Chapter 3

Population

I

The global rate of population growth over the past half century has been the highest in history. Most of this growth has occurred in poor countries. The rate of growth of the population in the poor countries currently is approximately two percent per year, down from its 1960s peak of almost two and a half percent. This compares to an historical rate of population growth in Europe and North America of less than one percent during the 18th and 19th centuries.

The current high rate of population growth has been driven by a large and sustained decline in mortality rates as a consequence of improved public health and rising incomes. Mortality rates in poor countries have fallen much faster over the past 50 years than was the case during the historical development of the industrial countries.\(^1\) At the same time, fertility rates have also fallen at an historically unprecedented rate, but not fast enough to avoid a large increase in the population growth rate. Thus the “demographic transition” - the shift from a period of high mortality, high fertility and relatively stable population through a period of lower mortality with still relatively high fertility and thus rapid population growth, to a period of low mortality and fertility and thus once again stable population - is still incomplete in most of the poor countries.

Simple Malthusian reasoning has proven incorrect. The rapid population growth of the

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\(^1\)Birdsall (1988, p. 481) cites the case of India, which in 1982 had a life expectancy of 55 and a per capita income under $300 (and a literacy rate below 40 percent). In contrast, life expectancy in England, Sweden and the United States was below 50 years in 1900, while their per capita income was over $1000 and literacy was above 80 percent.
past half century has not brought about falling real incomes and increasing mortality. Per capita income in poor countries has continued to rise (with the important exception of recent decades in sub-Saharan Africa). At the same time, there is a strong negative relationship (in both cross sectional and time series data) between national income *per-capita* and aggregate fertility and population growth rates. On average, women in richer nations have one and a half to two children over their lifetime, while women in poor countries average three and a half to four children over their lifetime. An average women in Africa has between 6 and 7 children over the course of her life (Haab and Cornelius, 1997). A similar regularity can be found in microeconomic data - richer women tend to have fewer children.

These simple correlations do not provide enough information to permit inference about the effect of population, or its growth, on income or its growth. Population growth and income growth influence each other, hence determining causality through statistical regularities is quite difficult. Nor does economic theory offer clear conclusions. To the extent that increasing returns to scale underlie growth, population growth can have a positive effect on growth. The existence of any fixed resources and diminishing returns, of course, tends to implies a negative effect of population on economic growth.

The remainder of this chapter examines the reproductive decisions of families in order to begin to unravel the connections between fertility, population and income. In section II, we present a conventional model of household decision making with respect fertility and investment in the human capital of children. It will be seen that this household model provides a number of insights into the demographic transition. However, the assumption of a unitary household is particularly problematic in the context of fertility decisions. Explicit acknowledgment of the
potentially divergent preferences of men and women is appropriate and opens up important areas of inquiry.

In the remainder of the chapter we examine the interconnections between the fertility decisions of different families and the possibility that these interconnections give rise to multiple fertility equilibria. In section III, we argue that there may be important externalities associated with fertility decisions. People’s notion of appropriate behavior concerning the determinants of fertility is strongly conditioned by the behavior of other members of the community. Hence, a strategic complementarity arises in fertility decisions, and using a model by Dasgupta (1993), we show that there may be multiple (Pareto-ranked) fertility equilibria. Finally, in section IV, we discuss another avenue through which fertility decisions are strongly influenced by the choices of other households, even when there are no direct externalities. The link we explore (using a model by Basu and Van (1996)) is via child labor. If fertility is low, labor is relatively scarce, adult wages are high, then families can afford to keep their children out of the labor force. On the other hand, an equilibrium might also exist in which families are large, wages are low, and impoverished families must send their children to work.

II

The conventional approach to understanding fertility decisions is based on the household model described in Chapter 2. The choices of a household with regard to fertility are treated in a manner analogous to all other decisions taken by the household. Most work by economists,
following the seminal contributions by Becker (1960) and Becker and Lewis (1973) has focused on the trade-offs households face between the number of children, investment in these children, and current consumption of goods. Thus let $x$ be (parental) consumption and $n$ be the number of surviving (to an arbitrary, and for current purposes unspecified, age) children. For simplicity, we assume that each child is treated similarly, so let $z$ be the level of human capital achieved by each child, known in this literature as “child quality”. Household utility is described by the function $U(x, n, z; \alpha)$. We assume that $U(.)$ is increasing in $x$ and $z$, and increasing in $n$ at least for small $n$. The human capital achieved by the household’s children depends on their own consumption $c$ and also on an input of time and effort by the parents $t$. Thus $z = Z(c, t; \beta)/n$. The opportunity cost of the time that the parents invest in children’s human capital is the forgone wage that the parent would have earned. $\alpha$ and $\beta$ are vectors which incorporate exogenous factors which influence the preferences of the household and the technology for producing child human capital in the household. The household’s problem, then, is to solve:

$$\text{Max } U(x, n, z; \alpha) \text{ s.t. }$$

$$z = Z(c, t; \beta)/n$$

where we have chosen units so that the time endowment of the parents is 1. Thus parents face a tradeoff between the human capital achieved by their children, the number of children they raise, and their own consumption.

This model provides a framework in which many of the features of the demographic transition can be understood. For example, as the wage (particularly the female wage) increases with economic growth, the opportunity cost of rearing children increases, sharpening the tradeoff between adult consumption and both the number and human capital of the household’s children.
At the same time, \( \alpha \) is likely to be changing. Part of utility derived from children and their human capital is the expected contribution that the children will make to the parents’ consumption in the future. That is, children can be seen (at least in part) as investments. As economic growth occurs, the return to skilled labor increases relative to the return to unskilled labor. This change will be reflected in parental preferences over the number of children and the human capital embodied in each child. As a consequence, households move towards investing more resources into each of a smaller number of children. Similarly, \( \beta \) can change as a consequence of economic growth or government policy. The provision of free primary education would permit children to achieve higher levels of human capital at given inputs of \( c \) and \( t \), and thus raise both \( z \) and \( n \).

