and women are sorted. This sorting combines the various maxima, and it need not be the same as the sorting that maximizes aggregate output. In the example provided by matrix (4.7), combining the maxima sorts M_2 with F_1 and M_1 with F_2, whereas maximizing aggregate output sorts M_1 with F_1 and M_2 with F_2. Yet these sortings are the same in perhaps the most important instances, which means that the sum of the maxima equals the maximum of the sums in those instances.

If men and women were numbered from lowest to highest values of their traits, and if an increase in each trait always increased output, then $\hat{Z}_1$ is obviously the output of M_N with F_N, $\hat{Z}_2$ is that of M_{N-1} with F_{N-1}, and $\hat{Z}_N$ that of M_1 with F_1. Consequently, combining the various maxima implies perfect positive assortative mating when traits have monotonic effects on output.

from Gary Becker, *A Treatise on the Family*, Enlarged Edition, 1991.

CHAPTER 5

The Demand for Children

Chapters 2 to 4 have argued that the main purpose of marriage and families is the production and rearing of own children, but they have not considered explicitly the demand for children. This chapter uses the price of children and real income to explain, among other things, why rural fertility has traditionally exceeded urban fertility, why a rise in the wage rate of working women reduces their fertility, why various government programs (such as aid to mothers with dependent children) have significantly affected the demand for children, and why families with higher incomes have had more children, except during the past 150 years in Western and developing countries.

The analysis is then extended to consider the interaction between quantity and quality of children, probably the major contribution of the economic analysis of fertility. This interaction explains why the quantity of children often changes rapidly over time even though there are no close substitutes for children and the income elasticity of quantity is not large. The interaction between quantity and quality also explains why education per child tends to be lower in families having more children, why rural fertility has approached and may even be less than urban fertility in advanced countries, and why blacks in the United States have had relatively many children and invested relatively little in each child.

Price and Income Effects

The most famous and influential theory of population change is that of Malthus, who assumed that populations grow at a rapid rate unless checked by limited supplies of food and other "subsistence" goods. When incomes fall because the growth in population exceeds the growth in subsistence goods, marriages are delayed, the frequency of coition within marriage is reduced, and fewer children survive to adulthood. The first two factors are "moral restraints" and the last produces "misery" (Malthus, 1933, bk. I, chap. II). Moral restraint would be the main check on excessive population growth if the demand for births had a high income elasticity, whereas misery would be the main check if the number of births were insensitive to income.

Darwin stated[1] that the Malthusian theory greatly influenced his own theory of evolution by natural selection, which brilliantly extends Malthus in the following way. The children of fertile parents will constitute a larger fraction of their own generation than their parents do of the earlier generation. The grandchildren and subsequent descendants of fertile parents will constitute a still larger fraction of their own generations *if fertility is strongly "inherited" from parents*, because the children of fertile parents would then also be fertile. It follows from Darwin's argument—that is, from natural selection—that populations tend to become dominated by the highly fertile.

Although the Darwinian theory is highly relevant to nonhuman populations, it appears less applicable to human populations. Most families have controlled their fertility and have had fewer children than their capacities permit. For example, seventeenth-century Italian village women marrying at age twenty-five averaged only six children, whereas their biological capacity probably exceeded eight children (Livi-Bacci, 1977, table 1.2). Even the Malthusian theory of a highly

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1. Darwin (1958, pp. 42–43) wrote:

> In October 1838, that is, fifteen months after I had begun my systematic enquiry, I happened to read for amusement Malthus on *Population*, and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favourable variations would tend to be preserved and unfavourable ones to be destroyed. The result of this would be the formation of new species. Here, then, I had at last got a theory by which to work.

Alfred R. Wallace (1905, p. 361), codiscoverer of the theory of natural selection, also stated that he was influenced by Malthus.

elastic demand for children is unable to explain the large decline in Western countries during the last hundred years in the average number of children per family as family incomes rose dramatically.

However, any discrepancy between these and related facts and the Malthusian or Darwinian theories is not so apparent if the number of children is distinguished from parental expenditures on each child. A reduction in the number of children born to a couple can *increase* the representation of their children in the next generation if this enables the couple to invest sufficiently more in the education, training, and "attractiveness" of each child to increase markedly their probability of survival to reproductive ages and the reproduction of each survivor. Therefore, these theories can be combined and generalized by assuming that each family maximizes a utility function of the quantity of children, n; the expenditure on each child, called the quality of children, q; and the quantities of other commodities:

$$U = U(n, q, Z_1, \ldots, Z_m). \tag{5.1}$$

The Malthusian theory ignores quality and assumes that the demand for births (or number of children) is highly responsive to changes in income (hence, the demand for other commodities may be negatively related to income). The Darwinian theory, on the other hand, ignores these other commodities and assumes that quantity and quality are chosen to maximize the number of descendants in subsequent generations. The analysis developed in this and the next two chapters combines aspects of both these theories into a more general one. To be sure, the Darwinian theory is highly relevant to nonhuman species and, modified to include cultural selection, may also be relevant to some primitive human societies (see the argument in Blurton Jones and Sibly, 1978), while the Malthusian theory can explain changes in human populations during much of recorded history. However, the analysis developed here is far more suited to explaining fertility changes in Western countries during the last few centuries and in developing countries during this century.

