, and obviously depends on the cost of food, clothing, and housing. It also depends on the value of the time spent on child care by parents, typically mothers. The foregone value of the time spent rearing children in modern economies is well over half the total cost (see Espenshade 1984). The net cost of children, especially in less developed countries, is often greatly reduced by the value of their contribution to family earnings, and by their expected contribution to the support of parents when they become elderly or ill. The cost to parents of having children is also affected by public policies that in effect tax or subsidize children, such as the explicit tax on large families in China.

The modern adjustment to the Malthusian model involved in considering cost has important implications for behavior. Locay (1991) considers differences in both incomes and the cost of children in an excellent Malthusian-style analysis of population equilibrium among different tribes of American Indians prior to contact with Europeans.

Differences in the cost of children also help explain, for example, why rural fertility has invariable exceeded that in cities, even though rural incomes have usually been lower. For it is cheaper to rear children on farms, especially when young children contribute to milking cows, tending herds, and other farm tasks.

Attention to the cost of children shows how various public policies influence fertility. For example, the income tax deduction for children affected the demand for children in the United States by reducing their cost (see Whittington et al. 1990). The rise of Swedish fertility in recent years relative to that in West Germany and other countries of Western Europe has been related to the generous subsidies to child care facilities and the lengthy paid leaves for parents of newborn children (see Gustafsson and Willis (1990)). And the big subsidies to child rearing in what had been the German Democratic Republic apparently raised birth rates there, at least for a while (see Vining 1984; Monnier 1990).

But perhaps the most significant contribution from recognizing the importance of cost is its help in explaining the fall in fertility as countries develop. Economic growth not only raises incomes, but also increases the cost of children, partly because time spent on child care becomes more valuable as an economy

develops (see, e.g., Lindert 1980). The induced substitution effect against children could outweigh a positive income effect from development to produce a strong negative relation between per capita income and the demand for children. Studies from several countries indicate that the negative effect of wives' wage rates on child-bearing dominates the effect of larger family resources (Butz and Ward 1979; Ermisch 1988; Heckman and Walker 1990; Cigno 1991).

3. Quality of children

In Malthus's time, parents in most families had relatively few ways to spend on children since education, training, and medical care well all quite rudimentary. But an analysis of the demand for children that ignores various dimensions of their "quality" became less and less relevant with the economic development and other changes that began during the nineteenth century. It would be absurd now to omit education, training, and health when considering parental interest in children.

The utility function in (1) is readily modified to incorporate the quality of children:

$$U = v(x)+b(n,q) \ , \tag{5}$$

where I assume all children are of the same quality (q), and where the function b is assumed to be weakly concave in both n and q. Quality also has a major effect on the resource constraint because the cost of an additional child depends on its quality, while the full cost of higher quality children depends on their number. A simple modification of the constraint in (2) is

$$p_x x+p_n n+pnq = I \ , \tag{6}$$

where $p_n+pq = \prod_n$ is the full marginal cost of an additional child, and $pn = \prod_q$ is the full marginal cost of higher quality. The term p_n refers to the cost of child-bearing and other fixed expenditures that are independent of quality, while p refers to education, health, and other variable costs.

The interaction between the quantity and quality of children in the non-linear budget equation and also in the utility function has several paradoxical implications for fertility. For example, a rise in income could reduce the demand for children – even when there is a positive "pure" income effect – if higher income greatly increases the education and other training of children. The reason is that higher expenditures on training increase the variable cost of children, and could dominate the increased demand due to the income effect.

Technical details are developed elsewhere (see, e.g., Becker 1960; Willis 1973; Becker and Lewis 1973; Cigno 1991, chap. 5). Here let me sketch a few applications. Rates of return to expenditures on the education and training of children have been relatively high in cities partly because the division of labor is carried much further in cities than in rural areas. This encourages smaller families in cities as parents substitute toward quality and away from quantity. The same considerations help explain why economic development raises investments in human capital while reducing fertility and family size (see, e.g., Wahl 1991) – I come back to this important relation later on. Moreover, it is not surprising to find

within a country that large families tend to have less well-trained and less healthy children than small families (see Blake 1989), and that ethnic groups in the United States with smaller families tend to have better-educated children (see Chiswick 1988).