The conventional household model of fertility decisions also provides valuable guidance for empirical work. The household makes simultaneous and interdependent decisions regarding fertility, investment in child human capital, adult consumption, and labor market participation. It would be an error to treat any of these decisions as exogenous in an econometric exercise. Thus, for example, an analysis of the effect of household income on fertility has to be conducted with care. A simple regression in which fertility is the dependent variable and income an independent variable would be subject to simultaneity bias because income depends on the labor market decisions of the household. The household model provides a context for designing an appropriate empirical strategy; in this case, the wage could serve as an instrument for the endogenous explanatory variable.

The household fertility model provides insight into the reproductive behavior of families. Most importantly it emphasizes the point of view that people evaluate the relative merits of their options regarding their family size and the health and education of their children. At the same
time, the model is extremely incomplete and therefore can be misleading. On the one hand, this model of a unitary household obscures the potentially divergent goals of men and women regarding the number and treatment of children. On the other hand, the model neglects the potentially strong influence of the social context on fertility decisions. These comments are not mere cavils. Although it can be argued that they are true for all economic choices, they gain particular weight in the context of fertility decisions. Moreover, both lines of reasoning provide avenues through which the conventional model might be enriched to shed light on a crucial pair questions: (1) is the rate of population growth in the poorest countries too high?; and (2) why has fertility responded so slowly to declining mortality in some areas, particularly in Africa?

The divergence between men and women in the costs and benefits of bearing and raising children is stark. Women bear all the physical risks of child birth (which are very substantial in poor countries - one in a hundred births results in death for the mother in Africa (Haab and Cornelius, 1997)). Most of the effort required to raise children is provided by women. Here, more than in virtually any other context, the fiction of “household preferences” is inappropriate.

There is striking empirical evidence that men and women have divergent preferences with respect to fertility and investments in children’s human capital. Men and women often express different targets for total fertility (Birdsall 1988). Much of the empirical evidence (reviewed in Strauss and Thomas (1995)) which casts doubt on the unitary household model concerns investments in child human capital. In a number of countries, additional income in the hands of mothers leads to larger increases in child health and education than similar additional income in the hands of fathers. Finally, there is strong evidence that more educated women have lower fertility and are more likely to use modern methods of birth control. It is likely that there are a
number different mechanisms through which female education affects fertility. Wages increase with education, so the opportunity cost of the time spent rearing children is higher for more educated women. More educated women tend to have healthier children, lower mortality amongst their children, and thus lower fertility. They may also place a higher value on education, and thus prefer fewer children with higher investment in human capital in each child. Finally, it may be the case that more educated women are able to negotiate or bargain more effectively within the household, so that fertility outcomes are closer to their own preferences than is the case for women with less education.

If men and women have divergent preferences with regard to fertility and investment in children, then an understanding of fertility outcomes and thus the determinants of population growth rests on an understanding of the process of household decision making. It is apparent that the process of decision making within households is quite variable across societies, and thus general lessons are difficult to draw. However, to the extent that decisions over fertility are made or influenced by individuals who do not bear the full cost of child bearing and raising, then there exists the potential for an equilibrium in which fertility is too high.

**III**

Fertility decisions are made through a process of negotiation within households, but they are not made in isolation. Here, more obviously than is the case with most decisions, the behavior of households depends upon the choices of their neighbors. The proximate determinants of fertility - the use of contraceptives, the timing of breast feeding, the frequency of intercourse -

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2This section draws extensively on the discussion in Dasgupta (1993, chapters 12 and *12).
are actions that are strongly influenced by cultural patterns. Put most simply, it may be the case that imitation plays an important role in fertility decisions. As long as all or most other couples engage in practices which encourage high fertility, any individual couple might find it difficult to do otherwise. The same couple, however, might prefer a smaller household size in a different social context. If this is the case, then choices regarding fertility generate an externality: each household’s child-bearing decision helps set a cultural pattern, and this affects the preferences of all other households.

The form of the externality generated by fertility decisions involves strategic complementarities (Cooper and John, 1988). The marginal utility to a household of having an additional child is increasing in the number of children in other households. Following the notation in Dasgupta (1993), suppose that there are M households in a society, and let \( \mathbf{X} = (X_1, X_2, \ldots, X_M) \) be a vector describing the number of children in each household. Suppose that each household i has preferences over its own number of children, and also over the number of children in each other household. We ignore the obvious integer constraints, and assume that preferences can be summarized by the (twice continuously differentiable) utility function \( U_i(\mathbf{X}) \). For each household i, the externality we have described implies that \( \frac{\partial^2 U_i(\mathbf{X})}{\partial X_i \partial X_j} > 0 \) for \( i \neq j \).

Strategic complementarities raise the possibility of multiple Nash equilibria. Suppose each household decides on the number of children taking the decisions of other households as given. Then household i solves a problem of the form: \( \max_{\mathbf{X}_i} U_i(\mathbf{X}) \). Let \( \mathbf{X}_i = (X_{i1}, X_{i2}, \ldots, X_{iM}) \). If we make the conventional assumption of diminishing marginal utility over the number of the household’s own children, then for each vector \( \mathbf{X}_i \), there is a unique value of \( X_i \), say \( X^* \), which
solves household $i$’s problem. The function $X'(X_i)$ is the household’s reaction function, describing its decision given the actions of all other households. The implicit function theorem implies that $\delta X'(X_i)/\delta X_j > 0$. The number of children chosen by a household is an increasing function of the number of children in any other household.