The various other commodities will be combined into a single aggregate commodity, Z, because there are no good substitutes for children. Although the interaction between quantity and quality is a major theme of this chapter, the demand for children is first discussed by ignoring their quality. The utility function in Eq. (5.1) then becomes

$$U = U(n, Z). \tag{5.2}$$

To simplify the analysis without a great loss in relevance, the utility functions in Eqs. (5.1) and (5.2) and the discussion throughout this chapter ignore life-cycle changes in the ages of children and in the timing and spacing of births.

Children are usually not purchased but are self-produced by each family, using market goods and services and the own time of parents, especially of mothers. Since the cost of own time and household production functions differs among families, the total cost of producing and rearing children also differs. If this cost is denoted by p_n and the cost of Z by π_z, the budget constraint of a family equals

$$p_n n + \pi_z Z = I, \tag{5.3}$$

where I is full income. Given p_n, π_z, and I, the optimal quantities of n and Z are determined by the budget constraint and the usual marginal utility condition:

$$\frac{\partial U}{\partial n}\Big/\frac{\partial U}{\partial Z} = \frac{MU_n}{MU_Z} = \frac{p_n}{\pi_z}. \tag{5.4}$$

The demand for children would depend on the relative price of children and full income. An increase in the relative price of children, in p_n relative to π_z, reduces the demand for children and increases the demand for other commodities (if real income is held constant). The relative price of children is affected by many variables, some unique to children, and several of the more important are now considered.

The evidence over hundreds of years indicates that farm families have been larger than urban families. For example, the average household in the city of Florence was about 20 percent smaller in 1427 than the average household in the surrounding countryside (Herlihy, 1977, table 2); the number of live births per 1,000 women aged 15–49 was about 45 percent higher in small than in large Italian *comuni* in 1901 (Livi-Bacci, 1977, table 3.8); and in 1800 the reproduction rate in rural areas of the United States was about one and one-half times that in urban areas (Jaffe, 1940, p. 410). Part of the explanation is that food and housing, important inputs in the rearing of children, have been cheaper on farms.

The net cost of children is reduced if they contribute to family income by performing household chores, working in the family business, or working in the marketplace. Then an increase in the "earning" potential of children would increase the demand for children. Indeed, I believe that farm families have had more children mainly because children have been considerably more productive on farms than in cities. For example, children in rural India and Brazil begin to contribute to farm work by age five or six and are sizable contributors by age twelve.[2]

The contribution of farm children has declined as agriculture has become more mechanized and complex in the course of economic development. Both of these elements have encouraged farm families to extend their children's schooling.[3] Since rural schools are too small to be efficient, and since the cost in time and transportation of attending school is greater to farm children (Kenny, 1977, p. 32), the cost advantage of raising children on farms has narrowed, and possibly has been reversed, as farm children have increased the time they spend in school. Not surprisingly, therefore, urban-rural fertility differentials have narrowed greatly in developed countries during this century and rural fertility is now slightly *less* than urban fertility in some countries. (See the evidence for the United States, Italy, Japan, and Taiwan respectively in Gardner, 1973; Livi-Bacci, 1977; Hashimoto, 1974; and Schultz, 1973.)

Programs providing aid to mothers with dependent children have reduced the cost of children; aid increases as the number of children increases, and the decline in the labor force participation of mothers induced by these programs (Honig, 1974) reduces the opportunity cost of time spent on children. Since mothers without mates have more readily qualified for aid, the growth of these programs in recent years has contributed heavily to the sharp growth in the ratio of illegitimate to legitimate birth rates since the 1960s. The illegitimate birth rate has remained constant[4] (while the legitimate rate has fallen substantially),

2. See Makhija (1978); Singh et al. (1978). Adam Smith said about colonial America, "Labour is there so well rewarded that a numerous family of children, instead of being a burthen is a source of opulence and prosperity to the parents. The labour of each child, before it can leave their house, is computed to be worth a hundred pounds clear gain to them" (1937, pp. 70–71). For a recent study of the contribution of farm children in the United States, see Rosenzweig (1977).