The Malthusian analysis links fertility (and mortality) to the economy through the effects on population and labor supply. The neo-classical growth model stresses that population growth affects the capital-labor ratio and the degree of capital deepening. The quality-quantity analysis retains both these forces, but also relates fertility to the economy through the education and other human capital of the labor force. It is increasingly recognized that the accumulation of knowledge largely embodied in people is crucial to the economic development process. Therefore, as I illustrate later on, the connection between fertility and human capital provides a vital link between demographic change and economic growth.

I have intentionally left the specification of "quality" vague since no single formulation is best for all purposes. But an inclusive and surprisingly flexible approach equates quality simply with the utility of children. Their utility obviously depends on how much human capital they have, but utility depends on many other variables as well.

If quality (q) does equal the utility of each child, and if parents' utility is linear in child's utility, then parental utility can be expressed as

$$U_t = v(x_t) + a(n_t) n_t U_{t+1} \ , \tag{7}$$

where $n_t U_{t+1}$ is the total utility of children. The utility of parents and children are distinguished by time subscripts that refer to overlapping cohorts or generations.

This utility function of parents can be interpreted not only from the quantity-quality viewpoint, but also as a representation of altruism toward children. Altruism per child is measured by $a(n)$, and it is plausible to assume diminishing marginal utility from children in the sense that altruism per child falls as the number of children increases ($\mathrm{d}a/\mathrm{d}n < 0$).

The degree of altruism per child also determines the intergeneration discount rate in the dynastic utility function. This can be seen by using the equivalent of (7) to substitute for U_{t+1}, U_{t+2}, etc. to get an explicit representation of dynastic utility:

$$\left.\begin{aligned} U_t = v(x_t) &+ a(n_t) n_t v(x_{t+1}) \\ &+ a(n_t) a(n_{t+1}) n_t n_{t+1} v(x_{t+2}) \\ &+ \ldots + A_{t+i} N_{t+i} v(x_{t+i}) \end{aligned}\right\} \ , \tag{8}$$

where $N_{t+1} = n_t \cdot n_{t+1} \ldots n_{t+i-1}$, and $A_{t+i} = a(n_t) \ldots a(n_{t+i-1})$. (9)

Dynastic utility is the discounted sum of the utilities of each generation of descendants [$N_{t+i} v(x_{t+i})$], where the discount rate in each generation (A_{t+i}) depends on the altruism and fertility of all ancestors (for elaborations, see Becker and Barro 1988).

John Caldwell (1976) and others (see, e.g. Willis 1982) emphasize that economic development changes the direction of intergeneration transfers. Instead

of children contributing to their parents – partly through old age support – development helps reverse the direction, as parents begin leaving larger bequests and investing more in the human capital of children. Equations (7) and (8) imply that the fall in fertility with development raises the degree of altruism per child and the intergeneration discount rate ($a(n)$ rises since $a'(n)<0$). This encourages greater transfers from parents to children even with no social security, pensions, or other institutional changes. Of course, fertility and transfers are jointly determined, and Sect. 7 analyzes this determination in a simple model of economic growth.

Models of parental altruism were developed originally to discuss intergeneration transfers within families and the organization of family production and consumption (two early studies are Barro 1974, Becker 1974). Issues in public finance, including the effects of government debt and social security on private savings, and in family economics, including the effects of anticipated bequests on the behavior of children, continue to be vigorously pursued. I discuss some of these topics in the next section.

Some students of fertility behavior object to formulations like that in (7) and (8) because of a belief that these fail to capture demands for children not motivated by altruism. But these equations do not necessarily presume that altruism toward children is strong – it could be weak or even nonexistent ($a(n)$ could equal zero). It should be clear from what I have already discussed that the demand for children depends not only on the utility function, but also on how children affect parental resources. Even selfish parents would have large families if children were profitable: if they contribute more to parental support than they require in outlays on food, parental time, and other goods and services. In particular, parental altruism is fully consistent with a demand for children motivated mainly by their expected contribution to the old age security of parents.

