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CENTER DISCUSSION PAPER NO. 737

DEMAND FOR CHILDREN IN LOW INCOME COUNTRIES

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Abstract

Microeconomic theories of the demand for children emphasize several features of children in the context of a simplified model of family choice. The cost of children is heavily affected by the opportunity cost of the time of mothers, who in most societies contribute a disproportionate share of their time to child rearing. Increasing women's schooling and wage opportunities is consequently associated with lower demand for children. Children are an important vehicle for human capital investment; these dimensions of child "quality" appear to be substitutes for the numbers of children demanded by parents, and consequently rising returns to human capital depress fertility. Other factors in the environment of families affect the relative cost or labor productivity of children, which includes prevailing production technologies and the exogenous component of child mortality. This paper surveys a variety of approaches to the economic determinants of fertility and then summarizes the empirical literature that seeks to explain mostly cross-sectional differences in individual/family data. Differences between countries at one point in time, and changes within countries over time in fertility and child mortality during the last several decades are also shown to be consistent with these microeconomic approaches to fertility. This century has seen both a remarkable acceleration and deceleration in population growth, and beneath these enormous changes in societies, numerous behavioral puzzles remain that might be better understood with the judicious use of Microeconomics.

KEY WORDS: Fertility Survey, Child Mortality, Family Planning

1. Introduction

The decline in average fertility in low income countries that has occurred since 1960 can be partly understood in terms of models of household demand behavior, as can the variation across individuals in fertility at one point in time. But the origins and ramifications of these differences in fertility are far from fully understood. Much recent research on fertility has been guided by the realization that the family functions as coordinator of many demographic and economic production and consumption activities. Economic and time constraints on families are therefore thought to influence not only births, but also to affect many other forms of interdependent family behavior, including inter and intra household transfers, migration, savings and consumption behavior, and investments in human and nonhuman capital. Separating individual and family decision making into compartments is a common practice designed to facilitate modeling a particular behavioral relationship. But it is a shortcut that can compromise the realism of analysis of family behavior and distort its implications.

In this chapter, economic models for understanding empirical regularities in fertility in low-income countries are first outlined in their simplest form. Assumptions are then relaxed or behavior is allowed to interact among several "compartments". Two alternative research strategies can be adopted for modeling more of these compartmentalized outcomes, such as fertility and parent investments in child quality. Reduced-form relationships can be estimated that may answer some overall questions on how exogenous constraints affect each family outcome, but do not decompose how one outcome depends on other jointly determined outcomes in some full model. Alternatively, a "structural model" can be specified, and additional information can be used to recover or identify the interdependencies represented in the model's structure. A recurrent theme in this chapter is the limits to our knowledge about the "full" structural model linking fertility to other family outcomes. A consequence of this view is that

estimation of reduced-forms continues to perform an important analytical function for the study of the demand for children, despite its obvious limitations.

In general, the empirical patterns in fertility and family behavior discussed in this chapter have their counterparts in high-income countries, and often can be documented in both contemporary and preindustrial periods for those countries. It is, therefore, unclear that the economic models and methods used to study fertility in high- and low-income countries should be segregated as in this volume (Schultz, 1981). But the salient questions and the available data often differ between the two groups of countries, and hence the choice of models and statistical methods that receive the most attention will also differ somewhat between the studies of these two types of populations.

In many low-income countries, total fertility rates have declined by 50 percent or more since 1960. Regional and country-specific variation in the timing of this demographic transition is striking and calls for a coherent quantitative economic explanation. Most empirical analysis of fertility has focused on explaining cross sectional variation within a single country, first across subnational regions and then, as household surveys became more widely available, across individuals. Much less analysis of changes in fertility over time has occurred, either within (relatively closed) aggregates, such as nations, or within extended families between generations. Therefore, in section 5.6 below, national data are examined to test some hypotheses regarding the demand for children that may help to account for the broad outlines of the contemporary demographic transition. The paucity of economic studies of the fertility transition may reflect more than a shortage of data. It may also signal that many observers do not think that this remarkable decline in fertility is due to the changing economic constraints facing families. Rather, they associate this decline in fertility with the provision of subsidized modern birth control through organized family planning programs.

Thus, the cost effectiveness of family planning, education, and health programs as means to help people achieve a lower level of fertility are considered later in this chapter.

2. Regional Trends in Birth and Death Rates

Table 1 reports the size of the world's population from 1750 to 2000, as well as population by current income level and region of the developing world. All of these estimates are subject to substantial uncertainty and yet illustrate certain broad regional patterns in the demographic transition, by which I mean sustained declines in death and birth rates that lead to a slowing of population growth. The difference between the crude birth rate and the crude death rate (per 1000 population) is equal to the rate of population growth, not including immigration and emigration. In the higher income countries, i.e., Europe (including Asiatic USSR), North America, Australia, New Zealand, and Japan, the population increased 2.8 times from 1750 to 1900, supported by agricultural and industrial revolutions, whereas the rest of the world's population did not quite double (80 percent). Conversely, in the twentieth century the population of the higher income countries will increase 1.3 times, while the population of the lower income countries will increase 3.7 times. As a consequence, the share of the world's population living in the high-income countries increased from a fifth in 1750 to a third in 1900, and will subside back to a fifth by the year 2000.

Different regions thus experienced their "population explosion" at different times, and the amplitude of the explosion has tended to be larger, though the duration shorter, for those entering later into their demographic transition. The higher income countries experienced their most rapid population growth from about 1850 to 1900, when they grew at about 1.0 percent per year. This population growth rate was again briefly exceeded during the baby boom of 1950-55, but today these more developed countries are growing at less than .4 percent per year, and will probably reach zero growth, in the

Table 1

Population of World by Region
with Vital Rates and Population Growth*

	1750	1850	1900	1950	1960	1970	1980	1990	2000
1. World Population (millions)	728	1171	1608	2516	3020	3698	4448	5292	6261
Birth Rates (per thousand population)	-	-	-	37.5	35.2	31.5	27.6	26.4	22.9
Death Rate (per thousand population)	-	-	-	19.7	15.4	12.1	10.4	9.2	8.2
Population Growth Rate	4.5	6.5	7.8	17.0	22.9	19.4	17.2	17.2	14.7
2. Higher Income Population ^a	145	329	554	832	945	1049	1137	1207	1264
Birth Rate	-	-	-	22.6	20.1	16.7	15.2	13.9	13.1
Death Rate	-	-	-	10.1	9.0	9.3	9.6	9.6	9.7
Population Growth Rate	6.5	10.6	9.9	12.5	11.1	7.4	5.6	4.3	3.4
3. Lower Income Population ^a	583	842	1054	1684	2075	2649	3312	4086	4997
Birth Rate	-	-	-	44.6	41.9	37.1	31.7	30.0	25.3
Death Rate	-	-	-	24.3	18.3	13.2	10.6	9.1	7.8
Population Growth Rate	4.0	4.9	6.7	20.3	23.6	23.9	21.1	20.9	17.5
4. Latin America Population	16	33	63	166	218	286	323	448	538
Birth Rate	-	-	-	42.5	41.1	35.4	30.6	26.8	23.1
Death Rate	-	-	-	15.4	12.1	9.7	7.9	7.0	6.5
Population Growth Rate	8#	13#	20	27.1	29.0	25.7	22.7	19.8	16.6
5. Southeast Asia and East Asia Population ^b				853	1017	1274	1536	1781	2045
Birth Rate				41.5	37.0	31.2	21.9	21.7	16.6
Death Rate	475	741	915	23.5	16.4	9.83	7.49	6.97	6.80
Population Growth Rate	-	-	-	18.0	20.4	21.7	14.4	14.7	9.80
6. South and West Asia Population ^c				523	652	829	1047	1333	1668
Birth Rate				45.1	43.4	40.4	37.6	33.6	27.7
Death Rate	4.7	4.3	5.4	25.0	19.8	16.3	13.0	10.3	8.15
Population Growth Rate				20.1	23.6	24.1	24.6	23.3	19.6
7. African Population	95	95	120	2.22	279	362	477	642	867
Birth Rate	-	-	-	49.2	48.7	46.6	45.3	43.5	39.5
Death Rate	-	-	-	26.9	22.9	19.2	16.4	14.6	11.6
Population Growth Rate	-1.1	4.8	9.4	22.3	25.8	27.4	28.9	28.9	27.9

*Population estimates in millions. Crude birth, death and natural population growth rates in annual growth per thousand population in the five-year period following the year reported from 1950 to 2000, for the 50 year period following the year reported in 1750, 1800, and 20 year period after 1900. Estimates for 1750, 1850, 1900 from: S. Kuznets, Modern Economic Growth, 1966, Table 2.2 derived by him from Carr-Saunders (1936), except where modifications drawn from (#) J.D. Durand, 1974, Historical Estimates of World Population: An Evaluation. Estimates for 1950 to 1990 and projections for the year 2000 from United Nations, 1991, World Population Prospects 1990 medium variant.

- Estimates for the disaggregation between birth and death rates are not reported.

^aHigher Income Industrially Advanced Countries includes Europe, Asiatic USSR, North America, Australia and New Zealand and Japan. Lower Income Countries includes all other countries.

^bSouth East and East Asia extends from Myanmar to Mongolia excluding Japan and Asiatic USSR.

^cSouthern and Western Asia extends from Bangladesh to Turkey.

absence of immigration, early in the next century. Population growth in Latin America peaked in the 1960s when it approached 3.0 percent per year, and will have declined to 1.7 percent by 2000. The population of East and South-East Asia increased at its maximum rate of 2.2 percent in 1970, and will plunge to 1.0 percent by the turn of the century. This region is of course dominated by China, which experienced a sharp decline in its fertility from 1970 to 1980, but many other countries in the region have reported similarly large fertility declines, without the imposition of the Chinese "one-child family" policy. South and West Asia had its peak population growth rate of 2.5 percent somewhat later, in 1980, and this rate may decline to 2.0 percent by the year 2000. For example, India, Pakistan, and Bangladesh have not shown much decline in population growth rates since 1960, because gradual declines in death rates have numerically counterbalanced declines in birth rates. The population of Africa is still growing at its peak rate of 2.9 percent, and forecasts for this continent are particularly uncertain given gaps in data and the AIDS epidemic.

Crude birth and death rates are influenced by swings in the age composition of populations. It is useful for comparative purposes, therefore, to consult measures of fertility and mortality that are independent of age composition, and although they may appear to refer to a birth cohort or a representative agent over her lifetime, they are actually derived from vital rates for a particular year or period. The "total fertility rate" is the average number of children that would be born alive to a woman during her lifetime, if during her childbearing years she were to bear children at each age at the prevailing age-specific birth rates. "Infant mortality" is the number of deaths of infants under one year old in a given year per 1000 live births. Although infant mortality has declined most dramatically, the entire schedule of age-specific mortality can also be summarized in "life expectancy" at birth, or the average number of years a newborn would live, if current age-specific mortality were maintained. Estimates and projections of these three

demographic indicators are reported in Table 2 from 1950 to 2000 for the same regions of the world.

Total fertility rates in the higher income countries have fallen from 2.8 children per woman in 1950 to 1.9 in 1990. In the long run, a total fertility rate of about 2.1 is required for a population to just replace itself, in the absence of immigration or emigration. Table 2 suggests the marked decline in infant mortality and increase in life expectancy in East and South-East Asia in the 1960s was followed by the decline in total fertility rates in the 1970s. Latin America, South and West Asia, and particularly Africa achieved a more gradual decline in infant mortality, and this may help to explain the timing and pace of the subsequent fertility declines in these regions.

Antibiotics, insecticides (that curbed vector borne diseases such as malaria), vaccines, and other public health measures that spread after the Second World War are attributed a central role in the decline in mortality in lower income countries (Preston, 1980). The persisting high levels of child mortality and the relatively low levels of female education in Africa are mentioned as contributing to the high levels of fertility in Africa. Others have argued that special features of the African family, such as co-residence of the extended family, fostering of children, and limited responsibility of fathers for the costs of childrearing, could help to explain the high African fertility levels (Caldwell and Caldwell, 1987). The shortage of reliable household survey data containing a combination of economic and demographic information has, until recently, prevented researchers from contributing much to debates of this nature about the causes for high fertility. But progress in understanding the household and community constraints on the demand for children promises to also account for some of the variation in African experience as it already has in Latin America and Asia.

Table 2

Period Measures of Fertility, Infant Mortality and
Life Expectation at Birth for World's Regions*

	1950	1960	1970	1980	1990	2000
1. World						
Total Fertility Rate	5.00	4.98	4.46	3.65	3.31	2.96
Infant Mortality Rate	155.	118.	93.	79.	63.	51.
Life Expectation	47.5	53.2	58.6	60.4	63.9	67.0
2. Higher Income						
Total Fertility Rate	2.84	2.69	2.20	1.93	1.88	1.91
Infant Mortality Rate	56.	32.	22.	16.	12.	9.
Life Expectation	66.0	69.8	71.1	72.8	74.9	76.6
3. Lower Income						
Total Fertility Rate	6.19	6.09	5.41	4.19	3.71	3.20
Infant Mortality Rate	180.	136.	105.	89.	70.	57.
Life Expectation	42.2	48.5	55.2	59.4	63.3	66.5
4. Latin America						
Total Fertility Rate	5.87	5.96	4.99	3.93	3.25	2.81
Infant Mortality Rate	126.	100.	81.	61.	48.	37.
Life Expectation	51.9	57.3	61.3	65.2	68.1	70.4
5. South East and East Asia						
Total Fertility Rate	5.78	5.47	4.59	2.77	2.47	2.13
Infant Mortality Rate	175.	114.	72.	46.	34.	24.
Life Expectation	44.1	51.5	61.6	66.3	69.7	72.1
6. South & West Asia						
Total Fertility Rate	6.17	6.07	5.78	5.16	4.47	3.61
Infant Mortality Rate	190.	157.	134.	111.	88.	68.
Life Expectation	39.6	45.4	50.2	55.1	59.9	64.4
7. Africa						
Total Fertility Rate	6.65	67.9	6.62	6.40	6.03	5.31
Infant Mortality Rate	188.	165.	137.	116.	94.	77.
Life Expectation	37.7	41.8	45.9	49.6	54.1	58.1

*See notes on regional definitions to Table 1. Rates refer to the five-year period following the year reported.

Source: United Nations, 1991, World Population Prospects 1990, medium variant.

3. Micro Foundations for Household Behavior

Household economic models of fertility originated in the writings of Becker (1960, 1965), Mincer (1963), and Leibenstein (1957), and have been restated with changing emphasis thereafter (T.W. Schultz, 1974; T.P. Schultz, 1976a, 1981). As currently employed, most household models of the demand for children share certain features. First, the traditional money income budget constraint is replaced by a time budget constraint, endogenizing the allocation of time between market labor supply and non-market activity. This is especially important for women because some of their labor market activities cannot be readily combined with child care.

Second, demographic and economic behavior depend on the household stocks of human and physical capital. Labor is particularly heterogeneous in its productive attributes and alternative uses and is valued distinctly for each family member, particularly if labor is used in rearing children. Separate labor supply equations for husband, wife, and children are a minimum accommodation to the existence of the multiperson family. Yet the family takes on a variety of extensive forms, and many models have been devised to represent this flexible institution across the world, possibly because different transactions costs can modify efficient long-term relationships that are designed to coordinate consumption, production, and reproduction in society (Goody, 1976; Ben-Porath, 1980; Pollak, 1985; McElroy and Horney, 1978; Gertler and Newman, 1992; Chiappori, 1992).

Third, labor market training, migration, marriage, children, and retirement savings may be accounted for by permanent and potentially foreseen life-cycle conditions and should be less strongly influenced by transitory developments in a person's lifetime. Since many of the same long-term opportunities, traits, expectations, and preferences are attributed a role in determining these interrelated life-cycle decisions and interdependent resource allocations, it is only reasonable to view these life-cycle outcomes as jointly and simultaneously determined.

However, estimation of household demand systems was initially based on the assumption that a block recursive stochastic structure adequately represented by time-ordered behaviors of the individual and household (Orcutt et al., 1961; Wold, 1964). Path analysis was analogously justified in the sociological study of the unfolding of life-cycle ordered events (Duncan, 1966). But this statistical approach depended on the simplifying assumption that errors are independent across demand equations. In the study of long-run household life-cycle behavior, such recursivity of errors is unlikely. To assume, for example, that the number of children a woman bears is an exogenous shock determining the schooling of her children contradicts the household demand framework, wherein both outcomes are evaluated together, even though the fertility decision formally occurs before the schooling decision and contains an unpredictable error component. Preferences of consumers and biological traits relevant to household reproduction, such as desired fertility and fecundity, are likely to be persistent. They are, therefore, impounded in statistical errors to equations accounting for many forms of demographic and economic behavior over the life cycle and tend to be serially correlated and correlated across behavioral equations. Identification of recursive structures in the household demand framework may be difficult, therefore. Even when plausibly approached as a simultaneous equation system or a multistate duration model, it may be difficult to identify convincingly the structural parameters that relate one endogenous outcome to another endogenous outcome within the same household.

There is growing agreement on suitable exogenous constraint variables and endogenous choice variables that the household determines jointly with fertility. Reduced-form equations are thus often estimated to explain several of the household economic and demographic choice outcomes in terms of a common list of conditioning exogenous variables: household endowments, skills, the local prices of inputs and outputs, wages, local public sector services, and environmental factors, such as climate and endemic diseases. An empirical

body of knowledge is thus accumulating on which to generalize about the relative magnitude of specific reduced-form parameters across a variety of populations. Parameters describing household production technology may also exhibit sufficient stability in some areas such as reproduction, nutrition or health to permit the replication of estimates (Rosenzweig and Schultz, 1988). Regularities are emerging in reduced-form and structural demand and technology parameters over time and across societies.