3. The substitution between schooling and farm work in rural India and in Brazil is analyzed by Makhija (1978) and Singh et al. (1978). Compulsory-schooling laws may also have contributed to the increased school enrollments of farm children (but see Landes and Solmon, 1972).

4. For example, in California in 1966 and 1974 the illegitimate birth rate per 1,000 unmarried women aged 15–44 was 18 and 19 respectively for white women, and 69 and 66 for black women (Berkov and Sklar, 1976).

even though abortions have become more accessible and birth control techniques have improved.

The relative cost of children is significantly affected by changes in the value of the time of married women, because the cost of the mother's time is a major part of the total cost of producing and rearing children (it contributes about two-thirds of the total cost in the United States; see Espenshade, 1977). Indeed, I believe that the growth in the earning power of women during the last hundred years in developed countries is a major cause of both the large increase in labor force participation of married women and the large decline in fertility. Since fathers have spent relatively little time on children, the growth in their earning power has not significantly affected the cost of children and in fact would have reduced the relative cost if children used relatively less time of fathers than other commodities used.

Household surveys provide direct evidence on the relation between the demand for children and the value of time of husbands and wives. The number of children is strongly negatively related to the wage rate or other measures of the value of time of wives, and is more often positively rather than negatively related to the wage rate or earnings of husbands (see, for example, Mincer, 1963; De Tray, 1973; Willis, 1973; and Ben-Porath, 1973). Part of the causation, however, is from children to wage rates, because women invest less in market skills and more in household skills and men do the reverse when families have more children. However, there does appear to be significant causation from the value of time of wives to their demand for children (Lazear, 1972).

Apparently households have preferred their own children to those available from others, for practically all households choose to have their own. The explanation may be that humans and other species are biologically selected to propagate their own genes (Wilson, 1975). However, Chapter 2 develops several reasons why persons prefer their own children even when cultural as well as genetic factors influence the demand for children. One reason is that own children can reduce the uncertainty of parents, who have more information about the genetic constitutions and early environmental experiences of their own children than of those obtainable from others.

On the other hand, parents have less prior information about the sex, color, physical condition, and other noticeable characteristics of children they self-produce than of those that could be seen in a "child market." Yet the scope of such a market would be limited because parents would be more likely to put their inferior rather than their superior children up for sale or adoption if buyers were not readily able to determine quality. (See Akerlof, 1970, for a discussion of the market for "lemons.")

Reliance on own children implies that some families might not be able to satisfy their demand for children because they are wholly or partially sterile, and that other families would exceed their demands because they are too fertile. In this statement, "demand" means the number of children desired when there are no obstacles to the production or prevention of children. Husbands with sterile wives have terminated their marriages or have married additional wives in societies permitting polygyny, and some women have had more children than they desired or had them at inopportune times.

But have major changes in average fertility been caused by changes in sterility and in knowledge of birth control methods? Although I once gave an affirmative answer (Becker, 1960), I now believe that the major changes have been caused primarily by other changes in the demand for children. The various forces discussed in this chapter appear sufficient to explain major declines in fertility, and simple and sufficiently effective birth control methods have been available to produce these declines.

To demonstrate the effectiveness of simple methods, consider the basic relation between the average number of live births (n), the period of vulnerability or "exposure" to births (E), the average time required to produce a conception resulting in a live birth (C), and the average period of sterility during and after the production of a live birth (S):

$$n = E/(C + S), \tag{5.5}$$

where $C + S$ is the average duration between live births. Since C is a "waiting time" to conception, it depends on the probability of conception during any coition (p) and the frequency of coition (f):[5]

$$C \cong 1/(fp). \tag{5.6}$$

Women marrying at age twenty and not using any birth control methods average about eleven live births (see the evidence for the Hutterites in Eaton and Mayer, 1953, p. 233). Since they would be fertile until an average age of about forty-four, or for 288 months, the average interval between live births is 26 months. The number of births could

5. See Becker (1956) for an early derivation of this formula; an extensive discussion may be found in Sheps and Menken (1973).

be reduced by almost 25 percent without mechanical methods of birth control simply by delaying marriage (and coition) for 3 years, reducing the frequency of coition during marriage by 10 percent, and extending breast feeding for 3 months. Moreover, the number could be reduced much further by coitus interruptus, a birth control method known even in many primitive societies.[6]