Let’s suppose that all households have identical preferences, and consider symmetrical Nash equilibria. Let $Z$ be the number of children in all other households. Thus $X_i = (Z, Z, ..., Z) = Z$. A symmetrical Nash equilibrium is a fixed point in which $X'(Z)=Z$, that is, if all other households have $Z$ children, a representative household would also choose $Z$ children. In Figure 3.1, the horizontal axis is $Z$, the number of children in each other household, and the vertical axis is $X^*$, the optimal choice of the representative household conditional on the choices of the other households. The number of children in a household must lie between 0 and $X_{\text{max}}$. We know that the reaction curve $X'(Z)$ is upward sloping - one example is drawn in the figure. Any intersection of the reaction function with the 45° line represents a symmetrical Nash equilibrium. We have drawn the reaction function so that there are three symmetric equilibria, corresponding to three different levels of fertility. Because the equilibria are symmetric and the households are identical, they can be Pareto ranked - (generically) one is better than the others. There may be asymmetric equilibria as well, but the general point has been made: when there are strategic complementarities it is possible that there are multiple equilibria and some of these equilibria are better than others.

Two similar societies (composed of households with similar preferences), therefore, might be found at different equilibria. Why should one society find itself in equilibrium at point $A$, while another is in equilibrium at the (say) Pareto-dominated point $C$? To answer this question it is necessary to move outside the model as we have constructed it so far. The notion of Nash
equilibrium rests on *expectations*. Given household i’s expectation of the fertility choices of other households, it selects its preferred number of children. When this selection matches the expectations of all other households, and the same is true for each household’s selection, then the society is at a Nash equilibrium.

In the context of fertility decisions, it is most useful to focus on the role of history in forming expectations. Suppose that a society is characterized by high fertility for conventional reasons (perhaps due to a high rate of infant mortality). Consequently, a set of practices (e.g., polygyny and a low age of marriage for women) which encourages high fertility is common. These practices are the empirical embodiment of the strategic complementarity that we have hypothesized, and they shape the expectations of each household. Even after infant mortality declines, these practices remain and as a consequence each household continues to choose high fertility. Thus the type of externality that we have hypothesized to be important with respect to fertility decisions raises the possibility of a social equilibrium which is sub-optimal and requires coordinated effort to change.

**IV**

Household choices with regard to fertility are strongly conditioned by the social environment even when there is no direct interconnection between preferences and the choices of one’s neighbors. The fertility decisions of households effect the demographic structure of the society, and this in turn can influence relative prices and thus other households’ fertility decisions. In this section, we present a simplified version of a model by Basu and Van (1996) which starkly illustrates the possibility of multiple fertility equilibria. In this model, if the economy is
characterized by small families, labor is relatively scarce, adult wages are high, families can afford to keep children out of the labor force, and all families prefer to remain small. An alternative equilibrium might exist in which adult wages are low, families are so poor that all children must work, and each family decides to have many children (and hence labor is abundant and wages low).

The model is driven by three crucial assumptions. First, preferences are such that a family will send its children to work only if income from adult labor is very low. Thus, child leisure is a luxury good. Second, technology is such that adult and child labor are substitutes. And third, children are capable of providing net economic benefits to the family. If children do work, they can contribute more than their consumption needs to the family. This final assumption is more likely to be valid in poor countries, where productivity is less tied to human capital than in rich countries. Children who work in poor countries are able to earn more than they consume at an earlier age than is the case in rich countries (see Dasgupta (1993) for a discussion).

These three assumptions are sufficient to generate the possibility of multiple fertility equilibria. For the remainder of this section, we will make a series of further (draconian) assumptions to simplify and clarify the analysis, but the general message that the interaction between fertility decisions and labor market outcomes might generate the possibility of multiple equilibria rests on these three core assumptions.

Suppose that there are $N$ families, each of which has one adult and $m$ children (the “one adult,” of course could be interpreted as a husband-wife couple). There is one good, and we will not examine issues of intrahousehold distribution. Instead, we assume that if the adult consumes $c$, then each child consumes $\beta c$ with $\beta < 1$. Thus $\beta$ is an “adult-equivalence” rating. Adult labor is
supplied inelastically, but the household chooses child labor supply (e). Again abstracting from
distributional issues within the household, we assume that all the family’s children supply the same
amount of labor. For simplicity, we restrict the available choices of child labor to 0 or 1.
Continuing to assume away issues of negotiation and power within the household, let there be a
household preference ordering over pairs of consumption (c) and child labor effort (e). These
preferences exhibit a particularly strong form of the “child labor as luxury good” assumption: the
household prefers that children work only if consumption would fall below some exogenously
specified subsistence level in the absence of income from child labor. Household preferences are
defined over pairs (c, e), for c ≥ 0 and e ∈ {0, 1} (recall that child consumption is simply βc).
Preferences are:

\[
\begin{align*}
(c + \delta, e) & > (c, e), \\
(c + \delta, 1) & > (c, 0) \quad \text{if } c < s, \\
(c + \delta, 1) & < (c, 0) \quad \text{if } c \geq s,
\end{align*}
\]

for \(\delta > 0, c \geq 0, e \in \{0, 1\}\). Thus preferences are such that higher (average) consumption is preferred
to lower, but children only work if the family is destitute in the absence of the income from their
labor.

The household budget constraint is

\[
c + m\beta c = mw_c + w_a
\]

(3)

where \(w_a\) is the adult wage and \(w_c\) is the child wage. The household chooses its preferred
combination of \(m, c\) and \(e\) subject to the budget constraint (3).

To begin with, consider the choice of \(c\) and \(e\) conditional on a given family size. Given \(m,\)
children work only if the adult wage is too low to provide sufficient adult income for the family to avoid destitution. Thus,

\[
C = \begin{cases} 
  \frac{w_a}{1 + m\beta} & \text{if } w_a \geq (1 + m\beta)s \\
  \frac{w_a + mw_c}{1 + m\beta} & \text{if } w_a < (1 + m\beta)s,
\end{cases}
\] 

(4)

\[
e = \begin{cases} 
  0 & \text{if } w_a \geq (1 + m\beta)s \\
  1 & \text{if } w_a < (1 + m\beta)s.
\end{cases}
\] 

(5)

The aggregate supply of adult labor is \( S_a = N \), and of child labor is \( S_c = 0 \) if \( w_a \geq (1 + m\beta)s \), and \( S_c = mN \) if \( w_a < (1 + m\beta)s \).