The general household demand model clarifies various types of relationships and classifications of variables, but in its unrestricted form it offers few predictions that can be tested empirically. Nonetheless, as with many conceptual frameworks, it also focuses the analysis and structures the empirical research. Simplifying and restricting the characteristics of the consumer's utility function (i.e., preferences) or the household production relations (i.e., technology) may be justified, in which case theory can undoubtedly provide more testable predictions. It is not always possible, however, to distinguish then whether a rejection of the predictions is due to the inadequacies of the general theory or the invalid specific restrictions imposed on the framework.

3.1 The General Household Demand Framework

Parents are assumed to maximize their lifetime utility, which depends on, say, six commodities: their number of children, C ; the average education and health of their children, E and H ; the average leisure activities of the husband and wife, L_h , L_w , respectively; and another composite household commodity, G :

$$U = U(C, E, H, L_h, L_w, G). \quad (1)$$

Each of these arguments of the utility function may be thought of as produced in the home by constant returns to scale technology with market goods, X , and the non-market time, t , subscripted to husband and wife:

$$i = \alpha_i (X_i, t_{hi}, t_{wi}, \mu_i), \quad (2)$$

where $i = C, E, H, L_h, L_w$, and G . A couple-specific trait represented by μ_1 influences production possibilities and is partially known to the couple, though it is not controlled by them. For example, it might be exogenous genetic or environmental factors that affect the couple's production of births, or what shall be called simply "fecundity" (Rosenzweig and Schultz, 1983a, 1985, 1987).

The allocation of each individual's time across household production activities is assumed to be mutually exclusive in Becker's (1965) original model; namely, no jointness in production is permitted. This can be relaxed with little added complexity (Rosenzweig and Schultz, 1983a). Together with time supplied to the market labor force, t_{jm} , the alternative uses of time sum in the Becker framework to an exogenously given time budget constraint:

$$\Omega_j = t_{jm} + \sum_i t_{ji} + \sum_j L_j \quad (3)$$

where $j = h, w$ and $i = C, E, H, L_h, L_w, G$. Market income is equal to the lifetime wage rate, W_j , received by each member of the family, times their market labor supply, plus income from non-human capital endowments of husband and wife, V_h and V_w . For simplicity, children are assumed to acquire property only as adults.

$$Y = t_{hm} W_h + t_{wm} W_w + V_h + V_w \quad (4)$$

If the household production functions (2) exhibit constant returns to scale, and all family members work some time in the market, i.e., $t_{jm} > 0$, full income, F , can be defined (below) as an observed exogenous budget constraint (5), and the shadow prices of the household commodities (i.e., π_1 = the opportunity cost of the market goods and household member's time inputs used to produce a unit of the commodity) are then fixed by market-set prices and wages and do not depend on the bundle of commodities consumed by the household. Otherwise, these shadow prices will depend on parent preferences and returns to scale and cease to be exogenous (Pollak and Wachter, 1975). If family members withdraw entirely from the market labor force, an interior solution does not occur, and the model takes on added complexity. If children worked, and their allocation

of time was an input in the production of E and H, full income would become endogenous because it would depend on fertility. Full income is designed here to replace market income as a new exogenous resource constraint that is not affected by the family market labor supply decisions. The concept of full income, although it contains all of these ambiguities for empirical analyses of life-cycle behavior (Gronau, 1986), is nonetheless heuristically valuable:¹

$$F = \Omega_h W_h + \Omega_w W_w + V_h + V_w. \quad (5)$$

Becker's (1965) household production framework suggests that household behavior can be interpreted as jointly allocating time between market and nonmarket production and combining market goods and nonmarket time to produce commodities that are the final source of utility to the members of the household. It also assumes that the family can be approximated as a unified optimizing consumer, an assumption that has since become standard in neoclassical studies of family labor supply (Ashenfelter and Heckman, 1974; Smith, 1980; Killingsworth, 1983).²

¹The household production approach is criticized because in a (less specialized) home production environment, time is frequently employed to advance several activities at one time, such as a mother caring for her children while doing housework, or tending some own-account business pursuits. Variable returns to scale are also expected in household production. The properties of household technology that Becker postulated are required to preserve the "adding up" property of full income and maintain the exogeneity of shadow prices. But neither shadow prices nor full income are generally observed or empirically needed except to facilitate comparisons of family welfare. This is difficult to interpret anyway when family composition is allowed to vary (Gronau, 1986). Another feature ignored is the public-good aspect of some commodities. Children may be enjoyed by both parents without necessarily reducing either's pleasure. How these restrictions on technology actually distort analysis has not been demonstrated without an alternative model to Becker's which could be estimated (Schultz, 1981, 1990; Gronau, 1986; Lam, 1988).

²Aside from casual empiricism, which suggests individuals do not always submerge their individual interests in a consistent manner within a family, there are opportunities to test empirically whether the restrictions implied by demand theory applied to the family are consistent with observed behavior. For example, the income compensated husband's market labor supply response to his wife's wage should be symmetric (equal) to the compensated wife's labor supply response to her husband's wage (Killingsworth, 1983). Similarly, it is sometimes suggested that the wife values more highly than does her husband certain allocations of family resources, such as investments in child quality (H, E and perhaps L_c). In this case, increments to her wealth (e.g., dowry) or V_w should increase the demand for these qualitative attributes of children more than would equal increments to the husband's wealth, V_h . Indeed, for this reason, the standard

Reliance on the existence of a well-behaved nuclear family utility function is a limitation of the conceptual framework. In practice, however, the decision problem can be reframed in terms of the constraints facing an independent individual, as is standard practice in the study of the factors conditioning the establishment and dissolution of cohabiting relationships or legally/religiously contracted marriages (Becker, 1981; Boulier and Rosenzweig, 1984; Montgomery, 1986; Chiappori, 1992).

Nash-bargaining models of demand behavior of spouses within marriage draw attention to the distinctive effect of each spouse's own wealth, V_h and V_w , as they influence a spouse's "threat-point." Individualistic approaches to family behavior direct our attention to customary arrangements associated with family property rights and the origin of family assets, such as inheritances, gifts, or dowry, in order to be able to impute more accurately the ownership of these assets to specific family members. If V_h and V_w influence family demands in the same way empirically, then there is no empirical gain from preserving the distinction, and the family utility-maximizing model that generally pools V_w and V_h is the more parsimonious representation of household demand behavior (McElroy and Horney, 1978). The implied neoclassical restriction on family behavior is testable if V_h and V_w can be separately observed and represent comparable assets, e.g., equally liquid (Schultz, 1990; Thomas, 1990).

Reduced-form demand equations for the household produced commodities are implied by maximizing (1) subject to (2) and (3) and can be generally written as follows:

$$i = Z_i (P, W_h, W_w, V_h, V_w, M, e_i), \quad (6)$$

where P is a vector of average prices of market goods and public services available to the household, M is the vector of exogenous household-specific

household model generally only includes an aggregate nonearned-income variable. Testing for significant differences in the husband and wife wealth effects is one check on the family demand model (Schultz, 1990).

traits, including μ 's that affect household's production of i 's, and e_i are random disturbances that embody the effects of the couple's preferences and unobserved technology plus uncorrelated errors in measurement and specification.

The reduced-form derived demand functions for market goods and time allocations of household members may be written analogously:

$$X_i = X_i(P, W_h, W_w, V_h, V_w, M, f_i), \quad (7)$$

$$T_{ij} = T_{ij}(P, W_h, W_w, V_h, V_w, M, g_{ij}), \quad (8)$$

where f_i and g_{ij} are also uncorrelated disturbances.

Since it is assumed that market prices, local public programs, life-cycle market wages, and family nonearned income are exogenous, the reduced-form equations (6), (7), and (8) can usually be estimated consistently by standard single-equation methods. Although the researcher is unable to observe all of the productive traits of the couple, M , their omission from the analysis need not bias the remaining estimates. This depends, of course, on the assumption that the unobserved productive traits of the couple, such as fecundity, are distributed independently of economic endowments, prices, and programs, or that the other elements of M are uncorrelated with the P , W 's and V 's. The reduced-form demand equations embody the more fundamental technological parameters from the household production functions (2) and the behavioral demand parameters from the utility function (1).

3.2 A Simple Production - Demand Model of Fertility

Children are assumed to be a source of satisfaction for parents, or they may also produce future services that parents value, and their children consume resources that have alternative uses. In addition, parents must have some, albeit imperfect, control over how many children they have (see, for example, Becker, 1960; Willis, 1974; Coale, 1973; Bryant, 1990). If only two goods are distinguished that yield utility for parents, children and a composite bundle of other goods, G , some assumptions must be made about how C

and G are produced, beyond the linear homogenous production technology implied by (2). One empirical generalization that fits most societies is that the opportunity value of a mother's time in child bearing and rearing exceeds the value of a father's time in child rearing, i.e., $t_{wc}W_w > t_{hc}W_h$, and that the value of the mother's time input to children as a share of the total opportunity cost of producing children, called mother's "time intensity", α_{wc} , exceeds her time intensity in the production of the other good G, i.e. $\alpha_{wc} > \alpha_{wg}$. If the wage or shadow value of her time increases, this will then raise the opportunity cost of children relative to other goods, and if "full" income is held constant, this will lower the demand for children. However, when the woman's wage is observed to increase, so does full income. The (negative) income-compensated price effect of an increase in a woman's wage is offset by a (positive) income effect, for children are thought to be a normal good. The observed uncompensated female wage effect may, therefore, be either positive or negative on the demand for children.

In the case of the man's wage, it is less obvious whether children are more male-time intensive than the composite good, or, in other words, whether the income-compensated price effect of the male wage on the demand for children is negative, and if negative, whether it is sufficiently large to outweigh the positive income effect. The elasticity of the demand for children with respect to the wage of the man or woman in this two commodity case can be decomposed according to the Slutsky equation into compensated full price (π_c) and full income elasticities (Ben-Porath, 1974; Schultz, 1981):

$$\eta_{cw_j} = \eta_{c\pi_c}(\alpha_{jc} - \alpha_{jg}) + \eta_{cf}\left(\frac{W_j t_{jg}}{F}\right), \quad j = w, h. \quad (9)$$

The income elasticity (η_{cf}) is weighted by the market earnings of the individual whose wage is varying. Thus, the presumably positive income effect associated with a man's wage is weighted more heavily than for a woman's wage, to the extent that his wage exceeds hers and to the extent that he works more hours in the market labor force than she. The compensated price elasticity

(η_{Cn_e}) is weighted by the difference between that spouses time intensities in C and G. Although the sign of the male or female wage effect on fertility is not prescribed by this theory, it is clear that the male wage will exert a more positive (or less negative) effect on fertility than the female wage.

As an empirical observation, virtually all cross sectional studies of fertility have found fertility to be inversely related to women's wages, or to the most common proxy for wages, education (Schultz, 1976a). Thus, the child price effect associated with women's wage rates empirically exceeds in absolute value the income effect. The male wage is often associated with higher fertility in traditional agricultural societies, but is also found to be associated in some instances with lower fertility in industrially advanced, high-income societies. The extent of land ownership or value of physical assets is often associated positively with fertility, but it is moot whether these wealth variables are indeed exogenous as is generally assumed within this framework (Stys, 1957; Rosenzweig and Evenson, 1977; Schultz, 1990, 1994).

The most important implication of the household demand framework is that different sources of family income have different effects on the demand for children. The woman's wage has the most negative (or smallest positive) effect on fertility, the man's wage a less negative or possibly positive effect, and inherited wealth or natural resource income has the largest positive effect, because it does not embody any offsetting price effect to deter the demand for children (Schultz, 1981).

Willis' (1974) model of fertility advanced two additional restrictions on this more general framework: men provide no time in the rearing of children, and women's education increases woman's market wage opportunities but does not increase her home productivity. This latter assumption followed an earlier approach of Becker (1964, p. 178) and suggested that women would productively benefit from education only to the extent that they worked in the market labor force. This line of reasoning has subsequently been rejected by

some researchers because it led to downward biased estimates of the returns to education for women compared to men if nonmarket productivity was enhanced by education (Schultz, 1989). Given his assumptions, Willis showed that as women allocate some of their time to the labor market (for a constant wage), education would only then raise market wages and reduce fertility, a prediction that is not confirmed in low-income country studies. More interesting, the direct effect of a man's wage is to increase fertility for it embodies only an income effect; men do not allocate time to childrearing. But this male wage effect is larger for women who participate in the labor market, because their marginal value of time does not depend on their husband's wage. For a woman working entirely within the home, additions to male income raise her marginal product at home and hence raise the price of children which are intensive users of her time. Because the woman's labor force participation is endogenous in Willis' model, empirical implications of this setup are difficult to test.³ More important, the working assumption regarding men's time allocation and women's benefits from education are not particularly attractive ways to simplify the model.

Becker's (1960) idea that children are consumer durables that come in various qualities met with understandable skepticism (Blake, 1968). The price of children could rise, Becker suggested, for two possible reasons: first, the demand of parents to invest in higher quality children could increase; and second, the price of inputs to produce a constant-quality child could increase. The inverse empirical relationship between fertility and the resources a parent invest per child is known as the "quantity-quality tradeoff". Sociobiologists speculate on why a particular balance of quantity and quality occurs in various species, in addition to man (Becker, 1981).

³Assuming linear specifications for the fertility demand equations and the participation equation, a reduced form fertility equation is expressed as a mixture model of the distinctive fertility demand equations for participating and nonparticipating wives. Only the quadratic terms on women's education and male income are signed by the restricted theory, and these higher order terms are only briefly examined by Willis based on his analysis of a 1960 U.S. Census sample.

When inputs to produce children are viewed as contributing to the production of both the number of children and their quality, and both are to some degree parental choices, the simple cost of a child is not an exogenous price to which consumers respond, but is itself a choice variable. The problems with then constructing a constant-quality child price series have proven to be insurmountable (Lindert, 1980b; Espenshade, 1984). What began as an appealing empirical regularity between quantity and quality must not be interpreted as a causal relationship; both outcomes embody an element of choice and are affected by the same consumer's budget constraint (Becker and Lewis, 1974; T.W. Schultz, 1974; Becker and Tomes, 1976; Rosenzweig and Wolpin, 1980a).

3.3 Quantity and Quality of Children

Willis (1974) assumed that child services (S) were produced as the product of the quantity of children (C) and quality (Q), both of which are produced by linear homogeneous household production functions (2) (quality could be either education, E, or health, H, in the previous notation). The full income constraint is then rewritten as follows where π_i refers to the shadow price of the i^{th} commodity, inclusive of its market and time inputs:

$$F = \pi_s CQ + \pi_g G. \quad (10)$$

The marginal cost of quantity or quality of children then depends on the other dimension of child services demanded by the couple:

$$\begin{aligned} \partial F / \partial C &= \pi_s Q \\ \partial F / \partial Q &= \pi_s C \end{aligned} \quad (11)$$

This specification involving an interaction between commodities in the budget constraint implies that parents view quality and quantity as substitutes (Rosenzweig and Wolpin, 1980a), and that they also do not treat quality of any one child as distinct from that of their other children. Parents are thus assumed to be "bound" to treat all of their children equally. This simplification in the Becker/Willis framework can be contrasted with earlier analyses of consumer expenditures that allowed for quantity and quality to

vary independently with income (Houthakker, 1952; Theil, 1952). Casual empirical evidence is not entirely consistent with this simplified multiplicative quantity-quality model. Are first-born treated by parents in the same way as subsequent children? Psychologists are doubtful (Ernst and Angst, 1983; Zajonc and Marcus, 1975). Do parents invest the same amount in the quality of daughters as sons? Sex differences in human capital are still marked in some countries, and these appear to stem mostly from school enrollment decisions within the family (Schultz, 1993b). It is, of course, possible to think of male and female births as different commodities in the utility function of parents, with also perhaps distinct costs and benefits. Thus, it is not innocuous to assume that parents demand uniform quality for their children.

The assumption of the quantity-quality model should be viewed as a testable restriction on the more general framework in which quality and quantity are not necessarily a source of interactive costs or substitutes for each other. It is not straightforward, however, to estimate the cross commodity effects, because all market prices, household endowments, etc. are arguably determinants of both Q and C , leaving no obvious exclusion restriction to account for exogenous variation in C in the demand equation for Q or to identify Q in the C equation.

Two approaches are used to measure exogenous variation in fertility to estimate behavioral adjustment of child quality. Having a twin on first birth is uncorrelated within a sample of mothers with factors determining the demand for children, e.g., endowments, prices/wages, and preferences, and yet twins are correlated with children ever born because some couples want only one child or want few births and are unable to perfectly avoid subsequent births. Twins are, therefore, a valid instrument to predict children ever born and thereby estimates without simultaneous equation bias the effect of exogenous variation in fertility on other forms of household behavior. Rosenzweig and Wolpin (1980a) rely on information on twins to predict C that is used to

explain the demand for Q , measured in a large Indian rural survey by the schooling received by children in the family. They use the same econometric approach to assess how unanticipated fertility "shocks" affect subsequent labor force participation of mothers in the United States (Rosenzweig and Wolpin, 1980b).

A second strategy for isolating the behavioral effects of unanticipated variation in fertility first obtains consistent estimates of the (biological) technology of reproduction and uses these estimates to derive residual variation in reproduction given predicted contraceptive behavior. Unpredictable failures of specific contraceptive practices, which yield unplanned births (adjusting for the heterogeneous biological\behavioral fecundity of couples), are then used to explain subsequent fertility, contraceptive choice, and child quality (Rosenzweig and Schultz, 1985, 1987, 1989; Schultz, 1992a). In all of these studies, discussed further in Section 3.6, the empirical evidence supports the hypothesis that the number of children and the quality of children are substitutes, insofar as parents adjust to unanticipated increase in fertility by reducing child quality.