Perhaps Malthus considered changes in age at marriage to be a major method of birth control because it is much more effective than equal percentage changes in the frequency of coition during marriage when birth rates are as high as they were in the eighteenth century. For example, if women married at age twenty and produced eleven births, a 10-percent increase in age at marriage, which is about a 9-percent decrease in exposure to births, would reduce the number of births by almost three times as much as a 10-percent decrease in coital frequency. On the other hand, if women marrying at age twenty produced only two births because of effective birth control methods, a decrease in coital frequency would have almost as large an effect as an equal percentage increase in age at marriage.[7]

Prior to the nineteenth century, even in advanced countries no more than about half of all live births survived to age ten. Therefore modest changes in age at marriage, frequency of coition, and breast feeding—combined with coitus interruptus—would have reduced the

6. From Eq. (5.5) and the observation of about 11 births in 288 months' exposure, we infer $C + S = 26$ months. If S, infertility during and after pregnancy, is about 17 months (Menken and Bongaarts, 1978), then C is about 9 months. A 10-percent reduction in f would raise C by 10 percent to about 10 months, and a 3-month extension of breast feeding would extend S by about 2 months. Then $C + S$ would be increased from 26 to 29 months. If, in addition, marriage is delayed to age twenty-three, E is reduced to 252 months. So $n' = 252/29 \cong 8.7$.

Coitus interruptus reduces the probability of conception by more than 90 percent (Michael, 1973). If used during half the coitions,

$$C'' = \frac{1}{p\frac{(0.9f)}{2} + 0.1p\frac{(0.9f)}{2}} = 2\left(\frac{1}{fp}\right) = 2C \cong 18.$$

Then $n'' = 252/(18 + 20) = 6.6$.

7. An increase in age at marriage from twenty to twenty-two—a decrease in E from 288 to 264—always reduces n by 8.3 percent if $C + S$ is unaffected by the decrease in E. The effect of a decrease in f, however, depends on the ratio of C to S. If, say, $S = 17$ and $C = 9$ ($n = 11$), a 10-percent decrease in f reduces n by only 3 percent, whereas if $S = 17$ and $C = 127$ ($n = 2$), a 10-percent decrease in f reduces n by 8 percent.

average number of surviving children to only three or less. However, without significant declines in the number of births per family, the number of survivors would have greatly increased during the nineteenth and twentieth centuries owing to the dramatic increase in the probability of surviving to age ten. Surely improvements in older methods of birth control, such as the diaphragm (Himes, 1963, pp. 321, 391), and the development of new methods, such as the pill, permitted births to decline sharply during the last 150 years even though age at marriage also declined and frequency of coition may have increased.[8] But I believe that these improvements in birth control methods are mainly an induced response to other decreases in the demand for children rather than an important cause of the decreased demand.

Evidence that more effective birth control methods are not sufficient to reduce fertility is provided by societies that have maintained high levels of fertility even when they have had the means to reduce their fertility substantially. For example, the ruling families of Europe averaged more than 5.5 births from the beginning of the sixteenth to the end of the eighteenth centuries (Peller, 1965, p. 90), although they could have had considerably fewer births with methods known at that time (Himes, 1963, chap. 8) and presumably available to these families. Or poor Indian families stubbornly maintain their fertility levels until economic and other conditions change (Makhija, 1977, 1980), despite the resources spent to encourage—and even force!—them to use effective methods of control.

Moreover, many societies managed large reductions in their fertility long before modern methods of birth control were developed. More than two thousand years ago the Greeks and Romans had very small families through delayed marriage, infanticide, reduced coition during marriage, abortion, primitive contraceptives, and nonproductive modes of sex (Wilkinson, 1978). The Jews in Florence and Leghorn reduced their birth rates by 50 percent between 1670 and 1840 only partly by raising their average age at marriage (Livi-Bacci, 1977, pp. 40–44). These Jews can hardly be said to have had access to the best information on contraception, since they were forced to live in ghettos and were excluded from many schools. Even the "contraceptive revolution," to use the term of Westoff and Ryder (1977), ushered in by the

8. Reliable historical evidence obviously is lacking, but apparently the frequency of coition increased in the United States during the 1960s, whereas birth rates fell rapidly (Westoff, 1974).

pill has probably not been a major cause of the sharp drop in fertility in recent decades. The decline began in the 1950s in countries like the United States and Japan, although the pill is illegal in Japan and was not extensively used in the United States until the 1960s. Moreover, women in the United States born between 1900 and 1910 had quite small families without the pill by using other contraceptives, abstinence, and induced abortions (Dawson et al., 1980).