4. Overlapping generations

Biological reproduction requires that the analysis of fertility be imbedded in an overlapping generations framework, where prime-age men and women produce children who become the adults of future generations. In the Malthusian model, the children produced by this generation become the workers of the next generation. Demographic theorems on stable populations and population pyramids rely on the systematic overlap of different generations (see, e.g., Coale and Demeny 1966), but the overlapping framework did not become common in economics until Samuelson's classic paper (1958).

Economists now use overlapping generation models to study the determinants of old age support and other "transactions" between the old and young, the demand for money, the accumulation of capital over time, and many other issues. Family economics brings to these problems recognition of the obvious, although frequently neglected, fact that the old and young are not strangers who engage in market transactions, but that the young are typically the children of the old (one searches in vain for such recognition in many theoretical articles on overlapping generations; see e.g., Geanakopolus's article on overlapping generations in the *New Palgrave Dictionary* 1987). Altruism, loyalty, guilt, and other emotional ties link the young to the old that color and often dominate so-called "transactions" between them (Becker 1991; also see Cigno 1991, chap. 9).

Most relevant for present purposes is that the number of younger persons who are available to support or "transact" with the older generation is determined partly by fertility decisions, which in turn depend on the relations between generations. For example, especially in undeveloped countries, the gain from having a large family depends on whether children can be expected to care for parents when they are old or ill. These expectations partly depend on whether norms and other social pressures force adult children to chip in and help out. They also depend on whether parents can instill in children – through control over their upbringing – guilt, love, and other attitudes that make children willing to help out even when they receive no material quid pro quo.

The relations between generations also help determine fertility in developed countries. Consider as an example, social security taxes on the young that finance payments to the elderly. Such public support of the elderly reduces their need to depend on children, which is why social security has a huge effect on whether parents live with their children (see Michael et al. 1980). The reduced support from children, even when parents get social security, still depresses the value of having children, and thereby reduces fertility. However, the induced decline in family size ultimately lowers the equilibrium number of working adults per retired person, which makes it more difficult to finance the public system of old age support that caused this reduction in fertility in the first place.

As is suggested by this discussion, and can be proven more rigorously, social security systems create a discrepancy between private and social gains from having children. For parents do not take into account the benefits their children confer on other families through the taxes that children pay to support other people's elderly parents. Such a discrepancy provides a justification for subsidies to parents who have larger families.

A still more subtle implication of the analysis is that social security, public debt, and other intergeneration transfers to older generations discourage fertility, even when elderly parents do not get support from children, but instead help support children with bequests. For altruistic parents who are providing children with bequests raise their gifts and bequests to help offset the government taxes on younger generations that finance social security payments or interest on debt. But such higher transfers to children raise the effective cost of having children, which also reduce the demand for children (see Willis 1980; Becker and Barro 1988; Wildasin 1990).

This is not the end of the story, for the lower fertility encourages, through quality-quantity interactions, still larger bequests to each child and greater investment in their human capital. Therefore, the endogeneity of fertility implies that full Ricardian Equivalence does not hold even with simple altruism stories. But it does not restore conventional results about the effects of social security or public debt on private savings. For the reduction in fertility due to a more generous social security system (or increased government debt) *raises* rather than reduces *per capita* private savings by raising bequests to and investments in later generations.

However, the overlapping generations framework also implies that the initial impact on fertility of social security and other variables may differ from their ultimate impact as behavior evolves over generations. Links between the demand for children in different generations have been emphasized by Richard Easterlin (see, e.g., Easterlin 1968, 1980).

Each generation within a dynastic family simultaneously determines its number of children, bequests and its investments in children's human capital. Similar-

ly, the fertility and other decisions of these children depend on their human capital and inheritances. Therefore, the behavior of parents and children are connected through the relation between the capital transferred to successive generations of descendants.