Another approach is to estimate directly cross-price effects. Does the provision of lower cost schooling and health services reduce fertility as well as increase the demand for the quality services? Does the provision of lower cost birth control supplies reduce fertility and raise the amount of schooling and nutrition that children receive in a community? Such estimates of cross-price effects are not compensated for their associated income effects. In the case of school and health prices on fertility, the income effect would operate so as to understate the income-compensated substitution effect. In the case of the effect of birth control prices on child quality, the income effect itself could be responsible for the observed substitution inferred from the observed uncompensated cross-price effect. The empirical patterns of cross-program price effects on the quantity of children will be discussed further in section 5.5.

3.4 Empirical Applications to the Demand for Children

To apply the general household demand framework outlined in 3.1, restrictions and simplifications can help to focus the empirical analysis. It is necessary for the researcher to decide first which are the more important constraints on the choice or choices studied in a particular setting and then to derive predictions that can be tested empirically. One study of district-level data from rural India illustrates how this general framework may be restricted to consider a variety of household decisions as parallel reduced-form outcomes. Rosenzweig and Evenson (1977) considered three outcomes recorded in the 1961 Indian census: surviving fertility (children age 5 to 9 per woman of childbearing age), child school-enrollment rates, and child labor-force-participation rates. These are explained in terms of district-level agricultural wage rates for men, women and children, as well as land holdings and other aspects of the district economy, society, and climate.

To assess the likely substitutability or complementarity of household behavioral outcomes, previous empirical studies can provide some guidance. For example, as noted in section 3.3, the number of children demanded is often assumed to be a substitute for child schooling and child leisure, while schooling and child leisure may themselves be viewed as complements, if leisure includes homework for school. Women are generally assumed to contribute time to the "production" of children and the other home commodity (G), whereas children allocate their time among only schooling, labor force work, and leisure. Without good measures of exogenous wealth income, such as inheritances, from which to infer income effects, only uncompensated price and wage effects are observable. Rosenzweig and Evenson assume, therefore, that compensated substitution effects dominate income effects in the relevant Slutsky equations, leaving the sign of the compensated and uncompensated effects the same. Adult leisure is neglected, whereas child health is viewed as captured in the surviving measure of fertility they analyze, viz. child-woman ratios. These restrictions imply that the own-wage effects on the

demand for children are reinforced by cross-wage effects, operating on the demand for other commodities, and that income effects do not outweigh the compensated wage effects that operate in predictable directions on the observed household demands.

With these restrictions on the general model, Rosenzweig and Evenson show that exogenously higher women's wages should then be associated with lower levels of fertility, higher child-schooling levels, and lower child labor-force-participation rates. Conversely, exogenously higher child wages should be associated with higher levels of fertility, lower schooling, and higher child labor force participation. More controversial restrictions are still needed to establish the signs of the effects of the size of land holdings on family size (positive), school enrollments (negative), and employment of children in the labor force (positive). An interesting feature of the data is that child labor force and schooling decisions can be analyzed separately for boys and girls, thereby shedding light on substitution possibilities among these types of family labor and intrahousehold gender-based resource allocations (see also Rosenzweig and Schultz, 1982a; Schultz, 1993b).

Wage rates for men, women and children are critical determinants of the demand for children, but they pose special problems for measurement and analysis at either the aggregate or individual levels. When observations relate to couples, and the wage rates are averages for their residential communities, the working assumption that such community wage opportunities are exogenous determinants of fertility appears defensible. Hence, these aggregated wage rate variables are admissible in reduced-form equations for individual household demand behavior. But when the units of observation are aggregates, as in the case of districts in India, inter-district variation in wages may be due to either demand factors or unobserved supply factors that could jointly determine fertility. Wage rates must then be treated as endogenous, at least for women and children for whom labor supply is not

inelastic (Cf. Schultz, 1985). Consequently, Rosenzweig and Evenson (1977) treated their child wage series as endogenous and based their estimates of the child wage effects on instrumental variables, such as rainfall, irrigation, and nonfarm employment opportunities that were thought to be exogenous and yet may have influence on the derived demands for child labor. However, they treat their female wage series as exogenous. Regardless, many of the behavioral patterns predicted by their restricted model are empirically confirmed in their district-level analysis of wage and farm asset variables that affect fertility, schooling, and child labor force participation (by sex). Their restricted household demand model does not imply the sign of the relationship between the husband's wage and the household's demand for numbers of children and their schooling. Regional male wages were found to be positively associated in rural India with surviving fertility and negatively associated with child schooling levels as suggested by the simpler models outlined in section 3.2. Most of these empirical patterns are also observed in other studies of fertility in low-income agricultural populations (Schultz, 1976a; Mueller, 1984).

Wage rates of individual family members are thought to play an important role as the opportunity cost of time in explaining many forms of household economic and demographic behavior and are particularly useful in the study of fertility. Life-cycle average wages, as an exogenous constraint on lifetime choices, are not straightforward to measure at the individual level for at least two reasons: (1) current wages of an individual become endogenous over the life cycle as they reflect prior cumulative investments in specialized skills; and (2) wages are not observed for all persons if, for example, some currently work only in the home or work as a self-employed or family worker. Both problems appear to be more serious for inferring the wage of women than the wage of men. Having and caring for children competes for the mother's time that could otherwise be invested in gaining skills and experience that are productive in market work. Current and future wages of women are thus

depressed by fertility.

A standard econometric procedure to approximate the exogenous or initial life-cycle wage profile is to use instrumental variables to impute a value for the wage to each individual, and this wage is thereby uncorrelated with the individual's previous idiosyncratic time allocation, career, and fertility decisions, etc. The specification of these instrumental wage equations builds on the human capital earnings function (Mincer, 1974), except that the dependent variable is the logarithm of the wage rate, and measures of labor supply, such as weeks worked, must be excluded from the instruments because they are themselves endogenous. This instrumental variable human capital wage function is fit for men and women (and potentially for boys and girls) separately, and the imputed value is assigned as the life-cycle wage for each person in the sample. Actual labor market experience or tenure on the job are for similar reasons not legitimate instrumental variables for predicting wage rates, for they are endogenously determined by past labor supply, job search and training behavior, particularly for women. Post schooling potential experience is treated as exogenous, being essentially the difference between age and years of schooling. Some studies hold post schooling experience constant (at, say, the "overtaking point" of ten years when investment in on-the-job training is small and the wage approximates labor's current marginal product (Mincer, 1974, p. 93)) to disentangle crudely the effect of life-cycle wage levels from age, which can exert its own effect on fertility over the life cycle and can differ between birth cohorts. Regardless, with predicted wages as explanatory variables in the household demand model, standard errors should then be adjusted (Murphy and Topel, 1985).

The wage equations should also be corrected for sample selection bias (Heckman, 1987) because they must usually be based on a relatively small and potentially unrepresentative sample of wage earners. This can be particularly serious in the case of women and children, whose wage participation rates are lower than for men. The most widely used

identification restriction in sample selection models for wage earners is nonearned income or nonhuman wealth, preferably from land or inherited assets that do not reflect the individual's own labor productivity, work, and savings behavior. Nonearned income is postulated to reduce the likelihood that the individual is observed to work for wages, but has no causal correlation with the market wage rate the individual is offered.⁴

3.5 Interdependencies Among Endogenous Variables: Fertility and Mortality

Studies of interregional variation in household demographic and economic behavior have analyzed jointly several household outcomes such as fertility, age at marriage, proportion legally and consensually married, female and child labor-force-participation rates, and finally, family market income (DaVanzo, 1971; Maurer et al., 1973; Nerlove and Schultz, 1970; T.P. Schultz, 1969, 1972, 1981). Evidence from Puerto Rico, Taiwan, Egypt, Chile, and Thailand suggests that in low-income countries increased women's education and wage rates help to account for women's increased participation in the market labor force, decreased or delayed marriage, and reduced fertility. These investigations also sought in addition to reduced-form estimates to measure how various endogenous variables (*i*'s and *t*'s) affect each other. A priori identification restrictions were exploited across structural behavioral relationships. The timing of marriage, and levels of fertility and family

⁴In estimating wage rates for use in household demand studies, sample selection bias can be a serious problem for men (Anderson, 1982) and women (Griffin, 1986) in low-income countries. There are many econometric issues that arise with such wage correction and imputation schemes. Multiple sources of sample selection may be present, such as nonreporting among wage earners. If the researcher understands what causes the different types of selection, and each selection rule can be identified by distinct variables, the selection bias corrected estimates should be considered even if the point estimate of inverse Mill's ratio (λ) is insignificant. But reliance on functional form alone (e.g., the normal distribution of the error terms in the probit selection rule) to achieve identification may not be sufficiently powerful to improve empirical results. Economic or institutional knowledge of the selection mechanisms is not only helpful but perhaps essential for dealing with this widespread econometric problem in micro research based on household surveys.

labor supply behavior were assumed to be jointly determined, but the choice of identifying exclusion restrictions were debatable.

Only under special conditions is it possible to estimate the consequences of a change in the level of one household demand commodity (or choice) on another; for example, as noted earlier, the effect of a decline in fertility on the average level of child schooling, or quantity on quality. Any of the reduced-form determinants of one outcome in equation (6) may be an important determinant in another reduced-form equation. The exception to this rule is when one of the commodities is not chosen by the household but is randomly allocated, as if by a stochastic rationing mechanism. The clearest example, already noted, is the occurrence of twins, which can then be related to other adjustments in the household's pattern of consumption and behavior. In rural India, Rosenzweig and Wolpin (1980a) show evidence that twins are associated with a decrease in the schooling levels of other children in the family. This accommodation of household demand for E to an exogenous fertility supply shock, i.e., twins, can be expressed:

$$\partial E / \partial \bar{C} = (\partial E / \partial \pi_c) / (\partial C / \partial \pi_c) \quad (12)$$

where the effect of an exogenous change in C on E is equal to the compensated cross (shadow) price effect of π_c on E, divided by the compensated own-price effect on C (Rosenzweig and Wolpin, 1980a).⁵ Since the compensated own-price effect is negative, the negative sign observed in India for $\partial E / \partial \bar{C}$ from twins implies that exogenous variation in children and child schooling are substitutes, i.e., $(\partial E / \partial \pi_c) > 0$. Without further restrictions on the cofactors of the general demand model, it is not possible to discriminate between (i) the interaction of child quality (schooling) and quantity in the full income

⁵When demand for one good exceeds supply, and existing supplies are allocated independently of preferences, prices or income, the problem of rationing arises (Tobin and Houthakker, 1950). The effect on fertility of supply shocks associated with twins which occur randomly are analogous to rationing, and twins are then expected to modify other forms of household consumption (and perhaps production) behavior in proportion to the compensated cross-substitution price effect between the rationed (shocked) and unrationed good divided by the compensated own price effect of fertility as shown in (12).

constraint, as hypothesized by Becker and Lewis (1974), or (ii) the conventional interpretation in consumer demand studies where child quality and quantity are viewed as substitutes by parents, i.e., an arbitrary restriction on the parents' utility function (1).

In a similar study of the effect of twins on mother's market labor supply behavior, Rosenzweig and Wolpin (1980b) identify the consequences of this exogenous supply shock on another household demand (i.e., women's labor supply). It should be noted, however, that these "twin"-based estimates of the effects of fertility need not provide an appropriate measure of how household demands would respond to voluntary changes in fertility, because these changes in fertility embody the demands of couples adjusting to changes in prices, wages, and technology.

One major demographic development is often interpreted as having been due primarily to exogenous and unforeseen technological developments. It is the sharp decline in mortality in low-income countries in the period after World War II that had a disproportionate effect on reducing infant and child mortality. Many observers have attributed the change in level of mortality to the spread of new public health technologies that progressed independently of economic development (Stolnitz, 1975; Preston, 1980). To the extent that this decline in child mortality was unrelated to parent resources, prices, or preferences, the resulting increase in surviving children that parents experienced could be interpreted as an exogenous shift in the biological "supply" of children (Schultz, 1981). The behavioral adjustment of parents to this development may then be analogous to that measured in the twin statistical studies.

However, it is more realistic to recognize that part of a decline in child mortality over time and variation in child mortality in the cross section is explained by economic variables that belong in the reduced-form equations of the family demand model. When the partial effects of parent education, wages, and family planning programs on fertility are held constant

by statistical means, child mortality is still generally observed to be related to fertility. But such a partial association could still reflect unobserved variables that affect both fertility and child mortality, or the reverse effect of fertility on child mortality by a "crowding" effect of a large number of siblings on a child's likely mortality. An exogenous factor must be specified that affects child mortality but does not influence parent reproductive demands in order to identify estimates of the parent fertility response to exogenous variation in child mortality. The choice of such an identification restriction should be dictated by a well-founded theory or knowledge of the technology of the relevant processes. If the identifying restriction is arbitrary, the estimates are likely to be misleading.

Household demand theory does not provide strong predictions when it comes to the nature of the response expected of parents to an exogenous change in child mortality, as in the case where public health interventions eradicate a childhood disease without requiring any change in parent behavior. Parent demand for births may be viewed as a derived demand due to the value parents attach to surviving children, i.e., those who do not succumb to the host of infectious and parasitic diseases that are particularly lethal to a malnourished infant or child in a low-income environment (Schultz 1969). An exogenous reduction in such child mortality reduces the cost of producing a survivor, while it also reduces the number of births needed to have a survivor. If parent demand for surviving children is price inelastic, and the cost per surviving child decreases in proportion to the increase in survival rate, then price theory implies that parents will respond to an exogenous decline in child mortality by reducing the number of births they demand (O'Hara, 1975; Ben-Porath, 1974; Schultz, 1981; Sah, 1991). This result may be strengthened if the decline in mortality extends to later ages, thereby increasing the expected returns to investments in the human capital of children, and these forms of child quality are seen by parents as a substitute for a greater number of children. Incorporating the consumer's aversion to

risk and the uncertainty of child mortality can further modify how parents react to changes in death rates over time. Section 5.2 reports the empirical evidence on this very important economic and demographic relationship, one that may tie together the demographic transition.

3.6 Estimating Household Production Functions

Another methodological approach for measuring the responsiveness of fertility to exogenous variation in demographic variables involves explicitly estimating more of the structure of the general model, and thereby isolating variation in mortality or fertility that cannot be attributed to behavior. This residual variability can then be viewed as an exogenous unexpected "shock". First, the reduced-form demand equations, (7) and (8), are estimated for the inputs to the household production function (2). Individual predictions of input demands based on these estimated equations then permit the estimation of the household production functions parameters by instrumental variable techniques. These estimates are consistent, because the instruments -- prices, programs, wages, and family wealth -- are assumed independent of the production trait, μ . Based on the estimates of the technical production parameters to (2), expected outcomes, i^e , are calculated, given the couple's actual input behavior. The deviation of the actual behavioral production outcome from that which is expected, $i - i^e$, is then a measure, albeit with error, of the couple-specific trait, μ_i . Data on individual outcomes over time can improve the precision of the estimation of the time-persistent component of this forecast error, which μ_i is intended to represent. This measure of the exogenous variation in, say, child health, measured, for example, by deviations of a mother's actual infant mortality from expected infant mortality, can then be employed to explain subsequent fertility (Rosenzweig and Schultz, 1982b, 1983a). This roundabout procedure provides another way to estimate the reproductive replacement response of parents to exogenous variation in child mortality, i.e., an exogenous shock to

child health⁶.

Estimation of a household production function (2) for a couple's conception probability leads to analogous instrumental variable estimates of a reproduction function (Rosenzweig and Schultz, 1985, 1987). Technically unexplained deviations in a couple's reproductive performance over time, given their contraceptive behavior, can be interpreted as a measure of exogenous fecundity or variation in the supply of births, again measured with error. This exogenous variation in "fertility supply" can then be employed to explain subsequent modifications in the couple's contraceptive behavior, the wife's market labor supply, and even her market wage rate. It is theoretically expected and empirically confirmed that couples who have a higher than expected probability of conceiving in one period are more likely to adopt a more effective method of birth control or sterilization in a subsequent period (Rosenzweig and Schultz, 1985, 1989; Schultz, 1992a).

The primary conclusion drawn from these estimations of household production functions is that a priori structure must be imposed on the household demand model to get behind the reduced-form equations (6), (7), (8). To estimate the underlying household production-demand structure requires a method to remove the bias caused by heterogeneity in the couple-specific traits, μ_1 . Estimates of bias due to omitted variables is a problem at all stages of household demand and production studies. The unavoidable omission of inputs is probably more serious in the estimation of complex cumulative

⁶It also provides an intuitive approximation for how couples respond to the anticipated portion of the child mortality they experience compared with the unanticipated portion. If the unanticipated variation in child mortality is measured with more error than the anticipated portion, estimates of the response to observed variables that includes this unanticipated component will tend to be biased toward zero compared to the estimates based on the anticipated portion. The response to expected child mortality may also occur throughout the lifecycle, or in other words through both ex ante "hoarding" as well as ex post "replacement" (See section 5.2). This may be most evident when the age-at-marriage is noted to occur earlier in communities that have higher child mortality rates (for the example of Taiwan, see Schultz, 1980). Malthus' model that relied on marriage age to compensate for economic and demographic conditions may have considerable explanatory power in some low income populations.

household production processes (such as those underlying adult health or even child health, nutrition, or education) than it is in the estimation of shorter and relatively simpler processes underlying the determination of conception and birth or even birth-weight. Because contraceptive behavior is the predominant and observable endogenous factor determining conception rates in modern societies (Bongaarts and Potter, 1983), the estimation of reproduction functions is a promising approach to integrate biological and behavioral factors in the study of fertility, a frequently stated goal of demographers (Easterlin, Pollak, and Wachter, 1980; Wolfe and Behrman, 1992).