The demand for children is affected not only by the price of children but also by real income. An increase in real income generally increases the demand for different commodities, and some of the evidence proves the relation between children and income to be no exception. In polygynous societies wealthier men tend to have many more children, chiefly because they are far more likely to be polygynous than poor men (Grossbard, 1978). Wealthier men also tended to have more children in monogamous societies prior to the nineteenth century; see the data relating wealth to children in fifteenth-century Tuscany (Klapisch, 1972, table 10.2; Herlihy, 1977, pp. 147–149) and in other parts of Italy during the fifteenth and eighteenth centuries (Livi-Bacci, 1977, tables 6.1 to 6.4). This positive relation between wealth and fertility in monogamous societies generally continued in rural communities throughout the nineteenth century; see the evidence for Canada in 1861 (McInnis, 1977, table 5), for the United States in 1865 (Bash, 1955, especially table 12), and for Germany in the late nineteenth and early twentieth centuries (Knodel, 1974, table 3.13).

Sometime during the nineteenth century, however, fertility and wealth became partially or wholly negatively related among urban families; evidence for German cities around 1900 can be found in Knodel, 1974, tables 3.14 and 3.15. The evidence for advanced countries during the twentieth century has been rather mixed, although income and fertility have generally been negatively related at lower income levels and unrelated or positively related at upper levels; the documentation is reviewed in Simon (1974, pp. 42–69). The economic approach suggests that a negative relation between income and fertility is an indication that the effective price of children increases with income, perhaps because the wives of men with higher incomes tend to have greater potential earnings from market activity (Mincer, 1963) or higher values of their time (Willis, 1973). I believe, however, that the interaction between the quantity and quality of children is the most important reason why the effective price of children rises with income.

The Interaction between Quantity and Quality

Let us return to the utility function, Eq. (5.1), that distinguishes the quality of children from other commodities. I assume here that all children in the same family have the same quality and that quality is fully produced by each family with its own time and market goods (these assumptions are dropped in Chapter 6). If p_c is the constant cost of a unit of quality, q the total quality of each child, and $p_c qn$ the total amount spent on children, the budget constraint would be

$$p_c qn + \pi_z Z = I. \tag{5.7}$$

This budget constraint is not linear in the commodities entering the utility function, but depends multiplicatively on n and q. The nonlinearity is responsible for the interaction between quantity and quality in the following analysis.

Maximizing utility subject to the budget constraint gives the equilibrium conditions

$$\left.\begin{aligned} \frac{\partial U}{\partial n} &= MU_n = \lambda p_c q = \lambda \pi_n \\ \frac{\partial U}{\partial q} &= MU_q = \lambda p_c n = \lambda \pi_q \\ \frac{\partial U}{\partial Z} &= MU_z = \lambda \pi_z \end{aligned}\right\} . \tag{5.8}$$

The relevant shadow prices of n and q are π_n and π_q. Of course, each depends on p_c, the cost of a unit of quality, but what may appear surprising is that π_n depends on q and π_q depends on n. Since an increase in q raises the amount spent on each child, it raises the relevant cost of each child. Similarly, an increase in n raises the cost of adding to the quality of each child because a larger number of children would be affected.

Equations (5.7) and (5.8) can be solved for the equilibrium values of n, q, and Z as functions of these shadow prices and of income:

$$\left.\begin{aligned} n &= d_n(\pi_n, \pi_q, \pi_z, R) \\ q &= d_q(\pi_n, \pi_q, \pi_z, R) \\ Z &= d_z(\pi_n, \pi_q, \pi_z, R) \end{aligned}\right\} . \tag{5.9}$$

where shadow income, R, equals the sum of the *shadow* amounts spent on different commodities.[9] These demand functions have the usual substitution and income effects; for example, an increase in the shadow price of n, q, or Z, holding other shadow prices and shadow income constant, would reduce own quantity demanded. Note, however, that these demand functions depend on the quantities n and q through the shadow prices π_q and π_n respectively, and even on the interaction term nq through shadow income R (see the extensive discussion in Tomes, 1978).

Quantity and quality do not interact explicitly in demand functions that depend on shadow prices and income, but they do in demand functions that depend on "market" prices and income. If p_c, π_z, and I were held constant, an exogenous increase in n would raise the shadow price of q, π_q $(= np_c)$, and thereby would reduce the demand for q. The reduction in q lowers the shadow price of n because it depends on q, which further increases the demand for n. But this raises π_q and lowers q still further, which lowers π_n and raises n still further, and so on. The interaction between n and q continues until a new equilibrium position is established.