Now we turn to our second assumption, regarding the demand for labor. We have assumed that child and adult labor are substitutes in production. Let us go further to assume that they are perfect substitutes, so that output in any firm \( i \) is determined by \( f(A_i + \gamma C_i) \), where \( A_i \) is the amount of adult labor used in firm \( i \), \( C_i \) is the amount of child labor used in firm \( i \), and \( \gamma < 1 \). So \( 1/\gamma \) children can do the same work as 1 adult. Let there be \( n \) identical price-taking firms. If \( \gamma w_a < w_c \), then adult labor is cheaper than child labor and no firm demands child labor. The aggregate demand for child labor \( D_c = 0 \), while the aggregate demand for adult labor \( D_a \) is determined implicitly by \( f'(D_a/n) = w_a \). Similarly, if \( \gamma w_a > w_c \), child labor is cheaper than adult labor and no firm demands adult labor. Thus \( D_a = 0 \) and \( D_c \) is determined by \( \gamma f'(\gamma D_c/n) = w_c \). Finally, if \( \gamma w_a = w_c \), then firms are indifferent between hiring adults or children. In this case, each firm only
cares about the effective labor \((L_i = A_i + \gamma C_i)\) it hires; the composition of \(L_i\) is a matter of indifference. Thus in this case \(D = D_a + \gamma D_c\) is determined implicitly by \(\gamma'(D/n) = w_a = w_c/\gamma\).

Conditional on fertility choices (that is, given \(m\)), the labor market will clear if there is a pair of wages \((w_a, w_c)\) such that at those wages \(D_a = S_a\) and \(D_c = S_c\). First consider only wage pairs such that \(\gamma w_a = w_c\), so that firms are indifferent between hiring adults or children. We set the level of fertility at \(m = m^1\) for the purposes of this illustration. In figure 3.2 we graph the supply of effective labor \(S^l = S_a + \gamma S_c\) against the adult wage (remembering that as the adult wage is changed, the child wage also changes to maintain \(\gamma w_a = w_c\)). If \(w_a \geq (1+m^1\beta)s\), the supply of effective labor is restricted to the adult labor force, so equals \(N\). However, if the wage drops to \(w_a < (1+m^1\beta)s\), then families faced with destitution send their children to work and the labor supply increases to \((1+\gamma m^1)N\). Our assumptions on preferences suffice to guarantee that this economy is characterized by a “backward-bending” supply of labor. At higher wages, less labor is supplied. Obviously, we have made an extreme assumption for the sake of simplicity. Such stark behavior is not required for the conclusions we will draw. Any preferences which incorporate the assumption that child labor is withdrawn once adult wages are high enough, and that the rate at which child labor is withdrawn exceeds the rate at which adults increase their own supply of labor, will suffice to raise the possibility of multiple equilibria.

In Figure 3.2, we also graph the demand for effective labor (still restricting attention to the case in which \(w_a = w_c/\gamma\)), which is determined by \(w_a = \gamma'(D/n)\). We have drawn the supply of and demand for labor such that there are two equilibria. At \(E^0\), adult wages are high, children do not work, and the demand for labor is met entirely by adults. At \(E^1\) the adult wage is low, the child wage is very low \((w_c = \gamma w_a\) ) and both children and adults work. There are also equilibria at
which \( w_a \neq w_c / \gamma \). It cannot be the case that in equilibrium \( w_a > w_c / \gamma \), for in that case the demand for adult labor is zero while its supply is positive. However, if \( w_a = w^0 \) (as at \( E^0 \)), then any child wage such that \( w_c \geq \gamma w^0 \) is an equilibrium, for at those wage pairs both the demand for and the supply of child labor is zero.

Therefore, conditional on \( m \), it is possible that there are multiple labor market equilibria. We now show that these multiple labor market equilibria might correspond to multiple equilibria with respect to the fertility choices of households. Suppose that households have a choice of two levels of fertility: \( m \in \{m^h, m^l\} \), with \( m^h > m^l \). We have drawn the labor market equilibria conditional on an assumed (low) level of fertility. We now ask the question: given these labor market outcomes, would the households voluntarily choose the assumed level of fertility?

In figure 3.2, the supply function \( S^l \) is drawn with \( m = m^l \). The supply of labor with \( m \) exogenously assumed to be \( m^h \) would be \( S^h \). Now consider labor market equilibrium \( E^0 \), where \( m = m^l \), the adult wage is \( w^0 \), and children do not work. Would households choose the level of fertility \( m^l \)? At \( E^0 \), with children not working, \( c(m^l) = w^0 / (1 + m^l \beta) > w^0 / (1 + m^h \beta) = c(m^h) > s \). Hence children do not work (regardless of the choice of fertility) and lower fertility is preferred to higher fertility. Hence, \( E^0 \) is an equilibrium: households optimally choose low fertility, wages are high, and only adults work.

Now consider \( E^1 \). At \( E^1 \), we assumed that fertility is low (that is, \( m = m^l \)). The labor market clears with \( w_a = w^l \), \( w_c = \gamma w^l \) and children work. Consumption, therefore, is given by

\[
c(m^l) = \frac{w^l (1 + m^l \gamma)}{1 + m^l \beta} < \frac{w^l (1 + m^h \gamma)}{1 + m^h \beta} = c(m^h).
\]

The inequality is true because of our third
assumption, that children provide net economic benefits to their families (that is, that $\gamma > \beta$). At $E^1$ children are working, and so families prefer high to low fertility in order to capture the economic benefits offered by the additional children. $E^1$, therefore, is not an equilibrium.

Instead, consider $E^2$, where it is assumed that fertility is high ($m = m^h$). The labor market is in equilibrium with $w_s = w^2$ and $w_c = \gamma w^2$, and children are supplying labor. In this case,

$$c(m^l) = \frac{w^2(1 + m_h \gamma)}{1 + m^l \beta} < \frac{w^2(1 + m^h \gamma)}{1 + m^h \beta} = c(m^h)$$

and high fertility is chosen by the household.