3.7 Endogenous Preferences and Time Series Change

There is probably substantial individual heterogeneity in the demand for numbers of children, i.e., tastes, just as there is heterogeneity in biological supply of children, i.e., fecundity. The writings of Easterlin (1968, 1978), Easterlin and Crimmins (1985) and Easterlin et al. (1980) argue the desirability of endogenizing tastes for children, intertemporally and intergenerationally. Although some find this goal attractive, empirically testable implications of this line of research remain elusive (Stigler and Becker, 1977; Wolfe and Behrman, 1992). Are "taste" variables, such as "desired fertility" or "the value placed on one's children's education", exogenous or endogenous to an economic model of individual and family demands? (Wolfe and Behrman, 1992). When Easterlin's (1968) theory of intergenerational taste-formation and cohort fertility differences is used to account for cross sectional variation in individual fertility, it receives scant empirical support (Ben-Porath, 1975). But the paucity of time series studies of fertility based on the conventional household demand framework also leaves one to doubt whether the demand approach outlined here has much power to explain intercohort variation in fertility in high- or low-income countries (Cf. Schultz, 1994).

The study by Butz and Ward (1979) is an exception, but one that

illustrates how fragile the existing time series evidence on fertility determinants is. They examine variation in U.S. age-specific marital birth rates from 1947 to 1975. Lacking a national wage series for women in the United States, they use a Bureau of Labor Statistics series on the occupational category of personal services, which was predominantly female.⁷ Recognizing that this female wage series is endogenous in a model of fertility, they identify the wage with instrumental variables that are one and two year lagged wages. The lagged wage series are, of course, as endogenous as the current wage series, being affected by the same unobserved variables that explain evolving trends in women's careers and fertility in this period (Schultz, 1981). The issue that is unanswered by most such macroeconomic models of fertility is what underlying forces outside the influence of the household sector can explain the changing wage of women relative to men.⁸ When a more representative wage series for women was constructed by Macunovich (1991), and the same model as reported by Butz and Ward was reestimated, she found little consistency between her estimates and theirs. In addition, even their own estimates were not consistent with an important prediction of the Willis (1974) model: the positive effect on fertility of the male wage should be larger among women who participate in the labor force than among those who do not. Butz and Ward's estimates suggest that the male wage effect became smaller over time as the labor force participation rate of wives increased. Although there are few satisfactory efforts to explain cycles in U.S. birth rates, I know of no micro analyses of time series changes in fertility in low-income countries. Later, in section 5.6, some aggregate data are examined to

⁷ Their series on female earnings, divided by another series on hours, produced a wage rate series that did not parallel other population based series on women's productivity, earnings, or hours. A more defensible series has since been derived from the Current Population Survey by Macunovich (1991) that confirms the peculiar behavior of the Butz-Ward series.

⁸A study of Sweden from 1860 to 1910 suggests part of this trend can be linked to the changing relative prices of outputs that are dependent on more or less of women's time, dairy products versus cereal grains (Schultz, 1985).

determine if the secular changes in fertility levels that have occurred in the last two decades in low-income countries can be partially accounted for within the household demand framework.

There are many ways to expand further the household demand framework and add commodities or activities. Savings by the family in the form of physical capital formation for retirement is similar to the formation of human capital in children in that it extends over many years. Indeed, the Modigliani-Brumberg (1954) life-cycle savings hypothesis is well designed for study in the household demand framework. Savings over the life cycle may foster a variety of human capital investments, insurance arrangements across members of an extended family, and even transfers between generations. Economists have long speculated that families may invest in the migration of their members both to augment their income and to diversify their portfolio of human and physical capital, insuring themselves against the variation of income derived from a single livelihood, regardless of whether the variation is due to climate in agriculture or business cycles in other sectors of the economy (Rosenzweig and Stark, 1989; Stark, 1991). Little empirical analysis at the household level has sought to test the implications of these theories and to distinguish between various motives of altruism or market exchange and how they are related to fertility (Cox and Jimenez, 1992a; Hoddinott, 1992).

3.8 Dynamic Models and Birth Spacing

Most economic theories of fertility address the determinants of the number of children a couple demands over their lifetime. This demand for children is, however, satisfied by a supply of births, which is biologically produced and matured with much uncertainty. Sexual intercourse, lactation, birth control, and abortion interact to determine birth rates in a highly complex chain of uncertain events that are described by demographers (Bongaarts and Potter, 1983). A dynamic stochastic model of fertility decision making therefore has much appeal (Olsen and Wolpin, 1983; Wolpin,

1984; Newman, 1981, 1988; Newman and McCulloch, 1984). If these features of the fertility determining process are modeled as a general dynamic programming problem, complexity in other aspects of the choice problem must generally be sacrificed. It may be useful to briefly retrace the use of dynamic elements in models of fertility and refer the reader elsewhere to an introduction to the theoretical and econometric methods (Heckman and Singer, 1985; Eckstein and Wolpin, 1989; Lancaster, 1990).

The static choice framework can be supplemented by a stock-adjustment equation in which a proportion of the divergence between the actual and desired fertility rate is eliminated in each time period (Lee, 1980a,b; Schultz, 1974; 1980). As a means to model aggregate fertility rates, the approach provides a smoothing mechanism that may approximate time series data. Partial adjustment models often specify lagged fertility as an explanatory variable for current fertility. Lagged endogenous variables are themselves endogenous in a lifetime optimizing framework, and this problem is particularly serious in the case of fertility where unobserved heterogeneity in preferences and fecundity are undoubtedly persistent. Consequently, to obtain consistent estimates of these models legitimate instruments are needed to endogenize the measure of lagged fertility. No maximizing behavior is postulated to motivate the rate at which behavior converges to the "desired" reproductive goal, but this shortcoming is evident in most economic models of asset allocation behavior.

To incorporate birth spacing explicitly into a household demand model, the interval between births can be added directly as an argument to the couple's utility function. Perhaps a longer birth interval should be interpreted as a "good", if longer birth intervals enhance the quality of the resulting child, as postulated by Razin (1980) and suggested by psychologists (Zajonc and Markus, 1975). As completed fertility in industrially advanced countries, such as the United States, declined in the last century from 5-7 children to 2-3, the intervals between births did not increase on average, but

may have even decreased (Ryder, 1969). Thus, if wider birth intervals were viewed by parents, as Razin theorized, as a desirable increase in child quality, there must be some offsetting increase in the cost of having more widely spaced children. One way to explain these birth spacing patterns is to hypothesize that the technology of producing children embodies economies of scale, such that a woman rearing children at shorter intervals incurs lower costs per child (Newman, 1981). There is considerable empirical evidence to support this conjecture (Espenshade, 1984). A mother's market labor supply decreases on average by more hours with one child than it does with the arrival in close succession of a second or subsequent child. Although these data relate mostly to married women in the U.S., the existence of such economies of production with shorter birth intervals is a plausible hypothesis in low income environments as well. The opportunity cost of a child associated with a mother's loss of time from the labor force increases as a woman becomes better educated. It is not surprising then to observe that better educated women both reduce their completed fertility and shorten their average birth interval in order to minimize their time out of the labor force (Ross, 1974; Newman, 1981). Regardless of whether wider birth spacing is a good proxy for child quality (and maternal health), the benefits of longer intervals are certainly not linear or perhaps not even positive after several years. Most estimates of the consequences of birth intervals in low-income countries are potentially biased, for they treat birth intervals as exogenous and analyze the inverse association between the length of the prior birth interval and the health of a child and mother as an estimate of causal effect (National Research Council, 1989). It is not yet clear whether increments to birth intervals in a relatively healthy and well-fed population are indeed important for the health of mother or child, except in extreme cases.

Several methodological approaches have been used by economists to describe covariates of the spacing of births. The hazard rate of having a birth, given no birth has yet occurred in an interval, can be generally

expressed in terms of (1) systematic effects of exogenous conditioning variables, (2) a random component called heterogeneity of the population, and (3) a duration dependence of the hazard as the interval increases (Newman and McCulloch, 1984; Lancaster, 1990). The hazard framework is flexible and deals explicitly with right censoring of the data due to incomplete spells of childbearing; however, because of its nonlinear structure, it does not readily allow for the incorporation of endogenous explanatory variables. Another disadvantage of the model is that it often examines a sample conditional on the woman's being in the relevant birth interval, whereas, clearly, having the previous birth (initial condition) is also endogenous to the same type of reproductive choice process, and raises issues of sample selection bias. The risk of conception cannot be assumed to start with marriage, because marriage is endogenous to a model of reproduction and causation may be in the opposite direction. The left censoring problem can be mitigated by tracing the woman back to the age at menarche, which can be assumed exogenous, and then analyzing the onset of childbearing, or the hazard of the first birth. Indeed, the timing of this first birth may be a critical threshold for predicting the pace of subsequent childbearing in many parts of the world.

Multistate models can also jointly estimate the various transition hazards and accommodate the persistent effect of unobservables across parities for the individual, such as might be caused by fecundity or couple-specific heterogeneity (Heckman and Walker, 1991; Tarisan, 1993). Joint estimation of all birth interval hazards seeks to replicate patterns of fertility revealed in aggregate data better, and to simulate the consequences of changes in the conditioning variables over time more accurately than unrestricted reduced forms, presumably because they embody the nonlinear structure of the valid model.

In Southeast and East Asia and in Latin America the transition to lower fertility was generally signalled by a decision to stop further childbearing after presumably reaching a target family size, because age specific birth

rate for woman older than 30 declined rapidly. This pattern of not spacing but stopping births over the life cycle, which was also observed earlier in industrialized countries, provided a basis for demographers to measure the adoption of birth control as a function of fertility declines by parity relative to some "natural" schedule in age-specific fertility (Oken, 1991). But in Africa, birth intervals even at early parities may be increasing in some countries (e.g., Zimbabwe, Botswana, Kenya) where the education of females has been catching up to that of males and child mortality has fallen sharply. Alternative economic models are needed that can account for the adoption of such different regimes of fertility control in different regions of the developing world. This is a challenge for economists as economic-demographic household surveys become available for a growing number of African countries.

3.9 Birth Control and Family Planning

Differences in costs and benefits of a child to parents by birth order provided one motivation for modeling fertility as a dynamic process in the previous section. One set of costs of rearing a certain number of children is the search-, user-, and psychic-costs associated with finding and employing a technique to avoid unwanted births. These costs and the uncertainty of birth control can also be analyzed in an economic framework (Schultz, 1971, 1988, 1992a).

There is an interdisciplinary debate, however, on how to interpret the widespread adoption of birth control that often occurs with modernization. Customs and institutions, such as delayed marriage, prolonged breastfeeding, postpartum taboos on intercourse, are employed to some degree by all populations to control unwanted reproductive capacity (Dumond, 1975). Are these mechanisms merely strengthened and gradually supplemented by individual birth control practices as economic and demographic conditions motivate couples to gain greater control of their fertility? Or are fundamental

cultural changes required before people are able to even consider reproduction as amenable to individual control? Is "ideational" change a prerequisite for society to control fertility? If this is the case, this process is not, as economists have argued, a marginalist adjustment to a changing balance of costs and benefits of having various numbers of children (Cleland and Wilson, 1987; Coale, 1973). A third paradigm emerged in the 1950s, as it became clear how rapidly the population of the third world was growing. It was hypothesized that in order for people in low income countries to reduce their fertility substantially, they must be provided with socially acceptable, convenient, and low-cost modern means of birth control. Improved technological options of birth control developed in the 1960s in the form of the pill (steroid), the intrauterine device (IUD), and sterilization seemed promising in that they operated independently of coition and could be delivered at relatively low cost. Implementing this technological "solution" to rapid population growth, according to this third school of thought, depended on subsidies, outreach, education and communications programs to accelerate the diffusion of modern birth control worldwide. Debate has flourished on whether the supply of birth control methods (i.e., family planning) would substantially lower birth rates unless peoples' preferences changed or the opportunities and relative prices facing people changed so as to curb their demand for births (Bulatao and Lee, 1983; Lapham and Simmons, 1987; Westoff, Moreno and Goldman, 1989). But it should come as no surprise that both supply and demand must be taken into account (Rosenzweig and Schultz, 1985; Easterlin and Crimmins, 1985; Schultz, 1986, 1992a).

4. Institutional Change and Macro Economics of Fertility

Fertility, through its effect on the size, growth, and age composition of the population, can have consequences on the macroeconomic system, and social institutions can affect the microeconomic incentives to demand children. To the extent that the consequences of fertility extend beyond the

family; an externality may be associated with fertility. For example, population growth in excess of some level, say one percent per year, may generate congestion or pollution costs and may make it difficult for markets to adjust and equilibrate wages to minimize unemployment or attract sufficient investment required to create sufficient new jobs. In such cases, there may be a social need for a compensating tax or transfer to motivate parents to take into account the costs, and possible benefits, they cause the society through their private demand for children (National Research Council, 1986).

Alternatively, institutions may be established by the public or private sector that substitute for (or complement) some critical services that children provide to parents. Credit markets may permit parents to save reliably for their consumption needs in old age. Mandatory social security systems financed by a scheme of wage deductions would appear to contribute to reducing the private demand of parents for children (Cox and Jimenez, 1992b). Children of other parents will support through their wage deductions the pensions and medical care of the elderly even if the elderly have no children themselves (Becker and Barro, 1988).

The dilemma with these issues of macro economics of fertility is that the quantitative importance of the programs, incentives, and mechanisms that are modeled have not been assessed. Are social security programs responsible for below replacement fertility in high income countries today, or is the low desired level of fertility in these countries the reason why the public has voted for such institutionalized support mechanisms for the elderly? We can hypothesize many plausible effects of fertility on the environment that are not borne by parents, which might provide a justification for society to subsidize parents to have fewer children, and the case is more persuasive when a population is growing rapidly (National Research Council, 1986). But there is relatively little hard empirical evidence that these externalities are substantial in magnitude, or large enough to change parents' reproductive goals if they were appropriately shifted to parents through conditional taxes

and transfers. There are also those who argue that population growth induces certain changes in agricultural production technology such that, in the long run, it raises output per capita and encourages development (Boserup, 1965) rather than inducing the lower wage rates that Malthus foresaw. But these positive externalities of population growth anticipated by the technological optimists (Simon, 1981) are no easier to evaluate empirically than are the negative nonlinear externalities projected by the pessimists (Meadows et al., 1972).

4.1 Overlapping Generations Model

Changes in investments in children, fertility, and savings can be related in a general equilibrium system in which prices are determined endogenously within the model. A general equilibrium approach to the macroeconomic problems of growth, investment, and consumption over time has been formulated around a microeconomic theory of exchange between overlapping generations. Samuelson (1958) first used this model to provide a rationale for money, but its application to the demographic-economic transition is more recent. This application treats the fertility decision as endogenous (Eckstein and Wolpin, 1982). As capital accumulates and wage rates increase, parents substitute away from children and toward the consumption of goods, if the costs of children are linked to the wage rate or the value of time. Also, as income per capita grows, the demand for children increases. The path of fertility generated by this stylized model depends on the relative magnitude of the goods-cost and time-costs of rearing children. It is plausible that, according to these models, fertility could first increase and then decrease as the labor share of output increases with the onset of modern economic growth. Thus, Malthus' model of aggregate growth is provided with a growth path that leads, due to the time-cost of children, to a zero population growth rate while permitting the level of per capita income to secularly increase. But these overlapping generations models of growth (e.g., Becker and Barro, 1988)

do not distinguish between the wage rate of men and women, which is the strongest empirical regularity accounted for by the microeconomic demand for children framework (Schultz, 1981).

If the cost of children to parents is an increasing function of women's wage, and nonhuman capital is more complimentary with women's labor than with men's, capital formation affects fertility and prescribes the path to the demographic transition. Galor and Weil (1993) propose such a growth model with distinct male and female labor and specific technological assumptions with endogenous fertility that connects the gender wage gap to development, demographic transition, and also allows for multiple equilibria, or a low level trap. Growth theorists are thus beginning to grapple with the mechanism by which population growth is endogenized, yet there remains no consensus on what motivates parents or society to invest differentially in the human capital of females and males (Schultz, 1993). Developing hypotheses for what governs the increase in female-specific human capital will undoubtedly receive more study in the future.

4.2 Credit Markets, Social Security, and Life-Cycle Savings

Much of the early discussion of the probable consequences of rapid population growth assumed that increases in the size of surviving families would depress private household savings, public productive savings, and investments, as conventionally measured (Coale and Hoover, 1958). Empirical evidence is very limited on the direct association between the composition and level of savings and the size of surviving family (The World Bank, 1984). The aggregate record and existing household evidence (e.g., Kelley, 1980) do not confirm that the Coale-Hoover hypothesis is important; since the Second World War, population growth rates and national savings rates have both increased, as, for example, in India. Here again, to evaluate the consequences of fertility one should identify the cause of the variation in fertility. Would local child health, family planning, and schooling investments that reduced

fertility also raise (or lower) physical savings rates? Are children complements for bequest savings or substitutes for physical savings that provide for consumption requirements during retirement? What would be the consequences for household savings, if the increase in surviving fertility were due to exogenous eradication of endemic and epidemic childhood diseases that left parents in middle age with more living children? These are hard questions to answer. They will require unusual economic and demographic information at the household and intergenerational level. But given the centrality of the savings relationship in hypothesized models of demographic and economic development, more research can be expected on savings behavior within the demand for children framework.