Even a small exogenous increase in n (or q) could be responsible for a large decrease in q (or n) if the interaction between n and q were sufficiently strong. The interaction is determined by the substitution between n and q in the utility function: if they were sufficiently close substitutes, they would continue to interact until either n or q were negligible. In particular, if the elasticity of substitution between n and q, n and Z, and q and Z were the same, both n and q would be positive only if this elasticity were less than unity.[10] Consequently, the "spe-

9. Equation (5.7) can be written as

$$(p_c n)q + (p_c q)n + \pi_z Z = I + p_c nq \equiv R,$$

or as

$$\pi_q q + \pi_n n + \pi_z Z = R.$$

10. For proofs see Becker and Lewis (1973) and Tomes (1978). More generally, both n and q would be consumed only if

$$\sigma_{nq} < \frac{1 - k_z\sigma_z}{1 - k_z},$$

where σ_{nq} is the elasticity of substitution between n and q, σ_z is the elasticity of substitution between both Z and n and Z and q, and k_z is the share of Z in R. Therefore, $\sigma_{nq} < 1$ if $\sigma_z \geq 1$, and the maximum feasible σ_{nq} is negatively related to σ_z. That is, quantity and quality of children could not be close substitutes if other commodities were close substitutes for children.

cial" relation between the quantity and quality of children that derives from their interaction does not presume that they are close substitutes; on the contrary, equilibrium would not be possible if they were close substitutes! Therefore, the interaction between quantity and quality explains why the education of children, for instance, depends closely on the number of children—even though we have no reason to believe that education per child and number of children are close substitutes.

The interaction between n and q is shown graphically in Figure 5.1, where U_0 and U_1 are convex indifference curves between n and q (Z is ignored or held constant), and AB and CD represent the budget equation. The interaction between n and q implies that the budget curve is not a straight line but is also convex to the origin.[11] Equilibrium would be at an internal position (like points e_0 and e_1) only if the curvature of the indifference curves exceeded the curvature of the budget curve. Since the curvature of these indifference curves is smaller when n and

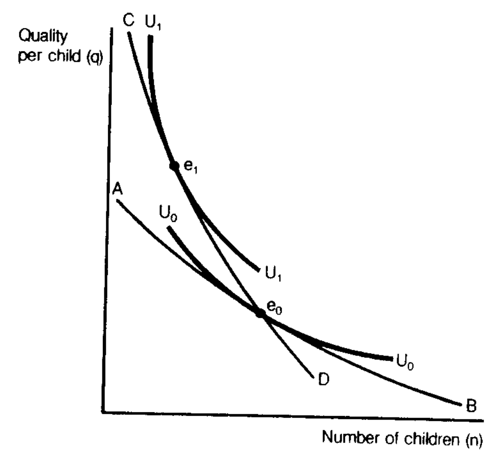

FIGURE 5.1 Interaction between quantity and quality: indifference curves and budget curves of a typical family.

11. If $p_c nq = S'$, then

$$p_c n + p_c q(dn/dp) = dS' = 0,$$

and

$$p_c(dn/dq) + p_c(dn/dq) + p_c q(d^2n/dq^2) = 0,$$

or

$$d^2n/dq^2 = (-2\ dn/dq)/q > 0.$$

q are closer substitutes, internal equilibria are possible only when they are not close substitutes.

The quantity and quality of other commodities are also related (see Theil, 1952, and Houthakker, 1952, and the application to firms by Hirshleifer, 1955), but may not interact so strongly because the qualities of different physical units are not so closely related as the qualities of different children. For example, a rich person might well plan to own both expensive and inexpensive cars, but is unlikely to plan on having both expensive and inexpensive children. Still, the analysis developed in this section can be usefully applied to other commodities.

Fertility in many countries has changed greatly during short spans of time. Table 5.1 shows that the birth rate in the United States declined by 38 percent between 1960 and 1972, and by 24 percent during the 1920s. The total fertility rate in Japan dropped by 45 percent between 1950 and 1960, and the total fertility rate in Taiwan declined by 51 percent between 1960 and 1975. Or, to take an early episode, the birth rate in England and Wales decreased by 26 percent between 1871 and 1901. Commodities like children, which are presumed to have modest price elasticities because they do not have close substitutes, generally do not change by large amounts except during severe business cycles.

Several alternative explanations for large changes in fertility have been suggested, including the contraceptive revolution ushered in by the pill (see Westoff and Ryder, 1977, pp. 302–309), but this cannot explain the large decline in births in the United States during the twenties

TABLE 5.1 Changes in birth rates in various countries and time periods.

	Country and period	Percent change in birth rate
(1)	United States, 1920–1930	−24
(2)	United States, 1960–1972	−38
(3)	Japan, 1950–1960	−45
(4)	Taiwan, 1960–1975	−51
(5)	England and Wales, 1871–1901	−26

SOURCES: U.S. Bureau of the Census, 1975c, 1977b; Japan Bureau of Statistics, 1962; Taiwan Ministry of the Interior, 1974, 1976; Great Britain Registrar General, 1957.