To illustrate the implications of these connections, consider a permanent rise in the social security tax or other permanent events that initially lower fertility and raise bequests and investments in each child. The greater wealth, human capital, etc. of the younger generation affects its own fertility choices. If the wealth effect dominates various possible substitution effects, fertility will begin to rise over time after its initial fall. Under some circumstances, eventually it *fully* returns to the equilibrium level that existed prior to the changes that triggered the reactions (see the analysis in Becker and Barro [1988]). Other long run outcomes are possible, but the intrinsic fertility dynamics due to the overlapping generation framework often create large differences between initial and very long run effects on fertility. I return to fertility dynamics in the section on economic growth.

5. Effects of mortality on fertility

The Malthusian model assumes that mortality as well as fertility is affected by changes in the standard of living. Even if mortality is exogenous, fertility and mortality are related, for mortality changes can cause fertility to change. In particular, since both fall over time as countries develop, it is worth investigating whether the falls in mortality could have helped produce the declines in fertility.

The modern analysis of fertility recognized early that changes in child mortality affect birth rates and the demand for children (see, e.g., Becker 1960; O'Hara 1975). For, presumably, parents care mainly about the number of children who survive childhood. If they want a fixed number of survivors, then obviously increases in the probability of survival cause equal percentage declines in births in order to hold fixed the number who survive.

A more sophisticated analysis recognizes that declines in child mortality reduce the expected cost of producing each surviving child by lowering the average number of births needed to get a survivor. Since the demand for children is negatively related to its price – quality considerations are ignored for the moment – declines in child mortality should increase the demand for survivors. This implies that the number of births would fall by less than the rise in the probability of surviving childhood. The number of births could even increase if the price elasticity of demand for children were sufficiently large.

Yet when measured by the number of surviving children, as well as when measured by the number of births, fertility fell along with child mortality during most of this century and much of the nineteenth century. Of course, the fall in fertility was perhaps entirely due to rises in the value of time, investments in human capital, and the other changes I have been discussing. But the relation between fertility and mortality may also have contributed, especially since youth and adult mortality also fell by a lot as countries developed. The effect on fertility of changes in youth and adult mortality is usually ignored, but they can reduce the demand for children through the interaction between the quantity and quality of children (the following discussion is heavily dependent on Meltzer 1991).

A decline in adult mortality raises rates of return on investments in education, training, and other human capital. The effects are not trivial when the declines

are large. For example, given the age-education structure of earnings in Mexico in 1963, its adult mortality experience of 1921 would yield a marginal rate of return on 9–11 years of education of 13%, whereas its mortality experience of 1983 gives a rate of return of 14.2% (see Preston 1975; Meltzer 1991, chap. 2). Meltzer also shows that such a 1.2 percentage point difference in rates of return is "large", as judged from evidence on the elasticity of supply of persons to high school and college education.

As a result, declines in youth and adult mortality would induce parents to invest more in the education and other human capital of children. The utility to parents from having larger families also rises when children live longer. Although this could increase the demand for children, not unreasonable assumptions about the sensitivity of parental altruism per child to the number of children implies that declines in youth and adult mortality reduce fertility because of the interaction with greater investments in each child (see Meltzer 1991, chap. 2).

Since declines in child mortality do not have such large effects on rates of return from investments in human capital, it is less likely, although still possible, that they too reduce the demand for surviving children. But even if declines in child mortality raise the demand for survivors, the large falls in mortality at most ages that have accompanied economic development could on balance have reduced fertility, even when measured by the contemporary number of surviving children and not simply by birth rates. Moreover, the evidence analyzed by Meltzer (1991, chap. 4) indicates that a negative relation between fertility and mortality is not just a theoretical possibility, but is suggested by the modern relation between fertility and mortality in countries at different stages of development.

These links between mortality, fertility, and investments in human capital imply that population growth is too gross a variable to introduce into models of economic development. More rapid rates of population growth due to lower mortality are likely to have quite different effects on economic progress than more rapid growth due to higher fertility. Declines in mortality both raise population growth – even if fertility is induced to fall too – and encourage the investments in human capital that help stimulate economic growth. By contrast, exogenous increases in fertility also raise population growth, but discourage investments in both per capita human and physical capital. Sometimes in the often bitter controversy over whether more rapid population growth speeds up or retards economic progress (for a glimpse at these controversies, see the National Research Council 1986), there is insufficient attention to whether greater population growth due to declines in mortality have different effects than greater growth due to higher fertility.