4.3 Mobility, Marriage, Risk, and Technical Change

Rosenzweig (1992) considers the management of risk ex post by the household through the sale of buffer stocks of livestock, credit, or interhousehold transfers that involve both the marriage of daughters (Rosenzweig and Stark, 1991) and the outmigration of sons and daughters into alternative production environments. He finds evidence in his Indian sample that the adoption of high yielding varieties (hyv), which is associated with the Green Revolution, is inhibited by the existence of extended family contacts, presumably because interhousehold transfers are predicated on families monitoring each other's incomes and risks. The cost of monitoring is lower if all family members use well-understood traditional farming methods. But once hyv adoption occurs, the diminished use of interhousehold transfers within the extended family may free women of performing their traditional function through marriage markets. Families may then be encouraged to invest more in the education of women, for daughters are then free to migrate to work outside of the family where market returns to education can be earned and potentially remitted to parents. This suggests that the extended family as a traditional institution to pool risk may initially resist technical change and

investing in women. When these investments are ultimately forthcoming, fertility declines, and new technology is adopted that further weakens the extended family as a provider of credit and insurance. As the "green revolution" begins to shift families from depending on the extended family to relying on the credit market and accumulation of their own buffer stocks, the family may demand more education for its females and seek fewer children for old age security. Here is another set of issues that may eventually illuminate the institutional and technical constraints that modify fertility and the status of women.

5. Empirical Evidence

Empirical studies have been cited earlier to illustrate methodological approaches to the study of fertility or justify a specific restriction on the more general demand framework. This section summarizes the empirical evidence and outlines some data and econometric problems that frequently arise in implementing the framework.

A central insight of the household production model of the demand for children is that different sources of household income imply different associated changes in the shadow price of children, and hence in the demand for children. These predictions have not been shown to be particularly sensitive to whether the family is viewed as a neoclassical integrated utility maximizing entity (Becker, 1981), or as a Nash cooperative bargaining pair who resist pooling resources to maintain their distinctive options outside of a marriage (McElroy and Horney, 1981) or their distinctive spheres of influence in a noncooperative family regime (Lundberg and Pollak, 1993; Schultz, 1989, 1990). Regardless of which model of the "family" is posited, an increase, for example, in the productive value of women's time should have a more negative effect on fertility than an increase in the value of men's time, at least as long as the bulk of child care occurs within the family and not within some alternative communal or market child care institution.

5.1 Fertility Effects of Wages and Nonhuman Capital

Because of the econometric complexities of estimating the shadow value of the time of women and men without selection or simultaneous equation bias, many studies rely on education as a proxy for the wage, even though it undoubtedly represents more than just the value of an individual's time (T.W. Schultz, 1974). A few studies are sufficiently detailed that they hold constant for both the wage opportunities and education of the spouses. But as a consequence, they typically assume education affects fertility linearly. Nonlinear effects of either or both education and wages are thus mixed in the jointly estimated education and wage coefficients (e.g., DeTray, 1974). Where only education is entered nonlinearly as a series of splines or unrestricted dummy variables, increasing education of women is generally associated with lower fertility, certainly after a threshold of about four years of schooling, a level which may be roughly equivalent to functional literacy (e.g., Cochrane, 1983; Schultz, 1976a, 1989; Lavy, 1985; Okojie, 1991; Ainsworth and Nyamete, 1992; Anker and Knowles, 1982; Wolfe and Behrman, 1992; Lam, Sedlacek and Duryea, 1993; Pitt, 1993).

Because there is generally positive assortative mating by years of education and the effects on fertility of male and female education may be in opposite directions (as in the case of female labor force participation outside of the family), controlling for husband's education in a fertility equation sometimes increases the negative partial association between female education and fertility. Nonetheless, although male education is not held constant, the tabulations of different dimensions of fertility in Table 3 by the woman's education in 38 countries where World Fertility Surveys were conducted during the 1970s illustrate the anticipated general pattern, with some informative variations. In all regions distinguished, women at age 40-49 with seven or more years of schooling have 1.6 to 2.9 fewer births than women with no schooling (column 1). Total fertility rates (TFR), which reflect current birth rates summed over ages, differ by even a larger amount between

Table 3

Measures of Cumulative, Recent, and Desired Fertility:
Averages for World Fertility Survey Countries Reporting,
By Region and Respondent's Education

Regions (Number of Countries Observed)	Children Ever Born ^a	Total Fertility Rate ^b	Desired Family Size ^c
Years of Schooling Completed by Women:	(1)	(2)	(3)
<hr/>			
Africa (8 to 10)			
0 years	6.4	7.0	6.9
1-3	6.5	7.2	6.4
4-6	6.1	6.2	5.9
7 or more	4.8	5.0	5.0
Difference (0-7+)	-1.6	-2.0	-1.9
<hr/>			
Latin America (13)			
0 years	7.1	6.8	4.8
1-3	6.8	6.2	4.7
4-6	6.0	4.8	4.2
7 or more	4.2	3.2	3.7
Difference (0-7+)	-2.9	-3.6	-1.1
<hr/>			
Asia and Oceania (9 to 13)			
0 years	6.7	7.0	5.4
1-3	6.7	6.4	4.3
4-6	6.4	5.8	4.2
7 or more	4.9	3.9	4.0
Difference (0-7+)	-1.8	-3.1	-1.4

^aWomen aged 40-49 years.

^bThe average number of children that would be born alive to a woman during her lifetime, if during her childbearing years she were to bear children at each age in accord with the estimated age-specific birth rates in the five years before in the survey.

^cMeans are adjusted for the effects of age differences between educational groups.

Source: Summary of data collected in 38 World Fertility Surveys around 1975. United Nations (1987), Tables 112 and 115.

women with more and less education (column 2). The difference between the children ever born at age 40-49 (column 1) and "desired" fertility across all ages (column 3) might be viewed as an indicator of the emerging demand for nontraditional birth control among women in the childbearing ages. In Asia and Latin America this measure of latent demand for greater birth control is concentrated among the least educated women. This is the group that would seem most likely to benefit from a family planning outreach program because the reproductive goals of this group are changing most rapidly. But as of the 1970s, there was little evidence of much latent demand to restrict traditional fertility levels among African women, either among those with high or low educational levels. This may be because the levels of child mortality in Africa remain unusually high (Okojie, 1991; Maglad, 1990; Benefo and Schultz, 1992).

Increasing men's education, although it does not exert a uniform effect across developing countries, is widely associated with increasing fertility in Africa, particularly in rural areas (Anker and Knowles, 1982; Ainsworth, 1989; Okojie, 1991; Benefo and Schultz, 1992; Montgomery and Kouame, 1993). It is also related to earlier childbearing, if not always greater completed fertility, during the early industrialization process with the shift of populations to urban areas (Schultz, 1985). Land ownership or other physical assets are generally associated with higher fertility in low-income agricultural societies (Stys, 1957; Rosenzweig and Evenson, 1977; Chernichovsky, 1982; Anker and Knowles, 1982, Table 37; Merrick, 1978; Maglad, 1990; Schultz, 1990; Mukhopadhyay, 1991; Benefo and Schultz, 1992). However, no effect of wealth or nonearned income on fertility is also found in other studies, such as Anderson's (1983) in Guatemala.

As economic development proceeds, it becomes more difficult to estimate the effect of nonhuman capital wealth on the demand for children. First, the share of income arising from nonhuman capital tends to decrease as investments in human capital mount. Second, nonhuman capital becomes

increasingly the product of lifecycle work and savings, and thus ceases to be exogenous to an individual's demand for children. Consequently, as societies shift from rural-agricultural to urban-centered production activities, inherited physical assets in the form of land and business capital become a relatively small source of income for most people. It is empirically more difficult, therefore, to assess the effect of nonhuman wealth on the demand for children in urbanized higher income societies (Cf. Schultz, 1990).

Measurement of the opportunity value of the time of children is easier to document at the anthropological level (e.g., Nag et al., 1978) than in a large representative household survey. Occasionally it is possible to measure major regional variations in the productivity of child labor. It has been observed that fertility is higher in high child wage regions (Lavy, 1985; Rosenzweig and Evenson, 1977). It is more common, however, for child and female wages to vary together, for both women and children are in many settings supplemental sources of unskilled labor, drawn into the agricultural work force mostly during peak labor demand periods, such as during harvest. At other times in the year, their wage opportunities may be low enough that they allocate their time to work in the home or school. If this is often true, then there may not be sufficient independent regional variation in child wages and female adult wages to estimate their separate effects (and presumably of opposite sign) on fertility (Lindert, 1980b). Surveys of rural areas of low-income countries suggest that many children work in the labor force, but they generally work for their parents in an unpaid capacity. Consequently, reporting a wage rate for child labor is rare, even though parents may be paid more when they hire themselves out with the assistance of their children.

There are, regrettably many studies of fertility determinants that include only adult education, literacy, or a single wage or household income variable, and do not distinguish between the productivity of men and women in the household. These studies are of little use here to confirm or reject the

relevance of the demand framework for fertility. It may be observed generally that rising incomes are associated with declining fertility, but the magnitude of this relationship is not likely to be similar in Kuwait and Libya as it would be in Thailand or Korea.⁹ The mix of income sources received by the household tends to change with modern economic growth, and how it changes should influence the effects of income growth on fertility. To use the household demand framework to explain fertility requires that income be disaggregated according to source, including male and female productivity, nonhuman capital income, and other exogenous entitlements that might substitute for or complement investments in children, such as communal land arrangements, and social security pensions.

Studies of fertility determinants can be potentially biased as a source of evidence on the demand framework because they include among the explanatory variables other simultaneously determined household choices or behaviors. For example, controlling for female labor force participation or child schooling rate (e.g., Anker and Knowles, 1982) raises the possibility that the coefficients on other economic variables in the model may be subject to simultaneous equation bias, as discussed earlier. It is essential, therefore, that a parsimonious set of male and female wage-education variables and nonearned income variables be included in the core economic reduced-form equation for fertility and that the inclusion of additional control variables be justified by the theoretical framework of the study.

5.2 Child Mortality

The positive covariation of child mortality and fertility was first interpreted as evidence of a causal relationship from the former to the latter (Schultz, 1969). This effect might come about through two reinforcing

⁹In the former countries income arises predominantly from nonhuman capital sources, i.e., oil exports, whereas in the latter countries, human capital is more important and women are today receiving a substantial share of the human capital (Schultz, 1994).

channels, however. The first involves a couple having or "hoarding" more births than "desired" because they have formed the expectation that some of their children may die. A second involves a "replacement" response following a child death (Schultz, 1969, 1976b; Ben Porath, 1976; Sah, 1991). Although birth and child death rates tend to be strongly positively associated in most aggregate (i.e., by administrative areas) and individual analyses of fertility determinants, extracting the causal relationships of interest from this correlation has proven more complex.

In estimating these effects, it has become clear that the likelihood of child mortality and fertility are often affected by many of the same household and community variables, some of which are probably unobserved. Moreover, having many children, presumably at short birth intervals, is likely to also strain the health of the mother and the resources of the family to care for each child, generating a "crowding" effect of high fertility on high child mortality (Cf. Birdsall, 1988, 1991; Rosenzweig and Schultz, 1982b). In the last two decades, therefore, various estimation strategies for dealing with the resulting simultaneous equation bias and the discrete and sequential nature of child death and birth processes have been developed and implemented.

Using the 1973 Census sample of Colombia, Olsen (1980) estimated that the replacement response effect was about .3, rather than the ordinary least squares estimate of .5, suggesting that for every three child deaths prevented there was one fewer birth. Rosenzweig and Schultz (1982b) estimated, from the same data source using instrumental variables method, the sum of replacement and expectation response rates of between .14 and .42 for various cohorts of women between the age of 24 and 54.¹⁰ Lee and Schultz (1982) estimated the replacement response in Korea in 1971 as between .35 and .51, using Olsen's

¹⁰They used information regarding the status of malaria eradication campaigns in the municipio, climate, and transportation infrastructure as variables that are significantly associated with child mortality, but they postulate that these variables are not directly responsible for elevating fertility.

(1980) method. Maglad (1990), using the instrumental variables method, estimated for a small sample in rural Sudan a replacement/expectation rate in 1987 of between .56 and .73. Okojie (1991) obtained significant estimates of replacement/expectation responses for Bendel state of Nigeria from a sample collected in 1985. Benefo and Schultz (1992) estimated by instrumental variables a replacement/expectation rate of about .2 from a national sample of Ghana collected in 1987-89 and obtained a similar value for Côte d'Ivoire in 1985-88. Mauskopf and Wallace (1984) estimated the replacement probability for Brazil was nearly .6 and found that it increased from .44 to .98 as the woman's education increased from none to five or more years. Dynamic models, discussed more extensively by Wolpin in this volume, were also formulated to deal with the timing of the child deaths and the subsequent birth histories of women in Costa Rica and Malaysia, respectively (Newman, 1981; Olsen and Wolpin, 1983; Wolpin, 1984). Finally, in a high-income environment, Rosenzweig and Schultz (1983a) estimated by instrumental variables a replacement effect of about .2 from a 1967-69 sample of legitimate births for the United States.

Aggregate data on fertility have also been used to estimate the response of fertility to child deaths, or dC/dD , with varied results. In Taiwan where the registration of child mortality and fertility is unusually complete for a low-income country, the cross district relationship of child survival to age 15 to total fertility exceeds the compensatory level, in other words that $dC/dD > 1$. If the relationship were causal a decline in child mortality would then lead to a sufficient decline in fertility to reduce the surviving size of families, and eventually lead to a slower rate of population growth. Examining different age-specific birth rates, the response in Taiwan appears to be relatively larger among older women. To correct for bias in these estimates that might arise from time persistent unobserved variables that could affect both child mortality and fertility, fixed effects for the 361 districts are included in the pooled cross sections from 1964 to 1969. The coefficients on

the two-year lagged child mortality variable remains significant for predicting age specific birth rates for women between the ages of 25 and 49, but the magnitude decreases about one half from that estimated from the district levels without fixed effects. The magnitude of the overall response of fertility obtained from the fixed-effect estimates is still more than fully compensating for changes in child mortality.

Census data for birth cohorts of (surviving) women in Taiwan also suggest that an overcompensating relationship exists across provinces between the log of average children ever born and log of child survival rates, when time trends are admitted (Schultz, 1976b). In section 5.6 below, data for low-income countries are analyzed using instrumental variable methods to identify the child mortality effect on fertility. Under the assumption that calorie availability may affect child mortality but not directly fertility, the response estimates exceed one, controlling for education, income and employment structure. Why should aggregate estimates of this relationship be substantially larger than those obtained from individual level data? One possible explanation of this difference is that actual child mortality is not a good indicator of the expected child mortality that leads parents to insure against this risk by their excess hoarding of births. The instruments that account for variation in actual child mortality may only estimate the ex post replacement response to deviations of actual from expected child mortality. If this were correct, the decline in child mortality is a more important factor in the declines in fertility than currently believed on the basis of microanalyses of household surveys. This hypothesis could also explain why in portions of Europe, such as the United Kingdom, where the decline in child mortality was limited until the end of the 19th Century, the decline in fertility did not start until then, whereas in the low-income countries in which the recent decline in child mortality has exceeded that among adults, fertility has fallen more rapidly than forecasted.

Because of the difficulty of finding valid instrumental variables that

account for the variation in child mortality, but which can be theoretically excluded from the fertility function, there is limited agreement on empirical methods for estimating this critical relationship. Until there is a better empirically based understanding of the policy and environmental determinants of child mortality in low-income countries, estimates of the effect of child mortality on fertility will be uncertain. An alternative estimation strategy for the further analysis of the demand for children is to omit child mortality and treat the resulting fertility equation as a reduced form that will capture the effects of household/community characteristics (including public health measures) on fertility (Schultz, 1994). Some portion of the effect of these conditioning variables on fertility, however, probably occurs through their intermediary effect of reducing child mortality. Section 5.6 presents evidence from low-income countries that the effect of women's education (or value of time) and family planning programs on fertility may be partly due to these conditioning variables operating through child mortality.

5.3 Sex Preference of Parents and Fertility

One aspect of the uncertainty of childbearing is the sex of offspring (Ben-Porath and Welch, 1976, 1980). Parents can have preferences between boys and girls for at least three reasons. First, net economic productivity of boys may exceed that of girls, given their respective child rearing and human capital investment costs. For example, the private economic returns to the education of boys could exceed the returns to girls in the labor market and home, although there is little evidence of this (Schultz, 1993b). Second, the remittance rate to parents from the economic productivity of boys and girls may differ such that the old age insurance value for parents of an investment in boys exceeds that of an investment in girls. Third, the noneconomic value to parents of boys may exceed that of girls, perhaps because boys can perform customary rituals at the death of parents or maintain the family line.

Whatever the reason, it is clear that some cultures exhibit a stronger

preference for sons than do other cultures. North India and China are often noted for a son preference. But even countries that have voluntarily made substantial reductions in birth rates, such as South Korea, reveal evidence that strong sex preferences for offspring remain (Park, 1983; Ahn, 1991). As long as the sex outcome of any conception is random, these asymmetric preferences of parents can have little impact on the aggregate sex ratio of births, although they change noticeably the sex ratio by family size and of the last birth (Park, 1983). Statistical tests to measure sex preference can, for example, distinguish how these preferences for sons are strongly evident among the Chinese in Malaysia but are not indicated among the Malays (Leung, 1988). The impact of such a sex preference on the level of overall fertility, however, may not necessarily be large (Schultz and DaVanzo, 1972; Ben-Porath and Welch, 1976, 1980; Cleland et al., 1983; Arnold, 1987; Leung, 1988, 1991; Srinivasan, 1992; Zhang, 1990; Davies and Zhang, 1992).