(1) and (2) Birth rate for women ages 15–44.
(3) and (4) Total fertility rate for women ages 15–49.
(5) Birth rate for women ages 15–44.

or in Japan during the fifties. I am convinced that the most promising explanation is found in the interaction between the quantity and quality of children, for it implies that the demand for children is highly responsive to price and perhaps to income, even when children have no close substitutes.[12]

The demand for children can be better discussed after adding a fixed cost of each child, p_n, that includes the time, expenditure, discomfort, and risk spent in pregnancy and delivery, governmental child allowances (a negative cost), the costs of avoiding pregnancies and deliveries, and all other psychic and monetary expenditures on children that are largely independent of quality. In addition, let p_q refer to expenditures on children that are largely independent of the number of children because of joint consumption by different children (items like hand-me-down clothes and learning from parents), and let marginal and average variable costs of quality differ, perhaps because of public subsidies to schooling. The budget equation can then be written as

$$p_n n + p_q q + p_c(q)qn + \pi_z Z = I. \tag{5.10}$$

Maximizing utility subject to this constraint gives the following equilibrium conditions for n and q:

$$MU_n = \lambda(p_n + p_c q) = \lambda p_c q(1 + r_n) = \lambda \pi_n$$
$$MU_q = \lambda\left(p_q + p_c n + \frac{\partial p_c}{\partial q} nq\right) = \lambda p_c n(1 + r_q + \epsilon_{pq}) = \lambda \pi_q, \tag{5.11}$$

where $r_n = p_n/p_c q$ and $r_q = p_q/p_c n$ are the ratios of fixed to variable costs for quantity and quality respectively, and $1 + \epsilon_{pq}$ is the ratio of marginal variable cost to average variable costs of quality. Hence

$$\frac{MU_n}{MU_q} = \frac{\pi_n}{\pi_q} = \frac{q}{n}\frac{(1 + r_n)}{(1 + r_q + \epsilon_{pq})}. \tag{5.12}$$

The ratio of the shadow prices of n and q now depend not only on the ratio of q to n, but also on the ratios of fixed to variable costs, and on the ratio of marginal to average variable cost of quality.

Therefore, an increase in, say, the fixed cost of n, perhaps because

12. I did not fully appreciate the significance of the interaction between quantity and quality in my first paper on fertility. I claimed that economic theory had "little to say about the quantitative relationship between price and amount. There are no good substitutes for children, but there may be many poor ones" (Becker, 1960, p. 215).

of reduced child allowances or reduced costs of contraception, would induce a substitution away from n and toward q as well as Z, because π_n would increase relative to π_q as well as π_z. The interaction between n and q implies that the increase in q raises π_n further, while the decrease in n lowers π_q further, which encourages still more substitution away from n and toward q. The decrease in n and increase in q could be sizable even if the increase in the fixed cost of n were modest and the elasticity of substitution between n and q were not large.

A compensated increase in p_n rotates the budget line of Figure 5.1 through the initial equilibrium position, from AB to CD. Revealed preference shows that the new equilibrium must be to the left of e_0, as is e_1. Since the interaction between n and q implies that the slope of CD at e_1 increases when n decreases, the decrease in n must be sufficient to raise the slope of the equilibrium indifference curve to equality with the increased slope of CD.

To illustrate, assume that p_n is 25 percent of π_n, p_q and ϵ_{pq} are negligible, expenditures on n equal 10/27 of R, and expenditures on q equal 8/27 of R. If n and q did not interact, a compensated 1-percent increase in the price of n would reduce the demand for n only by $0.01\,(17/27)\,\sigma$, where σ is the elasticity of substitution (for example, by 0.5 percent if $\sigma = 0.8$). The interaction with q, however, magnifies the response, for then a compensated 1-percent initial increase in π_n due to a 4-percent increase in p_n would reduce the demand for n by about 1.1 percent if $\sigma = 0.8$ and by about 2.3 percent if $\sigma = 1.0$.[13] These are $2\frac{1}{4}$ and $3\frac{2}{3}$ times as large as the reductions in n when n and q do not interact. Therefore, a moderate increase in the fixed cost of children (perhaps caused by an exogenous improvement in contraceptive knowledge) or a moderate decrease in the ratio of marginal to average costs of quality that raised the initial shadow price of quantity relative to quality by only 10 to 20 percent would reduce the demand for quantity and increase the demand for quality by significantly larger percentages.