6. Uncertainty and fertility

I have so far ignored the enormous uncertainty associated with having children: about whether and when sexual intercourse will produce a conception, about the health and abilities of children, about their loyalty and support when parents are older, about whether they can be reared in a stable and happy marital environment, and so forth. I cannot do justice to all aspects of the uncertainty, but will only briefly discuss a few issues that are important and also convey the flavor of how uncertainty impinges on fertility choices.

Parents partly adjust to uncertainty about child mortality by adopting a sequential decision-making strategy: the probability of having an additional child in a given interval becomes contingent on the mortality and other experience with prior births. Various empirical studies have estimated the magnitude of mortality "replacement ratios" (see, e.g., Ben-Porath 1976; Schultz 1976; Gomez 1981; Olsen and Wolpin 1983; Wolpin 1984).

Of course, a sequential choice strategy is not useful in responding to the actual youth and adult mortality experience of one's children. But still, fertility decisions would be conditional on expectations about the variability in the youth and adult life spans of children. This is important because the large mortality declines over time have not only greatly increased the expected length of youth and adult lifespans, but also significantly lowered their variability.

In a high mortality environment, the portfolio of "assets" that elderly parents can rely on when they are in need is much less diversified when parents invest a lot of human capital in only one or two children than little human capital in many children. For the death of a child with much human capital destroys most of the insurance protection. However, after mortality has declined to much lower levels, the diversifying advantage from large families is greatly reduced because the variability in length of lives also is much lower. This provides another reason why declines in youth and adult mortality reduce the demand for large families and raise the human capital invested in each child.

To turn to another subject, parents in many less-developed countries, especially in Asia and Africa, reveal a strong preference to have sons (see, e.g., Behrman et al. 1986). This inference is partly based on the much greater mortality of female children in these countries than is consistent with reasonably equal treatment of sons and daughters (see United Nations 1991, p. 27). There is also the evidence that parents are more likely to have another child when the prior children were girls (see, e.g., Leung 1988; Das 1987; Parish and Willis 1990).

The consequences for fertility of uncertainty about the sex of children are less obvious in an expected utility framework than in models that assume the desire – come what may – to have a given number of boys. Nevertheless, a preference for sons by parents who maximize expected utility often does raise their demand for children compared to a situation where they could choose the sex of their children. Leung (1987) concludes from his sophisticated theoretical analysis and empirical estimates that the Chinese population in Malaysia would be as much as 3% smaller if the first child in each Chinese families were a boy.

I believe that most of the desire to have sons stems not from any intrinsic preference for sons, but that sons have greater value to parents in undeveloped economies. Growth and development greatly lower the value of sons by reducing the earnings of children as parents invest more in children's human capital. Development also lowers the contribution of children to the old age support of parents by raising parental savings and social security. These considerations imply that there would be much less "preference" for sons in rich countries.

The empirical evidence supports this conclusion: in rich countries there is greater mortality of male than female children, and much more equal investments in the education and other human capital of boys and girls (see, e.g., Parish and Willis's (1990) discussion of trends in the education of boys and girls in Taiwan). The evidence on parity progression ratios in the United States suggests not a preference for either sex per se, but a mainly a desire for sexual variety (see Ben-Porath and Welch 1976).

What is the effect on fertility of more efficient contraceptive techniques, such as the pill, and of extensive family planning programs that reduce the cost of better contraceptive methods? Clearly, they can affect both the timing and number of children. Practically all discussions assume that improved contraception lowers fertility by reducing the number of "unwanted" births, although it is easy to show that it could actually raise the demand for children by improving the ability to control when children are conceived.