But when parental sex preference affects the survival probabilities of the fetus or infant, the sex composition of the population can, of course, be changed substantially (Rosenzweig and Schultz, 1982a). The excess in female child mortality over male child mortality in India and several other countries of South Asia, such as Pakistan, Nepal, and Bangladesh, implies that within the family in this region the allocation of nutrition and health care between boys and girls differs. When the one-child policy was pronounced in China, the male to female ratio of births increased from the standard level of 1.06 to 1.10 and 1.15 in the 1970s.¹¹ This pattern was also reflected in the higher female than male child mortality that occurred during the 1959-61 famine following Mao's "Great Leap Forward" (Coale, 1984; Ashton et al., 1984; Banister, 1987).

One measure of sex preference is a comparison of the sex ratio at birth across parities. With higher parities and with the prior births being only

¹¹As confirmed from analyses of The 1982 Fertility Survey that compiled retrospective pregnancy histories.

girls, the male to female sex ratio of births increases in Korea (Ahn, 1991, 1992). This is illustrated in Table 4 for 1980 to 1989, a period when fetal screening for sex increased. Although this pattern of change in the sex ratio of births by parity could be explained in Korea by fetal screening for sex followed by selective abortion, these sex determination technologies were less widely available in China in the 1970s where a similar pattern was noted. The explanation in China might involve the concealment of female births to avoid parents' being limited from having additional births, or possibly infanticide, historically a widely documented practice in the West and East (Langer, 1974; Scrimshaw, 1978). More recent data from China in Table 1 indicates a new trend upward in the sex ratio at birth to 114 by 1989, as ultrasound diagnostic equipment became more widely available (Zeng et al., 1993).

As screening of fetuses to determine sex by amniocentesis becomes more widely and cheaply available and ultrasound technologies provide less invasive technologies for obtaining approximately the same information, we may observe a substantial swing in sex ratios at birth in some regions. Economists should study these emerging imbalances in the sex composition of a cohort for evidence of how the marriage market equilibrates, and what changes in household and individual behavior occur when young brides become more highly prized.

5.4 Technical and Institutional Change

One reason parents are thought to demand children is that children provide parents with a relatively secure means of support and care in their old age (Cain, 1981). Lacking alternative means for savings and investment or credit, children can provide parents with a special service to smooth their consumption at the end of their life when their productive potential is likely to be low. This hypothesis that fertility is affected by parents' desire for old age support is plausible, but difficult to test. If, with the improvement of credit markets and the increased wealth holding of parents, fertility

Table 4

Male-Female Birth Ratios by Birth Order in Korea and China

<u>Country</u>		<u>Birth Order</u>				
<u>Year</u>	<u>Total</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5+</u>
<u>Korea</u>						
1980	1.04 (888355) ^a	1.06 (351213)	1.04 (278814)	1.03 (149015)	1.02 (59370)	0.96 (49859)
1985	1.10 (636621)	1.06 (328212)	1.08 (241201)	1.33 (47228)	1.57 (12778)	1.54 (7191)
1989	1.13 (613240)	1.05 (328044)	1.14 (241249)	1.90 (34794)	2.17 (6551)	2.14 (2605)
<u>China</u>						
1982	1.07	1.07	1.07	1.09	1.12 ^b	-
1985	1.11	1.06	1.16	1.14	1.22	-
1989	1.14	1.05	1.21	1.25	1.32	-

^a Number of births are in parentheses for Korea.

^b Fourth order and higher orders combined in China.

Source: Korea from Ahn (1991, Table 6). Data from Annual Report on the Vital Statistics (1990), National Bureau of Statistics, Economic Planning Board of Korea, Seoul; China from Zeng et al. (1993), Table 1.

declines, this could be construed as consistent with the hypothesis. The most radical change in institutions that would substitute for children in this regard is the introduction by the state of a mandatory social security system.

National systems of retirement pensions should, thus, devalue children, who traditionally perform this old age security function, and contribute to a decline in the demand for children. Cross country regressions to explain total fertility rates have included national data on the coverage of the social security system and the benefit level, while controlling for income per capita and infant mortality, among other things. The benefit level was then associated with lower fertility (Hohm, 1975). Critics of this work have readily found other indexes of modernization that made the social security benefit variable statistically insignificant (Kelly, et al., 1976). More compelling perhaps, the critics noted that there was no relationship between the timing of the introduction of social security systems in the various countries and the year when sustained declines in marital fertility began. One could be even more skeptical of such evidence and argue that what is needed is a forcing variable that would serve as an instrument and explain when social security is introduced in different countries, but this variable should have no independent role in modifying reproductive goals. Without such an identifying variable, it is not obvious how a time series analysis of country aggregate data could be used to test the old age security hypothesis or assign a magnitude to the effect of social security on fertility.

Other evidence has been assembled at a lower level of aggregation. Nugent and Gillaspay (1983) analyzed child-woman ratios across municipios (counties) of Mexico between the censuses of 1970 and 1980, and showed that the relative importance of sugar cropping, which was brought under the coverage of the social security system in this decade, explained fertility declines, while income and income inequality growth contributed to a rise in fertility. Nugent (1985) cites many other studies that suggest that the fertility of those covered by social security is lower than those not

covered.¹² However, this leaves the possibility that when social security is available only on certain jobs, workers who were otherwise indifferent might seek out, or be best qualified for, those certain jobs with social security. One hypothesis is then that self selection occurs whereby persons who want fewer children have a stronger reason to seek the jobs that provide them with a retirement scheme. Self-selection bias is possible, but how might it be corrected by the analyst (Cox and Jimenez, 1992b)? True randomized social experiments, or more commonly "virtual" experiments created by administrative rules and restrictions on eligibility or access, may permit researchers to evaluate the consequences of differing program treatments on the behavior of otherwise similar people.¹³ One such social experiment in south Indian tea estates provided retirement pension payments for avoiding higher order births to all women in a selected number of 18 surveyed tea estates. It was confirmed that a larger decline in fertility occurred from 1971 to 1977 among

¹²Studies based on individual household surveys have proposed other approaches to testing the old age security hypothesis for explaining fertility. Raut (1992) finds a negative partial association between fertility and wealth, interpreting this wealth as providing the parents with an alternative to depending on children for old age support. But the direction of the causality is unclear. He also estimates a probit equation to predict whether parents plan to rely on their children for support and finds it is less likely if the husband earns more or has more assets. Jensen (1990) hypothesizes that only parents who have provided for their own old age support will begin to contracept. He finds a relationship between relying on nonchild support and use of contraception. But both outcomes are choice variables and no causal interpretation is clear. See also review of literature by Nugent and Anker, 1990.

¹³ Fixed effect specifications or first differencing regional data also eliminates omitted time invariant regional variables that might be correlated with the program variables and bias estimates of program effects (Schultz, 1974, 1980; Gertler and Molyneux, 1993; Foster and Roy, 1992). Because the fixed effect methods do not deal with changing unobserved regional variables that may also be correlated with program allocations, it is preferable to model explicitly the allocation of program effort across regions and over time, and then instrument program treatment levels according to insights drawn from the model (Rosenzweig and Wolpin, 1986, 1988; Pitt, Rosenzweig and Gibbons, 1993). Unfortunately, insight into the administrative allocation rules of public welfare programs, such as family planning, is typically clouded by bureaucratic systems and political arrangements of governance.

the women workers in the treatment (pension) estates than in the control estates (Ridker, 1980).

Communal land tenure institutions are often singled out as being pronatal, for to rent or inherit the right to use the community's land, you must have a child. In Mexico the Ejido system also rewarded only male heirs unless the woman was without a husband and supported her family. Studies of municipio differences in child-woman ratios suggest that this institution is associated with unexplainably higher levels of fertility across two states (DeVany and Sanchez, 1979). It is also hypothesized that communal land holding deters women from gaining title to land and thus using this title to borrow the credit needed to adopt modern agricultural technologies (Boserup, 1970). These communal property institutions limit the income and productivity gains of women in Africa more than men, because women perform most of the work in agriculture. The deteriorating productivity of women compared to men in Africa is then another factor possibly contributing to the high levels of fertility in Africa (Schultz, 1989).

A study of West Bengal in India has sought to estimate how the adoption of new agricultural technologies affect fertility, labor market participation, and child schooling. High yielding variety adoption associated with the green revolution in this irrigated rice growing region has had the effect of raising male incomes more rapidly than female wages. Although household income has risen on average, women's participation in farm labor has declined and fertility has not markedly declined (Mukhopadhyay, 1991). Here is perhaps an example where gradual modern economic growth has not induced an improvement in women's productivity and, therefore, has failed to accelerate declines in fertility. Education is only slowly improving for Bengali women, reducing gradually their child mortality and fertility.

5.5 Cross-Program Effects

The consequences of programs and policies on household behavior can be evaluated by estimating reduced-form type relationships, if program activities are allocated across regions independently of individual preferences or unobserved environmental behavioral determinants (Schultz, 1988). Program services may substitute for or complement other consumption and investment activities which are distinct from those targeted by the program. Such cross-program effects can be important if household commodities are complements or substitutes for one another. As noted above, household demand studies have confirmed that child health services, schooling services, and family planning services often appear to exert reinforcing cross-price effects on child health, child educational attainment, and decreased fertility. For example, Rosenzweig and Schultz (1982b) report that the local availability of clinics and hospital beds and family planning expenditures per capita are associated with lower child mortality and lower fertility across women in urban areas of Colombia in 1973. The reinforcing effects are generally statistically significant among women from age 15 to 49. Rosenzweig and Wolpin (1982) assess cross-program effects on fertility, child mortality and schooling in rural India, and find reinforcing program effects from family planning clinics, dispensaries, hospitals, and secondary schools.

Rosenzweig and Wolpin (1986) also estimate the direct and cross-program effects of family planning and health clinics on anthropometric indicators of child health and nutritional status in the Philippines. In this study, however, the authors use cross-sectional information from repeated rounds of the Laguna Survey. Alternative estimates of the effects of programs on these long run measures of child health (viz. age-standardized height and weight) can then be based on three statistical specifications of the same reduced-form equation. Community fixed-effects and child fixed-effects are introduced to eliminate possible bias due to omitted time-invariant community and individual variables. But the fixed-effect estimates are also quite unstable and

imprecise, probably because the fixed-effect specification relies heavily on relatively small changes over time in the anthropometric measures of accumulated nutrition and health, and errors in measuring these variables can be substantial relative to the pertinent "signal" (Griliches and Hausman, 1986). Although the promise of longitudinal data to illuminate the behavioral effects of changes in economic constraints and program interventions is great, means must be found to exploit the panel features of such data without sacrificing the useful information contained in the cross section. The challenge of using time series of cross sections is reflected in earlier household demographic studies based on regional data over time (Nerlove, 1965; Nerlove and Schultz, 1970; Schultz, 1974, 1980).

Three issues may be distinguished in evaluating the effectiveness of social welfare programs: (1) how the benefits from expenditures on such programs are maximized, taking into consideration how the benefits may vary with scale of the program and interactions across programs; (2) how private and public sector programs differ in their cost-effectiveness and specific features of the populations served by these different delivery systems; and (3) how equitable the program benefits are in reaching different segments of the population. Combining data from household surveys with regional-level data on public expenditures on various social welfare programs provides a basis for program evaluations, including family planning (Schultz, 1971, 1988).

Programs that have the same objective may be complementary, in which case they strengthen the effectiveness of each other, or they may substitute for each other, in which case their effect in combination is less than the sum of their separate effects. It is also possible that these interactions may change sign with the scale of the program. They could potentially reinforce each other when the programs are operating at a small scale, and then begin to substitute for each other as the sizes of the programs increase and the market becomes saturated.

For example, in Thailand (Schultz, 1992a) public sector subsidies for birth control were channeled through both the public health ministry's clinics and through private, non-profit family planning programs. Since the objective of both programs was to reduce unwanted births, econometric estimation of program effects can be combined. Poisson regressions were estimated for the number of births that a woman had in the last five years.¹⁴ Nonlinear effects of regional expenditures per woman of reproductive age on this five-year birth rate confirmed that both the public and private programs were reducing fertility, after controlling for the principal demand determinants such as the woman's education and household expenditures. In this case the larger public program was subject to diminishing returns to scale, as was also found in Taiwan for two competitive field worker programs (Schultz, 1971, 1974, 1988). Provision of similar services through alternative delivery systems appeared to be substitutes, and each program or type of field worker had its greatest payoff where the other program was absent.

Finally, in the evaluation of social welfare programs, such as family planning, where a clear behavioral change is sought and can be measured, it is important to understand how the program benefits are distributed across the population. If it is more costly and difficult for a less educated woman to evaluate and adopt modern family planning methods than it is for a woman with more education, then subsidies to and educational promotion of family planning services are likely to have a greater effect on birth rates among the least educated in the country. This appears to have been generally the case in Latin America and Asia, but it depends on how the demand for children changes in these groups. If only better educated women want to reduce their traditional levels of fertility and thus they were the only ones who adopt and

¹⁴If fertility is treated as a time homogeneous process, the number of births during a specific time period takes a discrete value, 0, 1, 2,.... The Poisson model is one framework for describing the number of such events observed for different persons. Overdispersion may occur when the variance of such a count variable exceeds the mean, violating an underlying assumption of the Poisson model and require special adjustments. See Maddala (1983).

use modern methods of birth control, the benefits of a family planning program would be concentrated among the educated elite. Family planning programs during this early stage in the demographic transition may not benefit the poor but serve the needs of only the upper classes. Extending such programs into remote rural areas where the program's services are not yet demanded may be costly and ineffective. Later in the demographic transition, the opposite can be true, when urban subsidies for birth control are ineffective, and the rural outreach activities benefit the poor (Schultz, 1988).

Estimating interaction effects between the woman's characteristics (e.g., education, age, ethnicity, region, etc.) and the intensity of the program in her region can measure the nonuniform distribution of the benefits of the family planning program. These interaction effects also inform the policymaker of how the "price" elasticity of demand for the family planning service varies across segments of the population. This information might encourage a program to price discriminate across markets, if markets can be administratively separated along the lines of the consumer characteristics or regions. Maximizing the program's impact on birth rates for a given public sector budget might not always be a sufficient social goal. The equitable distribution of benefits may also be taken into account in setting priorities. Programs also assist people in shifting among methods of birth control, such as from abortion to modern contraceptives. Although this consequence of the program may not affect the numbers of births, it should be considered by the policymaker. How these benefits are to be measured is unclear.

5.6 Inter-Country Comparisons of Fertility

When models of individual behavior are estimated from variation in average behavior and average conditioning variables for large aggregates such as countries, the properties of the estimates depend on many tenuous

aggregation assumptions (Theil, 1954).¹⁵ There are, however, potential offsetting advantages of these aggregate data for testing hypotheses. The same relationship can be estimated on the basis of cross sectional or time series variation or on a pooled combination of both for the same sample of countries. It is then possible to assess whether the relationship observed across countries at various levels of development forecasts reasonably well changes occurring in countries over time.¹⁶ As already noted, the principal empirical puzzle motivating this paper is why the timing of the decline in mortality and fertility differs across countries and over time.

A static model of the demand for lifetime fertility has been outlined and suggests at least six empirical predictions (1) increased education of women raises the cost of childbearing and reduces fertility; (2) increased education of men may increase or decrease fertility, but in either case will reduce fertility less (algebraically) than will the education of women; (3) reduced child mortality, assuming the demand for surviving children is price inelastic, is associated with a decline in the demand for births; (4) increased national income per adult that is not associated with adult education approximates the share of wealth and natural resource income in a society, and this income from nonhuman capital sources is expected to increase

¹⁵I am particularly concerned about variables that may exert a nonlinear effect on fertility, but which exhibit little variation at the aggregate level, such as age, but are subject to substantial variation at the individual level. In such cases, the estimation of the effect of a variable such as age on fertility from intercountry variation in average age could be misleading. Moreover, other demographic linkages between age composition (youthfulness of the population) and (high) fertility are expected as long as fertility patterns are affected by unobserved variables that persist over time.

¹⁶Omitted country-specific effects can bias cross sectional estimates if they are correlated with included variables (Hausman and Taylor, 1981). By first-differencing the data on levels, the estimated time series relationship is purged of any country-specific omitted factors that might influence fertility, such as culture, assuming that they do not change during the observational period. Kuznets (1971) was also careful to juxtapose evidence of relationships he derived from comparisons of countries at different levels of development with that derived from comparisons over time within countries. Deviation between the cross sectional and time series evidence was frequently a basis for him to reappraise the relevant theory and assumptions underlying the empirical evidence.

the demand for children, if they are a normal good. It is also widely conjectured that (5) the net cost of child rearing is greater for parents in urban than in agricultural areas and the opportunities for children to work productively in a context where they can be monitored by parents tend to be greater in an agricultural setting than in a nonagricultural one; and (6) the cost of vocational training of a child appears greater for parents in urban than in rural environments in an open developing economy.