Thus $E^2$ is an equilibrium and this economy has multiple fertility equilibria. In $E^0$ there is low fertility, high adult wages, and a low supply of labor. In $E^2$ there is high fertility, low wages, and children work.

The high fertility equilibrium is clearly inferior to the low fertility equilibrium for each laboring household. Yet it is individually optimal for each of these households to choose high fertility, given that the other households are each choosing high fertility. The demographic structure generated by the fertility choices of the rest of the population yields low wages, and drives households to send their children to work. Given this environment, it is individually optimal to have many children. The general point is that, once again, there is a possibility of a 

coordination failure and thus a potentially valuable role for public policy. The design of appropriate policy, obviously, is not trivial. It could be easy to slip into the worst excesses of Indian or Chinese population policy using the argument that population has a natural tendency to

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3It is not true that this equilibrium is Pareto dominated by the low fertility equilibrium, however. We have not completely characterized this economy, as we have not described the consumption choices of the owners of the firms (which are making profits). If we assume that they are a separate population that consumes all the profits, then they are better off in the high fertility equilibrium.

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be to large as a consequence of these and related coordination failures. Even focusing more carefully on particular mechanisms through which the coordination failure arises does not always lead to simple policy recommendations. Basu and Van (1996), for example, demonstrate the complexities of policy towards child labor in the model we have just described. Even in this model, a ban on child labor can have dramatically positive or negative effects on household welfare and various forms of partial bans can raise or lower child welfare depending upon the specific characteristics of the economy.
References


Figure 3.1
Figure 3.2
Chapter 3

Population

I

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there are no direct externalities. The link we explore (using a model by Basu and Van (1996)) is
via child labor. If fertility is low, labor is relatively scarce, adult wages are high, then families can
afford to keep their children out of the labor force. On the other hand, an equilibrium might also
exist in which families are large, wages are low, and impoverished families must send their
children to work.

II

The conventional approach to understanding fertility decisions is based on the household
model described in Chapter 2. The choices of a household with regard to fertility are treated in a
manner analogous to all other decisions taken by the household. Most work by economists,
following the seminal contributions by Becker (1960) and Becker and Lewis (1973) has focused
on the trade-offs households face between the number of children, investment in these children,
and current consumption of goods. Thus let \( x \) be (parental) consumption and \( n \) be the number of
surviving (to an arbitrary, and for current purposes unspecified, age) children. For simplicity, we
assume that each child is treated similarly, so let \( z \) be the level of human capital achieved by each
child, known in this literature as “child quality”. Household utility is described by the function
\[ U(x, n, z; \alpha). \] We assume that \( U(.) \) is increasing in \( x \) and \( z \), and increasing in \( n \) at least for small \( n \).
The human capital achieved by the household’s children depends on their own consumption \( c \) and
also on an input of time and effort by the parents \( t \). Thus \( z = Z(c, t; \beta)/n \). The opportunity cost
of the time that the parents invest in children’s human capital is the forgone wage that the parent
would have earned. \( \alpha \) and \( \beta \) are vectors which incorporate exogenous factors which influence the
preferences of the household and the technology for producing child human capital in the
household. The households problem, then, is to solve:

\[
\begin{align*}
\max_{x, n, c, t} & \quad U(x, n, z; \alpha) \\
\text{s.t.} & \quad z = Z(c, t; \beta)/n \\
& \quad w(1 - t) = p_x \cdot x + p_c \cdot c
\end{align*}
\]

where we have chosen units so that the time endowment of the parents is 1. Thus parents face a
tradeoff between the human capital achieved by their children, the number of children they raise,
and their own consumption.

This model provides a framework in which many of the features of the demographic
transition can be understood. For example, as the wage (particularly the female wage) increases
with economic growth, the opportunity cost of rearing children increases, sharpening the tradeoff
between adult consumption and both the number and human capital of the household’s children.
At the same time, $\alpha$ is likely to be changing. Part of utility derived from children and their human capital is the expected contribution that the children will make to the parents’ consumption in the future. That is, children can be seen (at least in part) as investments. As economic growth occurs, the return to skilled labor increases relative to the return to unskilled labor. This change will be reflected in parental preferences over the number of children and the human capital embodied in each child. As a consequence, households move towards investing more resources into each of a smaller number of children. Similarly, $\beta$ can change as a consequence of economic growth or government policy. The provision of free primary education would permit children to achieve higher levels of human capital at given inputs of $c$ and $t$, and thus raise both $z$ and $n$.

The conventional household model of fertility decisions also provides valuable guidance for empirical work. The household makes simultaneous and interdependent decisions regarding fertility, investment in child human capital, adult consumption, and labor market participation. It would be an error to treat any of these decisions as exogenous in an econometric exercise. Thus, for example, an analysis of the effect of household income on fertility has to be conducted with care. A simple regression in which fertility is the dependent variable and income an independent variable would be subject to simultaneity bias because income depends on the labor market decisions of the household. The household model provides a context for designing an appropriate empirical strategy; in this case, the wage could serve as an instrument for the endogenous explanatory variable.

The household fertility model provides insight into the reproductive behavior of families. Most importantly it emphasizes the point of view that people evaluate the relative merits of their options regarding their family size and the health and education of their children. At the same
time, the model is extremely incomplete and therefore can be misleading. On the one hand, this model of a unitary household obscures the potentially divergent goals of men and women regarding the number and treatment of children. On the other hand, the model neglects the potentially strong influence of the social context on fertility decisions. These comments are not mere cavils. Although it can be argued that they are true for all economic choices, they gain particular weight in the context of fertility decisions. Moreover, both lines of reasoning provide avenues through which the conventional model might be enriched to shed light on a crucial pair of questions: (1) is the rate of population growth in the poorest countries too high?; and (2) why has fertility responded so slowly to declining mortality in some areas, particularly in Africa?