Probably most economists who work on fertility believe that increases in contraceptive use have usually been a response to lowered demand for children, that family planning programs fail when the value of having many children remains high, and more controversially, that families who want to have few children generally manage to get around both imperfect knowledge of contraceptive techniques and legal obstacles to the use of particular methods. A case in point is the Republic of Ireland. The total fertility rate there declined by more than 25% since 1980 even though access to contraceptives is restricted, and much of the population is devout Catholic (see Kennedy 1989). Also relevant is the evidence on the fall of Romanian fertility back to the original levels following a large initial rise after the government banned abortion and outlawed the pill (see Ceterchi 1974).

Nevertheless, it is likely that improved technologies like the pill and good family planning programs sometimes do significantly lower fertility. The relation between the cost of contraception and fertility is one of the more important unresolved questions in the analysis of fertility.

7. Fertility and economic growth

I have considered how the cost of rearing children, investments in human capital, mortality, and other variables influence the demand for children. At the same time, however, fertility affects an economy's performance through its connection with the number and skills of workers. This mutual interaction between the demand for fertility and economic change helps determine demographic and macroeconomic changes over time. Not enough is known yet to tell this story in a single way. To illustrate the processes involved, I will draw on a particular approach taken in my joint work with others.

Barro and Becker (1989) combine the dynastic utility function in (7) and (8) with a two-sector neoclassical growth model. A constant-returns-to-scale sector uses labor and capital to produce consumer goods and new capital, while another sector uses time and goods to produce children. This expands the neo-classical framework to include endogenous population growth due to fertility choices.

A more rapid rate of technological progress still increases the equilibrium rate of growth in per capita income and consumption, and the more rapid rate of growth in consumption lowers the marginal utility of future consumption relative to the present. In this framework, however, more rapid growth in consumption reduces the utility from having children, which is one way a dynastic family saves for the future. As a result, fertility and the rate of population growth both fall – if mortality does not change – which implies that the equilibrium rate of growth in aggregate capital also falls. The implied negative relation between equilibrium per capita income growth and the level of fertility is consistent with the evidence on intercountry growth since 1960 [see Kormendi and MeGuire 1985, but also see Levine and Renelt (1991)].

A catastrophe that destroys a big chunk of the population – perhaps the Black Death or the AIDS epidemic in Africa – initially raises wage rates and per capita incomes. Although even in this modified neo-classical model, eventually wage rates, per capita incomes, and fertility get restored to their initial equilibrium levels, the population level and capital stock remain permanently below what they would have been without the catastrophe. They stay lower even if fertility rose during the transition period while wage rates and incomes were high, and could be much lower if fertility fell during the transition because the higher wages raised the cost of children.

The Barro-Becker analysis follows the neo-classical growth literature in merging human and physical capital – or more accurately, in ignoring the special properties of human capital. Becker et al. (1990) add to the Barro-Becker model a third sector that produces human capital, while continuing to assume that physical capital is produced by the consumer sector. The production of human capital for the younger generation is assumed to depend on the time allocated by the older generation to the "teaching" sector, and also on the human capital of the older generation. I assume here that the output of human capital has constant returns to scale in the human capital of the older generation, although diminishing returns to the level of this human capital is also considered by Becker et al. (1990).

The addition of a human capital sector both complicates and greatly enriches the analysis, which can be developed with Fig. 1. The vertical axis measures the human capital of the younger generation, the horizontal axis the human capital of the older generation, and physical capital is ignored (its introduction requires a more complicated figure but does not change the basic conclusions). The policy function P_0 shows the dynastic utility-maximizing levels of children's human capital for different values of parents' human capital, given the utility function in (7) and production functions in the different sectors.

Steady states are where the policy function intersects the 45 °C line from the origin. With the function P_0, there are steady states at $H = 0$ and $H = \hat{H}$. The steady state at the origin has several "Malthusian" properties: human capital and skills are nil, per capita incomes and wages are stationary and low, and fertility and mortality may be quite high. There is little investment in human capital because rates of return on human capital are below both the endogenous rate of time preference and rates of return on physical capital (once such capital is brought into the analysis). Farmers and even most urban dwellers in poor and stagnating countries do, indeed, have little education.