To test these hypotheses suggested by the micro economic model of fertility and confirmed by studies of household data, a reduced-form demand equation is estimated from national data where fertility is measured by the current total fertility rate.¹⁷ The explanatory variables seek to measure sources of national income, because they embody different shadow-price effects for children. The productivity of women's time discourages fertility because women are primary child caregivers. On the other hand, the productivity of men's time is more neutral in its child price effects, and nonlabor income may accordingly be pronatal. Three additional explanatory variables represent other sources of variation in the relative price of children, holding constant the level and composition of national income: child mortality, rural/urban residence, and agricultural employment. It can be argued, however, that child mortality, rural/urban residence and sector of employment are endogenous, because the allocation of family resources may influence child mortality and

¹⁷The Total Fertility Rate (TFR) is the sum of current age specific birth rates, and is sometimes estimated from periodic sample surveys reporting births in the last five years. It is a synthetic approximation for the average lifetime fertility of women. It would be preferable to analyze the actual cumulative lifetime fertility of various birth cohorts and relate this measure of cohort fertility to the lagged conditions prevailing when the cohort made its fertility decisions. However, such cohort data is not available for many low-income countries and thus the common practice of analyzing TFRs is adopted. There may also be some improvement in model specification if the explanatory variables were lagged a few years to reflect biological time to conception and gestation (say two years) and the adjustment of expectations (unknown). Given the smooth evolution of many of these aggregate series, there may not be much to gain from introducing lags for those few variables that contain substantial annual variation, such as GDP. Child mortality was lagged five and ten years and GDP by two and five years without changing the findings discussed here.

interregional and intersectoral mobility. I shall interpret mobility as predetermined by demands for output. Only child mortality will be explained within the model and its exogeneity tested.

The priority society assigns generally to education, and, more specifically, to the education of women compared to that of men, may itself reveal the relative importance to society of women working at home and having a large number of children. One way to explore the role of such cultural value systems is to select features of the culture that are arguably fixed in the near term and add them as controls in the fertility equation to assess the robustness of the partial correlations between fertility and the previously enumerated determinants of economic demands. Therefore, controls for religion are included representing the proportion of the population that is reported to be Catholic, Protestant, and Muslim, where other religions are absorbed into the overall intercept.¹⁸

The variables suggested by the hypotheses outlined above are often available from standardized sources beginning with 1970 data; the definitions and sources are reported in the data appendix. In several instances the choice of an empirical measure of a variable is discussed further below. More flexible functional forms were explored to improve statistical fit, and where only a linear or log linear specification is reported, higher order terms and interaction variables were considered and rejected because they were not statistically significant at the five percent level. Not only does the high level of aggregation of intercountry analysis pose problems for interpreting the evidence, there are valid concerns that the quality of some of the national data is low. Some variables must be inferred in some countries from analysis of infrequent surveys and then interpolated between benchmark years, or estimated on the basis of data from neighboring countries, e.g., child

¹⁸An alternative set of controls might allow for fertility values to differ by region, which would overlap considerably with religion, but appear more ad hoc.

mortality in parts of Africa. If a dependent variable is measured with random error, such as fertility, it need not bias the estimates reported here. If it is an explanatory variable that is measured with error, however, standard estimates of the effect of that variable are biased toward zero in the simple two-variable case. Of course, the measurement error need not be random, and the multivariate case of even random error leaves the direction of the parameter bias in doubt. The credibility of intercountry multivariate regressions is consequently lower than similarly specified statistical studies based on micro data on households and individuals. Nonetheless, as noted earlier, something may be learned from the aggregate record if the empirical analysis is sufficiently well focused on the basis of prior microeconomic studies.

Income (GDP per adult) in constant local prices may be compared across countries in two alternative series. The purchasing power (PP) of the local currency for a broad bundle of consumer goods may be used (Summers and Heston, 1991), or the nations's productivity in producing internationally tradable commodities can be inferred from foreign exchange (FX) parities (The World Bank Staff, 1992). Since much of personal income is spent on nontradable goods, e.g., personal services and housing, the consumer purchasing power parity measure of national average income has more appeal for understanding how increasing productivity due to the accumulation of physical capital and natural resources (i.e., other than human capital) is related to household fertility choices. The results reported here are, therefore, based on the purchasing power parity equivalence, but the general conclusions are not affected if foreign exchange rates in 1980 are adopted as the basis of comparison.¹⁹

¹⁹The variance of the logarithms of income per adult, the explanatory variable in the subsequent regressions, is smaller when income is compared on the basis of PP rather than FX (.67 versus .96). As expected, the elasticities of fertility and child mortality with respect to income are, therefore, estimated to be larger based on the less variable PP than FX income series. The statistical significance of the partial association between fertility and the PP and FX

Information is not available in any country on the wage opportunities for all men and women. Only a handful of countries report sex-specific wages, and then these are not standardized for education, age, or other productive characteristics. Nor are the wage rates available for the entire population, but only for the labor force in wage or salary employment in specific sectors, such as larger firms in manufacturing (ILO, Yearbook of Labour Statistics). Unfortunately, there is no agreed-upon methodology for using available wage data to infer the level of labor productivity or shadow wage for all men or all women in a country.

An alternative approach is to treat average educational attainment for men and women as a proxy for wage rates. Until recently, macroeconomic growth models have relied on current enrollment rates to proxy stocks of educational capital embodied in the national labor force (Mankiw, et al., 1992; Barro, 1991). As noted some time ago (Denison, 1962), this is not a promising solution. The amount of education per adult is a better measure of the stock of educational capital embodied in the potential work force. "Years" of schooling have been found to be highly correlated with the logarithm of the wage rate of individuals and groups, and consequently national income per adult is also expressed in logarithmic terms when it is combined with years of schooling.²⁰

National product is thus represented by three variables -- different levels of education (human capital) of women and of men, and the logarithm of real GDP per adult. When the human capital endowments of female and male education are held constant, the GDP variable is expected to capture the

income series is nearly identical; for example, the t-ratios for the income variable do not change to two decimals.

²⁰Surveys and censuses are often available reporting the level of education attained by all men and women. Making plausible assumptions regarding the number of years that individuals have completed at each level of schooling in each country, it is possible to estimate the average number of years of education completed by men and women over the age of 15 in about 75 low income countries during the 1970s and 1980s (The World Bank, 1991, supplementary data base).

effects of physical capital and natural resource endowments per adult.²¹ Child mortality to age five, the supply of calories, urbanization, and labor force composition are estimates compiled by the Population Division of the United Nations, FAO, and ILO, respectively, based on periodic surveys or censuses, whereas several family planning variables are described later.²²

5.6.1 Empirical Findings

The analysis includes developing countries (i.e., excluding OECD countries and centrally planned European countries) for which data were available on total fertility rates (TFR) and years of education by sex, as well as (PP) income, child mortality, urbanization, and the share of male labor force in agriculture. The three years examined (1972, 1982 and 1988/89) were selected because information on family planning activity was available in each. The data appendix lists the countries in the sample and the source of data for each variable. Regression (1) in Table 5 is based on pooling of the three cross sections, providing a sample of 217 country-year observations. In interpreting the cross sectional estimates, the significance tests are undoubtedly overstated, because the repeated cross sections are initially treated as independent observations. Alternative assumptions regarding the structure of the errors underlying this panel of about 70 countries are incorporated into the later estimates. The six core variables alone explain two-thirds of the variance (R^2) in the total fertility rate. Regression (1) also allows the intercepts to shift for each period's cross section, although

²¹Clearly, future work is needed to construct a directly observable measure of nonhuman capital and natural resources that explains the variation in national productivity. The reason that GDP is divided by persons over age 15 and not all persons is to avoid including indirectly in this measure the fertility choice; the proportion of the population under age 15 is largely a function of fertility in the last decade or two. Elsewhere I have used a proxy for natural resource wealth or net fuel exports as a share of GDP (Schultz, 1994).

²²The share of the labor force in agriculture is approximated by the share of the male labor force in agriculture because the extent to which women working in agriculture are counted in the labor force varies substantially across countries and introduces error.

Table 5

**Cross Country Regressions of the Total Fertility Rate (TFR)
and Child Mortality Rate to Age 5 (CMR)^a**

Dependent Variable:	(1) Fertility (TFR)	(2) Child Mortality (CMR)	(3) Fertility (TFR)	(4) Fertility (TFR) Reduced Form OLS	(5) Means (Standard Deviations)
Estimation Method:	OLS ^c	OLS	2SLS ^c		
Explanatory Variables:					
Years of Female Education ^b	-.513 (7.35)	-13.2 (5.10)	-.225 (1.56) ^a	-.551 (8.37)	3.35 (2.21) ^a
Years of Male Education ^b	.175 (4.01)	1.42 (.83)	.145 (2.51)	.179 (4.14)	5.10 (2.49)
Log of GDP per Adult (1988\$, Purchasing Power Parity)	.478 (2.98)	-25.7 (4.12)	1.16 (3.43)	.517 (3.32)	7.97 (.818)
Urban Percent of Population	-.0117 (2.27)	.370 (1.80)	-.0175 (2.48)	-.0084 (1.61)	37.9 (21.5)
Percent of Male Labor Force in Agriculture	.0160 (3.49)	.861 (5.05)	-.0025 (.26)	.0190 (4.43)	50.9 (25.4)
Catholic Percent of Population	.0116 (5.03)	.261 (2.89)	.0050 (1.26)	.0115 (5.08)	34.8 (36.9)
Protestant Percent of Population	.0212 (3.97)	.540 (2.60)	.0103 (1.27)	.0239 (4.62)	8.87 (13.0)
Muslim Percent of Population	.0086 (2.84)	.645 (5.71)	-.0044 (.68)	.0119 (4.21)	26.1 (36.0)
Year 1982 Dummy	.023 (.16)	-9.09 (1.55)	.256 (1.19)	.0190 (.13)	.341
Year 1988 Dummy	.234 (1.43)	-12.7 (1.99)	.532 (2.19)	.202 (1.24)	.341
Calories consumed per capita per day		-.152 (2.07)		-.0035 (1.91)	2373. (367.)
Calories per capita squared x10 ⁻³		.0238 (1.60)		.00053 (1.43)	5764. (2474)
International Planned Parenthood Federation (U.S.\$/woman)				-.00036 (.34)	27.9 (60.4)
Child Mortality to age five (CMR)	.00460 (2.69)		.0251* (3.02)		136. (75.5)
Family Planning Activity Score (FPA)					34.6 (25.3)
Intercept	.454 (.33)	520. (5.29)	-6.90 (2.03)	5.79 (2.35)	5.35 ^d (1.54)
R ²	.710	.814		.722	
F	45.6	74.5	27.3	40.5	

Notes: *Treated as endogenous with identification as implied by calories included in Col. (3). Sample size is 217.

^aThe absolute value of t ratios are reported beneath coefficients in parentheses in columns 1, 2, and 4, asymptotic t ratios in col. (3) and standard deviations of variables in col. (5).

^bYears of education for female and male adults are estimated from The World Bank and UNESCO figures.

^cOLS refers to ordinary least squares and 2SLS to two stage least squares.

they are not jointly statistically significant at the five percent level, and three religion variables are included, which are highly significant. The coefficient on each of the core economic variables is statistically significant and of the expected sign. Countries which have a greater share of their population affiliated with the Protestant, Catholic or Muslim religions have, as expected, higher fertility. The joint F test of the equality of all slope coefficients in the three cross sections is not rejected at the five percent level ($F(9,190)=1.28, p=.25$).²³ In sum, one obtains a similar relationship in each separate cross section. In this sixteen-year period, from 1972 to 1988, there is substantial stability in the multivariate relationship across low-income countries between total fertility rates and the variables implied by the demand for children framework: women's and men's education, nonhuman capital income, urbanization, agricultural employment, and child mortality.²⁴ But should child mortality be treated as exogenous?

²³If the three cross sections are separately estimated, the effect of women's wage is significant in all three years but declines in value over time, as does urbanization, whereas the estimated effect of child mortality increases over time and the higher level of fertility associated with the Protestant faith increases in magnitude over time. As summarized by the Chow test, these slope coefficients are not statistically different over time at the five percent significance level.

²⁴According to regression (1), for a country in which men and women both have one more year of education the total fertility rate is .34 child lower, or 6 percent lower than the sample mean of 5.4 children. If only men's education tends to be higher by one year, fertility is higher by .18 children. If only women's education increases one year fertility tends to decrease by .51 children. Doubling of GDP per adult, holding human capital constant, is associated with an increase in the total fertility rate of .33. A country that has one-half of its population in urban areas compared with one which has only 10 percent, which is roughly comparable to Latin America vis-a-vis Africa in this period, is associated with fertility being nearly one-half child (-.47) lower in the more urbanized country, holding these other strategic variables constant. Removing one-quarter of the male labor force from agriculture is associated with fertility decreasing by .4 children. A decline in infant mortality from 150 to 50 per thousand live births is associated with a decline in fertility of .46 children. These estimates cross multiplied by the changes from 1972 to 1988 in the conditioning variables leads to the expectation that fertility in the 66 countries common to both cross sections would have declined by 1.0, whereas fertility actually fell by only .78 in this subsample of countries.

Similar factors, many of which are unobserved, affect both fertility and child mortality, introducing a spurious correlation between child mortality and fertility. It is also likely that high levels of fertility contribute to raising child mortality, causing conventional simultaneous equation bias. Finally, child mortality is probably subject to more errors in measurement than the other variables examined here, which could bias the coefficient on child mortality downward. For all of these reasons, it is advisable to treat child mortality as endogenous and measured with error in a model seeking to explain fertility.

Statistical specification tests (Wu, 1973; Hausman, 1978) of whether child mortality is exogenous to the fertility model can be implemented if mortality is identified by the a priori exclusion of a variable from the fertility equation that enters significantly into the determination of child mortality. Reductions in child mortality are often explained by availability of calories at the household and group level, most notably at very low levels of calories (Strauss, 1985; Fogel, 1990). Calorie consumption per capita is, therefore, specified as a determinant of child mortality, but the effect is allowed to vary by calorie level through the inclusion of a nonlinear quadratic term in calories.²⁵ Calories satisfy the conditions for an instrumental variable to identify the effect of child mortality on fertility,

²⁵It would also be desirable to include a measure of the within country variation in personal calorie consumption, because greater dispersion in individual consumption, given the average level, should be associated with higher child mortality. Unfortunately, I have found no indicators of the personal distribution of calories except those constructed by Fogel (1990) for 18th Century France and England. The FAO estimates of national calorie consumption are used here, from the World Bank World Development Reports of 1985 and 1991, and the figures for 1972 consumption are from the 1976 Food and Agricultural Organization Production Yearbook. A cubic approximation for the effect of average calories on average child mortality is not an improvement on the quadratic form reported here. The association of calories with mortality between a child's first and fifth birthday is particularly notable. Although only one-fourth of child deaths occur after infancy, they may be more sensitive to availability of calories because weaning is widespread by the second year of life. See nonlinear estimates of calorie effects on health and productivity in Brazil (Thomas and Strauss, 1992), Strauss's (1985) overview of field, and Dasgupta and Ray, 1987.

which are that it is correlated with mortality and may be reasonably excluded from the list of fertility determinants. The exclusion restriction is justified by biological and demographic investigations which conclude that the effects of nutrition on reproductive potential or fecundity are negligible.²⁶

To describe the channels through which economic development may lower fertility by reducing child mortality, child mortality determinants are estimated in a reduced-form equation. Other studies of household and aggregate data of child mortality and anthropometric indicators of child health, such as height for age and weight for height, suggest that a mother's education is the most important factor reducing child mortality and improving child health. In addition, some studies find that households employed outside of agriculture and with higher incomes also experience improved child health outcomes (Strauss, 1985; Schultz, 1993).

In regression (2) of Table 5, the child mortality rate (CMR) to age five is the dependent variable. The coefficients on the women's education and income are significant and negative, agricultural employment is significantly

²⁶It has been hypothesized that improvements in nutrition could also increase reproductive capacity (Frisch, 1978), but most recent evaluations of the evidence conclude that chronic malnutrition has at most a minor biological role in depressing fecundity (Trussell, 1978). If calories do increase somewhat fecundity in certain low income populations (e.g., Papua New Guinea) by increasing anovulatory cycles, lengthening the interval of menses, and increasing pregnancy wastage, this omission might mask some of the underlying positive relationship expected due to fertility responding to child mortality. Thus, the estimates reported below of the fertility response to endogenous child mortality are possibly biased downward. Another over identifying variable was also included in the later analysis of only 1988 data in Table 3: proportion of children immunized against diphtheria, pertussis and tetanus (dpt). This variable might capture the effect of a variety of allied child health programs across countries, and it is indeed negatively and significantly associated with child mortality. But its inclusion among the determinants of child mortality increases only slightly the two stage estimate of the effect of child mortality on fertility from .0205 to .0209. The hypothesis that calories or dpt is valid over identification restrictions conditional on the other restriction is consistent with these data. However, the dpt immunization variable is available for only 58 countries in 1988. The other estimates in the fertility equation were very stable, whether identified by only the nonlinear calorie variable or the child immunization rates, but the effect of family planning on child mortality declines by 1988, the child immunization variable is included, suggesting family planning in the child mortality equation may be capturing the effect of other child health programs.

related to higher child mortality, and the religion and time trend coefficients are also significant. As expected, the availability of more calories per capita in a country is associated with lower child mortality, and the nonlinear effect of calories noted in micro studies is also jointly significant in these aggregate data. The child health benefits from increased calories continue until a country reaches an average level of about 3200 calories per capita per day, or two standard deviations above the mean of the sample, 2373 calories.²⁷

Variation in calorie availability per capita, given the income, education, and agricultural employment of the population, is presumably due to international differences in the unobserved prices of nutrients, which may in turn be affected by trade and agricultural policies, poverty, and famine alleviation programs, as well as the domestic composition and productivity of agriculture.²⁸ Calories may influence child mortality because domestic factors affect the relative price of nutrients, such as the personal distribution of income, education, and prices.