The divergence between men and women in the costs and benefits of bearing and raising children is stark. Women bear all the physical risks of child birth (which are very substantial in poor countries - one in a hundred births results in death for the mother in Africa (Haab and Cornelius, 1997)). Most of the effort required to raise children is provided by women. Here, more than in virtually any other context, the fiction of “household preferences” is inappropriate.

There is striking empirical evidence that men and women have divergent preferences with respect to fertility and investments in children’s human capital. Men and women often express different targets for total fertility (Birdsall 1988). Much of the empirical evidence (reviewed in Strauss and Thomas (1995)) which casts doubt on the unitary household model concerns investments in child human capital. In a number of countries, additional income in the hands of mothers leads to larger increases in child health and education than similar additional income in the hands of fathers. Finally, there is strong evidence that more educated women have lower fertility and are more likely to use modern methods of birth control. It is likely that there are a
number different mechanisms through which female education affects fertility. Wages increase with education, so the opportunity cost of the time spent rearing children is higher for more educated women. More educated women tend to have healthier children, lower mortality amongst their children, and thus lower fertility. They may also place a higher value on education, and thus prefer fewer children with higher investment in human capital in each child. Finally, it may be the case that more educated women are able to negotiate or bargain more effectively within the household, so that fertility outcomes are closer to their own preferences than is the case for women with less education.

If men and women have divergent preferences with regard to fertility and investment in children, then an understanding of fertility outcomes and thus the determinants of population growth rests on an understanding of the process of household decision making. It is apparent that the process of decision making within households is quite variable across societies, and thus general lessons are difficult to draw. However, to the extent that decisions over fertility are made or influenced by individuals who do not bear the full cost of child bearing and raising, then there exists the potential for an equilibrium in which fertility is too high.

III

Fertility decisions are made through a process of negotiation within households, but they are not made in isolation.² Here, more obviously than is the case with most decisions, the behavior of households depends upon the choices of their neighbors. The proximate determinants of fertility - the use of contraceptives, the timing of breast feeding, the frequency of intercourse -

²This section draws extensively on the discussion in Dasgupta (1993, chapters 12 and *12).
are actions that are strongly influenced by cultural patterns. Put most simply, it may be the case that imitation plays an important role in fertility decisions. As long as all or most other couples engage in practices which encourage high fertility, any individual couple might find it difficult to do otherwise. The same couple, however, might prefer a smaller household size in a different social context. If this is the case, then choices regarding fertility generate an externality: each household’s child-bearing decision helps set a cultural pattern, and this affects the preferences of all other households.

The form of the externality generated by fertility decisions involves strategic complementarities (Cooper and John, 1988). The marginal utility to a household of having an additional child is increasing in the number of children in other households. Following the notation in Dasgupta (1993), suppose that there are M households in a society, and let \( X=(X_1, X_2, \ldots, X_M) \) be a vector describing the number of children in each household. Suppose that each household \( i \) has preferences over its own number of children, and also over the number of children in each other household. We ignore the obvious integer constraints, and assume that preferences can be summarized by the (twice continuously differentiable) utility function \( U_i(X) \). For each household \( i \), the externality we have described implies that \( \frac{\partial^2 U_i(X)}{\partial X_i \partial X_j} > 0 \) for \( i \neq j \).

Strategic complementarities raise the possibility of multiple Nash equilibria. Suppose each household decides on the number of children taking the decisions of other households as given. Then household \( i \) solves a problem of the form: \( \max_{X_i} U_i(X) \). Let \( X_i = (X_{i,1}, \ldots, X_{i,i-1}, X_{i,i+1}, \ldots, X_{i,M}) \). If we make the conventional assumption of diminishing marginal utility over the number of the household’s own children, then for each vector \( X_{i,-i} \), there is a unique value of \( X_{i,i} \), say \( X^* \), which
solves household i’s problem. The function $X_i(X_{-i})$ is the household’s reaction function, describing its decision given the actions of all other households. The implicit function theorem implies that $\delta X'(X_{-i})/\delta X_i > 0$. The number of children chosen by a household is an increasing function of the number of children in any other household.

Let’s suppose that all households have identical preferences, and consider symmetrical Nash equilibria. Let $Z$ be the number of children in all other households. Thus $X_i = (Z, Z, ..., Z) = Z$. A symmetrical Nash equilibrium is a fixed point in which $X'(Z)=Z$, that is, if all other households have $Z$ children, a representative household would also choose $Z$ children. In Figure 3.1, the horizontal axis is $Z$, the number of children in each other household, and the vertical axis is $X^*$, the optimal choice of the representative household conditional on the choices of the other households. The number of children in a household must lie between 0 and $X^{\text{max}}$. We know that the reaction curve $X'(Z)$ is upward sloping - one example is drawn in the figure. Any intersection of the reaction function with the 45° line represents a symmetrical Nash equilibrium. We have drawn the reaction function so that there are three symmetric equilibria, corresponding to three different levels of fertility. Because the equilibria are symmetric and the households are identical, they can be Pareto ranked - (generically) one is better than the others. There may be asymmetric equilibria as well, but the general point has been made: when there are strategic complementarities it is possible that there are multiple equilibria and some of these equilibria are better than others.

Two similar societies (composed of households with similar preferences), therefore, might be found at different equilibria. Why should one society find itself in equilibrium at point A, while another is in equilibrium at the (say) Pareto-dominated point C? To answer this question it is necessary to move outside the model as we have constructed it so far. The notion of Nash
equilibrium rests on expectations. Given household i’s expectation of the fertility choices of other households, it selects its preferred number of children. When this selection matches the expectations of all other households, and the same is true for each household’s selection, then the society is at a Nash equilibrium.

In the context of fertility decisions, it is most useful to focus on the role of history in forming expectations. Suppose that a society is characterized by high fertility for conventional reasons (perhaps due to a high rate of infant mortality). Consequently, a set of practices (e.g., polygyny and a low age of marriage for women) which encourages high fertility is common. These practices are the empirical embodiment of the strategic complementarity that we have hypothesized, and they shape the expectations of each household. Even after infant mortality declines, these practices remain and as a consequence each household continues to choose high fertility. Thus the type of externality that we have hypothesized to be important with respect to fertility decisions raises the possibility of a social equilibrium which is sub-optimal and requires coordinated effort to change.