This Malthusian steady state is stable against limited increases in the human capital of the current generation (as shown by the arrows on P_0), and moderate upward shifts in the policy function. For example, if the initial human capital is $H_0 < \hat{H}$, the economy returns over time along P_0 to $H = 0$. Moreover, for small values of H, fertility is likely to be positively related to income – as in the Malthusian story – so that the increase in fertility at higher levels of parental income and human capital discourages investments in children, and helps return the economy to the Malthusian equilibrium.

Therefore, the stagnating equilibrium and the transitional dynamics have Malthusian properties when deviations are not large. However, the Malthusian model looks myopic for large changes. For one thing, the relation between parents' human capital and fertility must turn negative at some point before $H = \hat{H}$. The substitution effect from higher wages eventually dominates the in-

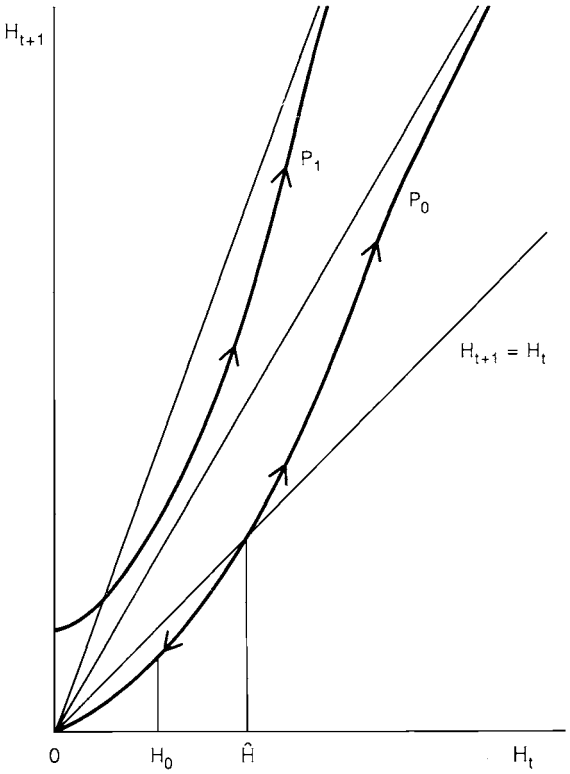

Fig. 1.

come effect since the foregone cost of time spent on children rises as parental human capital increases.

Unlike the steady state without human capital, the steady state at $\hat{H}$ is unstable for both small and large shocks. The instability of the equilibrium at $\hat{H}$ helps propel the economy forward when shocks to the Malthusian equilibrium become large enough. This instability is partly due to interactions between fertility and investments in children.

For example, a small increase in H beyond $\hat{H}$ reduces fertility because incomes and fertility are negatively related when human capital exceeds an amount that is less than $\hat{H}$. The decline in fertility as human capital increases encourages still larger investments in human capital not only by reducing the effective cost of investing in children, but also by lowering the rate of time preference for the present – since $a(n)$ in (8) is negatively related to n. The increased investment in human capital pushes the economy further away from $\hat{H}$ by lowering fertility further, etc.

To show in a different way the consequences of big shocks to the Malthusian equilibrium, consider an upward shift in the policy function that raises it above the origin (see P_1). The shifting variable might be a series of technological advances that raise significantly rates of return to investments in human capital. Or it might be large declines in adult and other mortality that also raise the incentive to invest in human capital.

Since the arrows show there is no longer a steady state at $H = 0$ if the policy function is P_1, human capital would increase over time no matter how low its initial level. Eventually, fertility begins to fall, so that a demographic transition sets in with lower fertility accompanying the declines in mortality that may have helped set off the destabilization of the Malthusian equilibrium. Presumably, further falls in mortality are also induced by the growth in incomes and knowledge as human capital increases.

The "demographic transition" toward low mortality and fertility (see Caldwell 1976; Coale 1987) is not simply the result of "modernization", but itself helps produce a modern economy partly by encouraging greater investment in human capital. Investments in human capital are much more sensitive to the demographic transition than are investments in physical capital because, as we have seen, rates of return of human capital depend much more closely on fertility and mortality than do returns on physical capital.