Moderate initial increases in relative price could explain both the large declines in fertility in Table 5.1 and the large increases in quality in Table 5.2. For example, while the fertility rate in Taiwan declined by 51 percent, the fraction of persons aged 25–34 with a high-school education rose by 100 percent, or while the birth rate in the United States declined by 38 percent, the fraction of persons aged 25–34 who graduated from high school rose by 33 percent.

13. See Becker and Lewis, 1973, eq. (A19). I am indebted to H. Gregg Lewis for correcting an error in earlier calculations.

TABLE 5.2 Changes in level of schooling in various countries and time periods.

	Country and period	Percent change in schooling
(1)	United States, 1920–1930	+81
(2)	United States, 1960–1972	+33
(3)	Japan, 1950–1960	+37
(4)	Taiwan, 1960–1975	+100
(5)	Great Britain, 1871–1900	+21

SOURCES: U.S. Department of Commerce, 1932; U.S. Bureau of the Census, 1963a, 1972; Japan Bureau of Statistics, 1961; Taiwan Ministry of the Interior, 1976; West, 1970, p. 134.

(1) Fraction of persons ages 14–17 enrolled in secondary school.
(2) Fraction of persons ages 25–34 who completed high school.
(3) Fraction of persons ages 25–34 who completed senior high school (current system) or middle school (old system); excludes youth training (old system).
(4) Fraction of persons ages 25–34 who completed high school.
(5) Fraction of males who were literate.

Further Empirical Implications of the Quality-Quantity Interaction

This analysis also can reconcile to some extent the view that family planning programs are necessary before fertility will fall significantly with the view that the value of children must be reduced before fertility falls significantly (see the discussion between Demeny, 1979a and b, and Bogue and Tsui, 1979). Suppose that an effective family planning program could be expected to reduce births by 10 percent because that many births are "unwanted." However, births would actually fall by a much larger percent; the interaction between quantity and quality implies that a 10-percent fall in births raises the demand for quality of children, which raises the cost of (lowers the value of) quantity and further lowers the demand for births. Although family planning might take credit for the whole decline in births because it is the initiating force, the induced increase in the demand for higher-quality children and the induced decrease in the demand for quantity of children are responsible for more than half of the decline in births.

Economic theory implies that a change in the price of any commodity changes in opposite directions the demands for that commodity and for substitute commodities. The interaction between the quantity and traceptive knowledge would reduce the quantity of children, raise the probability they survive childhood, and also improve other aspects of the quality of children. The decline in fertility is not "caused" by the decline in child mortality nor is the decline in mortality "caused" by the decline in fertility, but both of these result from a rise in the price of quantity and the interaction between quantity and quality (Gomez, 1980).

Even an exogenous decline in child mortality would induce a quantity-quality interaction. Parents might reduce their own efforts to prevent child deaths when, say, a public health program is introduced,[17] but they would increase their expenditures on other aspects of child quality because the rate of return on these expenditures would be raised by a decline in mortality. If total parental expenditures increased, the effective price of quantity could be *increased* by an exogenous decline in child mortality, and the demand for child survivors would then *decrease* (see also O'Hara, 1972). An exogenous increase of a given percent in the probability that children survive childhood would then reduce births by a larger percentage.

Economic development affects fertility and the quality of children not only because incomes increase but also because rates of return on investments in education and other human capital increase. Since even a "pure" rise in income can reduce fertility through the interaction with quality, a rise in income combined with higher rates of return on quality could reduce fertility significantly. Consequently, economic development can have significant negative effects on fertility even when the "true" income elasticity of demand for fertility is positive and sizable. A similar analysis that incorporates systematic differences in rates of return to different families in developed countries implies that richer families can have fewer children than poorer families, even though richer families in less developed countries have more children than poorer families.

17. Chapters 6 and 11 analyze the effects on parental efforts of changes in public and other "endowments"; Scrimshaw (1978, pp. 391, 395) provides empirical evidence on parental reactions to public health programs.

SUPPLEMENT TO CHAPTER 5

A Reformulation of the Economic Theory of Fertility

The economic approach to fertility emphasizes the effects of parents' income and the cost of rearing children. With the exception of work by Easterlin (1973) and a few others (see Chapter 7), this approach has neglected the analytical links between decisions by different generations of the same family. Moreover, despite Malthus' famous precedent, fertility has not been integrated with the determination of wage rates, interest rates, capital accumulation, and other macroeconomic variables (exceptions include Razin and Ben-Zion, 1975, and Willis, 1985).

Our model in this supplement is based on the assumption that parents are altruistic toward their children. The utility of parents depends not only on their own consumption, but also on the utility of each child

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