IV

Household choices with regard to fertility are strongly conditioned by the social environment even when there is no direct interconnection between preferences and the choices of one’s neighbors. The fertility decisions of households effect the demographic structure of the society, and this in turn can influence relative prices and thus other households’ fertility decisions. In this section, we present a simplified version of a model by Basu and Van (1996) which starkly illustrates the possibility of multiple fertility equilibria. In this model, if the economy is
characterized by small families, labor is relatively scarce, adult wages are high, families can afford
to keep children out of the labor force, and all families prefer to remain small. An alternative
equilibrium might exist in which adult wages are low, families are so poor that all children must
work, and each family decides to have many children (and hence labor is abundant and wages
low).

The model is driven by three crucial assumptions. First, preferences are such that a family
will send its children to work only if income from adult labor is very low. Thus, child leisure is a
luxury good. Second, technology is such that adult and child labor are substitutes. And third,
children are capable of providing net economic benefits to the family. If children do work, they
can contribute more than their consumption needs to the family. This final assumption is more
likely to be valid in poor countries, where productivity is less tied to human capital than in rich
countries. Children who work in poor countries are able to earn more than they consume at an
earlier age than is the case in rich countries (see Dasgupta (1993) for a discussion).

These three assumptions are sufficient to generate the possibility of multiple fertility
equilibria. For the remainder of this section, we will make a series of further (draconian)
assumptions to simplify and clarify the analysis, but the general message that the interaction
between fertility decisions and labor market outcomes might generate the possibility of multiple
equilibria rests on these three core assumptions.

Suppose that there are N families, each of which has one adult and m children (the “one
adult,” of course could be interpreted as a husband-wife couple). There is one good, and we will
not examine issues of intrahousehold distribution. Instead, we assume that if the adult consumes
c, then each child consumes βc with β<1. Thus β is an “adult-equivalence” rating. Adult labor is
supplied inelastically, but the household chooses child labor supply \((e)\). Again abstracting from distributional issues within the household, we assume that all the family’s children supply the same amount of labor. For simplicity, we restrict the available choices of child labor to 0 or 1.

Continuing to assume away issues of negotiation and power within the household, let there be a household preference ordering over pairs of consumption \((c)\) and child labor effort \((e)\). These preferences exhibit a particularly strong form of the “child labor as luxury good” assumption: the household prefers that children work only if consumption would fall below some exogenously specified subsistence level in the absence of income from child labor. Household preferences are defined over pairs \((c,e)\), for \(c \geq 0\) and \(e \in \{0,1\}\) (recall that child consumption is simply \(\beta c\)).

Preferences are:

\[
(c + \delta, e) \succ (c, e), \\
(c + \delta, 1) \succ (c, 0) \text{ if } c < s, \\
(c + \delta, 1) \prec (c, 0) \text{ if } c \geq s, 
\]

for \(\delta > 0\), \(c \geq 0\), \(e \in \{0,1\}\). Thus preferences are such that higher (average) consumption is preferred to lower, but children only work if the family is destitute in the absence of the income from their labor.

The household budget constraint is

\[
c + m\beta c = m e w_c + w_a \tag{3}
\]

where \(w_a\) is the adult wage and \(w_c\) is the child wage. The household chooses its preferred combination of \(m, c\) and \(e\) subject to the budget constraint \((3)\).

To begin with, consider the choice of \(c\) and \(e\) conditional on a given family size. Given \(m\),
children work only if the adult wage is too low to provide sufficient adult income for the family to avoid destitution. Thus,

\[
c = \begin{cases} 
\frac{w_a}{1 + m\beta} & \text{if } w_a \geq (1 + m\beta) s \\
\frac{w_a + mw_c}{1 + m\beta} & \text{if } w_a < (1 + m\beta) s,
\end{cases}
\]  

(4)

\[
e = \begin{cases} 
0 & \text{if } w_a \geq (1 + m\beta) s \\
1 & \text{if } w_a < (1 + m\beta) s.
\end{cases}
\]  

(5)

The aggregate supply of adult labor is \( S_a = N \), and of child labor is \( S_c = 0 \) if \( w_a \geq (1+m\beta)s \), and \( S_c=mN \) if \( w_a < (1+m\beta)s \).

Now we turn to our second assumption, regarding the demand for labor. We have assumed that child and adult labor are substitutes in production. Let us go further to assume that they are perfect substitutes, so that output in any firm \( i \) is determined by \( f(A_i + \gamma C_i) \), where \( A_i \) is the amount of adult labor used in firm \( i \), \( C_i \) is the amount of child labor used in firm \( i \) and \( \gamma < 1 \). So \( 1/\gamma \) children can do the same work as 1 adult. Let there be \( n \) identical price-taking firms. If \( \gamma w_a < w_c \), then adult labor is cheaper than child labor and no firm demands child labor. The aggregate demand for child labor \( D_c = 0 \), while the aggregate demand for adult labor \( D_a \) is determined implicitly by \( f'(D_a/n) = w_a \). Similarly, if \( \gamma w_a > w_c \), child labor is cheaper than adult labor and no firm demands adult labor. Thus \( D_a = 0 \) and \( D_c \) is determined by \( \gamma f'(\gamma D_c/n) = w_c \). Finally, if \( \gamma w_a = w_c \), then firms are indifferent between hiring adults or children. In this case, each firm only
cares about the effective labor \( (L_i = A_i + \gamma C_i ) \) it hires; the composition of \( L_i \) is a matter of indifference. Thus in this case \( D = D_a + \gamma D_c \) is determined implicitly by \( f'(D/n) = w_a = w_c/\gamma \).