After emerging from the Malthusian equilibrium, the economy follows a dynamic path toward a new steady state that depends on specification of the several production functions, especially that in human capital sector. In the figure, the economy proceeds along P_1 to a steady state growth equilibrium, where per capita incomes and capital per capita – physical as well as human capital – all grow at a constant rate. These growth rates and the equilibrium level of fertility are determined by the cost of raising children, the productivity of the human capital sector, and other parameters.

The differences between such a growth steady state and the Malthusian equilibrium appear to capture some of the actual differences between developed and undeveloped countries. Fertility is much lower, and per capita human capital and physical capital are much higher, in developed countries. However, in developed countries human capital would be relatively more important than physical capital because rates of return on human capital are sensitive to the declines in mortality and fertility, and also to the advances in technologies that are part of the development process.

This analysis suggests that interactions between investments in human capital, fertility decisions, and mortality changes may be crucial in understanding differences among undeveloped countries, and transitions from undeveloped to growing economies. Demographic variables have less of a role in explaining why one rich country grows faster than another rich country, yet the incentives to invest in human capital and new technologies continue to be fundamental.

It may take large shocks in technology, mortality, and human capital to enable an economy to escape the Malthusian "trap". But once well along the transitional path toward a modern economy, this analysis implies that either very silly policies or very bad luck are required to derail the economy back toward a stagnant position. The reason is that initial conditions are crucial in determining whether an economy ends up with robust growth, or stagnating with low incomes and skills. Put differently, a country's "history" counts in determining where its economy starts from and the shocks it experiences, which in turn determine where the economy goes to.

The modern analysis of fertility is part of a broader analysis of family decisions, including family formation and dissolution. I have concentrated on the relation between fertility choices and investments in children's skills, health, and other human capital. Fertility also interacts with the labor force participation of

married women, divorce rates, whether grandparents live with their children, and many other aspects of family life.

Economic models of fertility are useful not only in understanding the fall in fertility and growth in human capital during the development process, but also have useful implications regarding other changes in family structure. For example, declines in fertility and growth in wages should be accompanied by growing labor force participation and market skills of women, and declines in the gender gap in earnings. The greater economic independence of women would stimulate higher divorce rates and a growth in female-headed households.

Such changes in the economic role of women feed back to fertility since the causation goes in both directions. I should caution, however, that while the implications of the model for evolution of the family are "useful", the timing of various changes in family structure and behavior as economies grow and develop has many puzzles that are not yet resolved.

8. Concluding remarks

I have related the demand for children to parental incomes and the cost of rearing children – especially to the value of the time spent on child care and to public policies that change the cost of children. This paper also links the demand for children to investments in their human capital and other dimensions of the so-called quality of children. Fertility is shown to depend too on child and adult mortality, uncertainty about the sex of children – if there is a preference for boys, girls, or for variety – uncertainty about how long it takes to produce a conception, and other variables.

Since biological necessity dictates that succeeding generations overlap, it is not surprising that fertility in one generation influences the fertility of succeeding generations. The overlapping generations approach provides a useful framework for relating fertility choices to population growth and macroeconomic changes.

The modern approach to fertility leads to very different interactions between population growth and economic growth than is implied either by Malthusian or the usual neo-classical growth models. In particular, it provides a framework for analyzing how societies escape a Malthusian-like stagnating equilibrium and embark on the journey toward becoming modern economies, where per capita incomes, human capital, and physical capital all continue to grow, fertility declines to rather low levels, and married women participate extensively in the labor force.

I am confident that developments during the past several decades in the analysis of fertility have contributed much to our understanding of the relations between fertility and other important economic and social variables. However, unfortunately, as in most other parts of economics, our ignorance still greatly exceeds the amount of firm knowledge. Much remains to be done. But if progress in understanding fertility behavior during the next several decades is as rapid as it has been during the past few, we should be in good shape by some time reasonably early in the twenty-first century.

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