Conditional on fertility choices (that is, given \( m \)), the labor market will clear if there is a pair of wages \( (w_a, w_c) \) such that at those wages \( D_a = S_a \) and \( D_c = S_c \). First consider only wage pairs such that \( \gamma w_a = w_c \), so that firms are indifferent between hiring adults or children. We set the level of fertility at \( m = m^l \) for the purposes of this illustration. In figure 3.2 we graph the supply of effective labor \( S^l = S_a + \gamma S_c \) against the adult wage (remembering that as the adult wage is changed, the child wage also changes to maintain \( \gamma w_a = w_c \)). If \( w_a \geq (1+m^l \beta)s \), the supply of effective labor is restricted to the adult labor force, so equals \( N \). However, if the wage drops to \( w_a < (1+m^l \beta)s \), then families faced with destitution send their children to work and the labor supply increases to \( (1+\gamma m^l)N \). Our assumptions on preferences suffice to guarantee that this economy is characterized by a “backward-bending” supply of labor. At higher wages, less labor is supplied. Obviously, we have made an extreme assumption for the sake of simplicity. Such stark behavior is not required for the conclusions we will draw. Any preferences which incorporate the assumption that child labor is withdrawn once adult wages are high enough, and that the rate at which child labor is withdrawn exceeds the rate at which adults increase their own supply of labor, will suffice to raise the possibility of multiple equilibria.

In Figure 3.2, we also graph the demand for effective labor (still restricting attention to the case in which \( w_a = w_c/\gamma \)), which is determined by \( w_a = f'(D/n) \). We have drawn the supply of and demand for labor such that there are two equilibria. At \( E^0 \), adult wages are high, children do not work, and the demand for labor is met entirely by adults. At \( E^1 \) the adult wage is low, the child wage is very low (\( w_c = \gamma w_a \)) and both children and adults work. There are also equilibria at
which \( w_a \neq w_c / \gamma \). It cannot be the case that in equilibrium \( w_a > w_c / \gamma \), for in that case the demand for adult labor is zero while its supply is positive. However, if \( w_a = w^0 \) (as at \( E^0 \)), then any child wage such that \( w_c \geq \gamma w^0 \) is an equilibrium, for at those wage pairs both the demand for and the supply of child labor is zero.

Therefore, conditional on \( m \), it is possible that there are multiple labor market equilibria. We now show that these multiple labor market equilibria might correspond to multiple equilibria with respect to the fertility choices of households. Suppose that households have a choice of two levels of fertility: \( m \in \{ m^h, m^l \} \), with \( m^h > m^l \). We have drawn the labor market equilibria conditional on an assumed (low) level of fertility. We now ask the question: given these labor market outcomes, would the households voluntarily choose the assumed level of fertility?

In figure 3.2, the supply function \( S^l \) is drawn with \( m = m^l \). The supply of labor with \( m \) exogenously assumed to be \( m^h \) would be \( S^h \). Now consider labor market equilibrium \( E^0 \), where \( m = m^l \), the adult wage is \( w^0 \), and children do not work. Would households choose the level of fertility \( m^l \)? At \( E^0 \), with children not working, \( c(m^l) = w^0/(1 + m^l \beta) > w^0/(1 + m^h \beta) = c(m^h) > s \).

Hence children do not work (regardless of the choice of fertility) and lower fertility is preferred to higher fertility. Hence, \( E^0 \) is an equilibrium: households optimally choose low fertility, wages are high, and only adults work.

Now consider \( E^1 \). At \( E^1 \), we assumed that fertility is low (that is, \( m = m^l \)). The labor market clears with \( w_a = w^l \), \( w_c = \gamma w^l \) and children work. Consumption, therefore, is given by

\[
c(m^l) = \frac{w^l(1 + m^l \gamma)}{1 + m^l \beta} < \frac{w^1(1 + m^h \gamma)}{1 + m^h \beta} = c(m^h)\).
\]

The inequality is true because of our third
assumption, that children provide net economic benefits to their families (that is, that $\gamma > \beta$). At $E^1$ children are working, and so families prefer high to low fertility in order to capture the economic benefits offered by the additional children. $E^1$, therefore, is not an equilibrium.

Instead, consider $E^2$, where it is assumed that fertility is high ($m = m^h$). The labor market is in equilibrium with $w_s = w^2$ and $w_c = \gamma w^2$, and children are supplying labor. In this case,

$$c(m^t) = \frac{w^2(1 + m^t \gamma)}{1 + m^t \beta} < \frac{w^2(1 + m^h \gamma)}{1 + m^h \beta} = c(m^h)$$

and high fertility is chosen by the household.

Thus $E^2$ is an equilibrium and this economy has multiple fertility equilibria. In $E^0$ there is low fertility, high adult wages, and a low supply of labor. In $E^2$ there is high fertility, low wages, and children work.

The high fertility equilibrium is clearly inferior to the low fertility equilibrium for each laboring household. Yet it is individually optimal for each of these households to choose high fertility, given that the other households are each choosing high fertility. The demographic structure generated by the fertility choices of the rest of the population yields low wages, and drives households to send their children to work. Given this environment, it is individually optimal to have many children. The general point is that, once again, there is a possibility of a coordination failure and thus a potentially valuable role for public policy. The design of appropriate policy, obviously, is not trivial. It could be easy to slip into the worst excesses of Indian or Chinese population policy using the argument that population has a natural tendency to

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3It is not true that this equilibrium is Pareto dominated by the low fertility equilibrium, however. We have not completely characterized this economy, as we have not described the consumption choices of the owners of the firms (which are making profits). If we assume that they are a separate population that consumes all the profits, then they are better off in the high fertility equilibrium.
be to large as a consequence of these and related coordination failures. Even focusing more carefully on particular mechanisms through which the coordination failure arises does not always lead to simple policy recommendations. Basu and Van (1996), for example, demonstrate the complexities of policy towards child labor in the model we have just described. Even in this model, a ban on child labor can have dramatically positive or negative effects on household welfare and various forms of partial bans can raise or lower child welfare depending upon the specific characteristics of the economy.
References


Figure 3.1
Figure 3.2