²⁷Because only four countries which contribute eight of the 217 observations have levels of calorie consumption that marginally exceed this daily per capita value of 3193, there is little reason to attach much precision to this estimate of the calorie level that would minimize child mortality. But developed market and centrally planned economies have, on average, exceeded this level for some time, and calorie shortages should, therefore, be a minor factor elevating the levels of child mortality in the high income world. According to regression (2), a country where calories are one standard deviation above the sample mean (i.e., 2373+367), the expected child mortality rate is eight percent lower. Had calories been a standard deviation below the sample average, as many African countries were (i.e., 2373-367), the regression implies child mortality rates are expected to be 13 percent higher, other things equal. Adjustments of caloric availability for the biological needs associated with the age and sex composition of the national population using FAO controversial standards did not change these estimates noticeably, and, therefore, calories are expressed simply in per capita terms.

²⁸Several recent studies have linked the relative price of food or nutrients to the prevalence of child malnutrition and mortality in cross sectional surveys and over time, mostly in subSaharan Africa (United Nations, SCN News, 1992; Strauss, 1985). A recent study of a variety of measures of real income, output, and terms of trade for a number of subSaharan African countries did not find a relationship over time between these national series and child mortality within countries, although it did find evidence that declines in income were associated with later age at first marriage and first birth, as might be expected in a Malthusian preindustrial Europe (National Research Council, 1993).

The Wu-Hausman specification test rejects the null hypothesis that child mortality is exogenous to the fertility equation, at $p < .01$. Regression (3) in Table 5 is therefore estimated by two-stage least squares with endogenous child mortality identified as indicated in regression (2). Most notably, the estimated effect of endogenous child mortality on fertility is five times as large as the estimate based on the rejected hypothesis that mortality is exogenous (Cf. regressions (3) and (1)). The direct effect of the woman's education on fertility is decreased by half (regression (3)), but by solving out for the implied reduced-form relationship, one finds that more than half of the total effect of the women's education on fertility now operates through its indirect child mortality reducing effect (i.e., $.59 = (-13.2) * (.0251) / (-.225 + (-13.2) * .0251)$). The positive effect of income on fertility, given endogenous child mortality, more than doubles in magnitude, and the religion variables are no longer jointly statistically significant in the fertility equation, but are significant in the child mortality equation.²⁹ The unrestricted reduced-form equation is reported in regression (4) excluding child mortality, for comparison with the structural effects solved from regressions (2) and (3).

5.6.2 Family Planning

Another factor that may influence fertility is birth control. One element of the cost of birth control is the monetary and psychic cost associated with using a specific method. Another cost involves deciphering a new technology of control, evaluating it against alternatives, adopting the best method, and learning to use it effectively. This second element is a search cost which is essentially fixed, as long as technology and family constraints are unchanging. But these search costs may reoccur in a dynamic

²⁹Other conditions that might have been expected to improve child health outcomes were not statistically significant when added to regression (2) Table 5, for example, doctors, nurses or hospital beds per capita, or percentage of population with safe water supplies or sanitation facilities.

setting as innovative technologies are being introduced, such as the IUD and pill in the 1960s, and subsequent improvements in injections and sterilization. A previously rejected method may also become worthy of consideration because of changes in desired levels of fertility. As the cost of birth control decreases, individuals are expected to have fewer unwanted births. It is also likely that, in addition to reducing unwanted births, such a decrease in the cost of birth control would encourage people to switch to contraception from other less satisfactory arrangements for controlling their reproductive potential, such as Malthus' delay of marriage, reduction in the frequency of intercourse, or reliance on abortion or even infanticide. This second source of welfare gain is not evaluated here.

All countries do not provide their populations with access to all forms of birth control, or necessarily provide these technological options at the same price. Educational and outreach programs are mixed in many combinations, with subsidized family planning service systems taking many forms. It has been argued that countries which support more diversified and apparently effective family planning activities (FPA) and legislate facilitating population policies had, by the 1970s, lower total fertility rates (TFR) (e.g., Mauldin and Berelson, 1978; Lapham and Mauldin, 1985). Declines in TFR since 1972 are also linked with strengthening family planning programs (Bongaarts et al., 1990). To interpret these partial correlations between TFR and FPA as a measure of the causal effectiveness of these programs, researchers have implicitly assumed that family planning programs occur independently of other fertility determinants. Since family planning activity is related to observed determinants of fertility, such as income, education and religion, it is reasonable to conjecture that family planning activity is related to unobserved determinants of fertility as well, such as omitted measures of economic constraints that are responsible for shifting parent demands for children and differences in parents' preferences. It might be argued that political support for state provision of family planning services

would be stronger when an increasing share of a population "demands" fewer children, and hence want nontraditional methods of birth control. The error in the equation explaining fertility would then, almost certainly, be correlated with family planning activities (FPA). The partial correlation between fertility and family planning, even controlling statistically for other observed fertility determinants, is then a biased and inconsistent estimate of the causal effect of family planning programs on fertility. Despite these limitations of correlational analysis to answer this salient policy question, agencies involved in evaluating and funding family planning continue to present such correlational evidence as confirmation of the effectiveness of such programs in achieving their objective (Mauldin and Berelson, 1978; Bongaarts et al., 1990; The World Bank, 1991).

Activities of family planning programs are summarized by an index that has been frequently used to evaluate the contribution of family planning to fertility declines (e.g. Mauldin and Berelson, 1978; Ross, et al., 1988, Table 18). This "effort score" (FPA) has a mean in the current sample of 34 and ranges from zero to 84, depending on the country's commitment to family planning services and population policies.³⁰ Although the components in the series are not identical in every year, the index has been standardized to facilitate comparisons over time. Two model specifications are estimated: the first assumes the family planning score is exogenous (Regressions 1-3,

³⁰In 1982 and 1988 the index is based on 30 pieces of information in four groupings: policies and program organizational support, range of services provided, record keeping for improving services, supplies of birth control services (Lapham and Mauldin, 1985). The 1972 index is based on fewer series, but is offered as compatible (Mauldin and Berelson, 1978). Aside from the subjective nature of much of the information, the major limitation of the index is that it includes contraceptive supplies. A dominant source of variation in fertility in the world is use of birth control, which is the result of both the supply of such services and the demand for them. Thus the index does not represent only the "supply" price of birth control services, but the quantity used which also embodies factors affecting the "demand" for children. It is not possible to eliminate the contraceptive prevalence components in the index for 1972. See Entwisle (1989) for an analysis that decomposes this effort score into its more and less exogenous components. The household demand model can be used to assess statistically the fertility reducing effect of contraceptive use (see Schultz, 1992a).

Table 6), and the second seeks to endogenize family planning within the overall model (Regressions 4-6, Table 6). In regression (1) of Table 6 the child mortality rate is predicted as before but with the addition of exogenous family planning activities. The total fertility rate is then estimated in regression (2), using 2SLS and treating child mortality as endogenous, as the Wu-Hausman test again rejects its exogeneity. The results confirm previous research that finds that family planning, if it is treated as exogenous, is negatively associated with total fertility rates. But here the effectiveness of FPA is smaller than others have found. Few substantial changes in the other regression coefficients are evident, with and without the inclusion of family planning.³¹

In regression (1) of Table 6 family planning is associated with lower child mortality. A standard deviation increase in the family planning score, of 25 points, is associated with a six percent decrease in child mortality, or nine fewer deaths per thousand births. Half of the effect of family planning on fertility operates through its impact on child mortality, which then leads

³¹Several studies have sought to summarize development (or social setting) and family planning into two index variables to account for fertility. They find that there is a statistically significant interaction between them (Mauldin and Berelson, 1978; Bongaarts et al., 1990). In other words, the effect of a strong family planning program is greater in advanced social settings and smaller in less advanced social settings. This synergistic relationship between family planning and development was investigated here for each dimension of development. Interaction variables are constructed between the family planning activity score variable and all of the other demand variables. None is statistically significant in explaining fertility levels except the child mortality rate. Whether child mortality (CMR) is assumed to be exogenous or treated as an endogenous variable, the coefficient on the interaction of child mortality and family planning (CMR*FPA) is statistically significant and positive, suggesting family planning has its greatest effect on fertility in an environment where child mortality is low and vice versa. In the pooled cross section (sample n=217) the three variables have the following coefficients (Cf. Regression (2) Table 6):

$$\text{TFR} = .0182 \text{ CMR} - .0198 \text{ FPA} + .0000843(\text{CMR}*\text{FPA}) + \dots \quad R^2 = .77$$

(4.37) (3.26) (2.23)

These results indicate that programs that reduce child mortality and those that foster family planning are complements so far as they reinforce each other in achieving the goal of reducing fertility.

Table 6

Cross Country Regressions of the Total Fertility Rate (TFR)
and Child Mortality Rate to Age 5 (CMR)^a

Dependent Variable:	(1) Child Mortality	(2) Fertility	(3) Fertility	(4) Child Mortality	(5) Family Planning Activity (FPA)	(6) Fertility
Estimation Method:	(CMR)	(TFR)	(TFR) Reduced Form	(CMR)	(FPA)	(TFR)
	OLS ^c	2SLS ^c	OLS	OLS	OLS	2SLS
Explanatory Variables:						
Years of Female Education ^b	-11.3 (4.30) ^a	-.161 (1.21)	-.450 (7.46)	-13.0 (4.93) ^a	4.72 (3.24)	-.238 (1.32) ^a
Years of Male Education ^b	1.67 (.99)	.152 (2.60)	.195 (5.03)	1.33 (.77)	1.06 (1.11)	.144 (2.39)
Log of GDP per Adult (1988\$, Purchasing Power Parity)	-24.7 (4.03)	1.20 (3.64)	.567 (4.03)	-25.5 (4.09)	2.28 (.66)	1.15 (3.36)
Urban Percent of Population	.321 (1.58)	-.0194 (2.79)	-.0108 (2.33)	.355 (1.70)	-.0869 (.75)	-.0172 (2.18)
Percent of Male Labor Force in Agriculture	.821 (4.88)	-.0042 (.47)	.0168 (4.37)	.854 (4.98)	-.0923 (.98)	-.0022 (.22)
Catholic Percent of Population	.196 (2.13)	.0030 (.80)	.0078 (3.70)	.264 (2.90)	-.201 (4.01)	.0054 (1.01)
Protestant Percent of Population	.422 (2.02)	.0065 (.03)	.0173 (3.62)	.545 (2.62)	-.364 (3.18)	.0111 (1.04)
Muslim Percent of Population	.602 (5.37)	-.0062 (1.01)	.0095 (3.69)	.644 (5.68)	-.119 (1.92)	-.0040 (.57)
Year 1982 Dummy	-8.49 (1.47)	.278 (1.31)	.063 (.48)	-9.61 (1.60)	3.70 (1.12)	.252 (1.16)
Year 1988 Dummy	-8.22 (1.13)	.673 (2.89)	.465 (3.13)	-13.3 (2.04)	15.3 (4.24)	.503 (1.43)
Calories consumed per capita per day	-.140 (1.94)		-.0028 (1.69)	-.154 (2.09)	.0428 (1.05)	
Calories per capita squared x10 ⁻³	.0211 (1.44)		.00037 (1.10)	.0243 (1.63)	-.0098 (1.20)	
International Planned Parenthood Federation (¢/woman)				-.0174 (.41)	.0653 (2.80)	
Child Mortality to age five (CMR)		.0257* (3.15)				.0250* (3.01)
Family Planning Activity Score (FPA)	-.343 (2.80)	-.0102 (2.08)	-.0192 (6.82)			.0022* (.11)
Intercept	511. (5.28)	-6.97 (2.06)	5.23 (2.36)	523. (5.30)	-36.4 (.67)	-6.91 (2.02)
R ²	.821	-	.773	.814	.498	-
F	71.7	26.8	53.3	68.5	15.5	24.6

Notes: See Table 5. Sample size is 217.

to lower fertility ($-.343 * .0257 = -.088$).³² It has long been hypothesized that there may be this form of synergistic reinforcing effect of family planning and maternal-child health programs on fertility (Berelson and Taylor, 1968), and the magnitude of this interaction effect has been estimated from individual data for Colombia and India (Rosenzweig and Schultz, 1982b; Rosenzweig and Wolpin, 1982). It is possible, however, that family planning programs could in some circumstances be more effective when they are oriented toward a single objective of reducing birth rates and are not integrated with programs that foster the allied objectives of improving child health. One reason the prospects of population policies that go "beyond family planning" are said to be bleak is the comparative ineffectiveness and high cost of child health and women's education initiatives (Berelson, 1969). The first set of estimates in Table 6 suggests that both family planning and women's education programs exert half of their total effect on fertility through their intermediary role of reducing child mortality and should not be classified as ineffective population measures, until carefully costed out.

If, as discussed earlier, family planning effort is in part a government response to parent demands for fewer children, what measurable sources of variation in family planning would be independent of fertility "demands" and thereby allow a researcher to identify statistically the unbiased impact of the "supply" of family planning effort on fertility? The meaning of any estimate of the effect of endogenous family planning on fertility depends, of course, on this choice of identification restriction. Only one variable could be found: the annual allocation of centrally provided family planning funds

³²Bongaarts (1987) has drawn attention to the anomaly that if family planning programs reduce fertility they would also increase the proportion of first births and possibly shorten birth intervals. In most populations the incidence of child mortality is higher for first births than subsequent ones, probably for biological reasons. Consequently, this birth-order composition effect of family planning could increase child mortality. But the empirical evidence presented here suggests that this birth order composition effect is swamped by the mortality reducing effects of the mix of programs and policies measured by the family planning effort score.

by country and year reported by the International Planned Parenthood Federation (IPPF). These external subsidies in 1988 (FX) dollars to another country's family planning program are divided by the number of women in that country of childbearing age, 15-45, and used to help explain the family planning effort index in regression (5) Table 6. IPPF transfers represent in the sample only 28 U.S. cents per woman per year on average, and they are zero in 18 countries (See Table 5). The estimated effect of IPPF transfers on family planning activities is positive with a t of 2.80, suggesting IPPF may be a satisfactory instrument for FPA (regression 5). International transfers from other donor agencies, such as from USAID, UNFPA, The World Bank, etc. (avoiding, of course, any double counting) could not be found by country over time. It may be noted in regression (5) that family planning activities are also stronger in countries with fewer Christians and Muslims, and with more highly educated women. The Wu-Hausman test rejects again the null hypothesis that child mortality is exogenous, which has been accordingly estimated as an endogenous variable in regression (6) in Table 6. But when family planning activity is treated as endogenous and identified by IPPF transfers, the Wu-Hausman t statistic is only 1.34 for the family planning variable, which is only significantly different from zero for a two-tailed test at the 20 percent level. This specification test suggests that one cannot reject the null hypothesis that family planning is, contrary to expectation, exogenous.

When family planning is nonetheless treated as endogenous in regression (6) of Table 6 along with endogenous child mortality, the estimate of the effect of family planning is not significantly different from zero. Given the limited information available to identify the endogenous effects of family planning on fertility, there is no reason to conclude that family planning has affected fertility. If one treats the family planning variable as exogenous in regression (2), in accord with the Wu-Hausman test, a one standard deviation increase in the family planning policy variable from 34 to 59 is associated with a five percent decrease in fertility, or about .26 children.

Family planning's effect on child mortality indirectly contributes another .23 child reduction in fertility. If family planning is treated as endogenous, neither of these effects on fertility are statistically significant or substantial.

In terms of the fraction of the sample variation in fertility explained, or in terms of the change in fertility associated with a standard deviation in the conditioning variable, family planning program effort is no more "important" a determinant of fertility than women's and men's education, income, urbanization, and child mortality. The dilemma with these findings is that they do not provide a strong empirical basis on which to identify the parameter of interest--the effectiveness of family planning to reduce fertility while correcting for simultaneous equation bias.³³

5.6.3 Prices of Contraception

Among specific forms of birth control, prices for oral contraceptives are available from the largest number of low-income countries. In 1988, 58 low-income countries report such prices (Population Crisis Committee). The sample average price for an annual supply of 13 cycles of oral contraceptives is \$40.40. This is reported to be the method used by 12 percent of the contracepting couples in low-income countries, the third most popular method after the IUD (24 percent) and sterilization (45 percent) (United Nations, 1989). It is not known if the price of oral contraceptives is a reasonable proxy for the prices of other birth control methods in each country. Although the average price of pills may be affected by demand driven population policies, it would seem more reasonable to assume that this price variable is uncorrelated with other unobserved determinants of fertility than the

³³There are clear conceptual problems in regarding as exogenous some of the data series aggregated into the family planning effort index (Lapham and Mauldin, 1985). This index appears to measure contraceptive prevalence (Entwisle, 1989), and is thus certainly endogenous to a model of fertility determination (Schultz, 1992a).

previously analyzed family planning variable. Thus, the price is treated here as exogenous.

In Table 7, the price of oral contraceptives replaces the family planning index for the smaller sample of 58 countries in 1988 for which prices are available. Estimates of child immunization are also available for these countries in 1988, reflecting progress of a major international campaign to increase child survival. The percentage of children receiving dpt (diphtheria, pertussis and tetanus) vaccine by their first birthday is therefore added as a determinant of child mortality in regression (1). Regression (2) reports the two-stage least square (2SLS) estimates, based on the Wu-Hausman test that child mortality is not exogenous. Regression (3) Table 7 is the reduced form for fertility that omits child mortality but includes calorie consumption and dpt immunization. These reduced-form estimates are parallel to those reported in Regression (4) Table 5. Increasing child immunization for dpt by 17 percentage points, or a standard deviation, is associated with a reduction in child mortality of five per thousand births. The oral contraceptive price has the expected positive effect on fertility, and it is statistically significant at the .05 level one-tailed test. A standard deviation increase in the annual price of oral contraceptives, from \$40 per year to \$80, is associated with an increase in the total fertility rate of .26 children, or five percent. In short, these estimates confirm that the elasticity of fertility with respect to the price of one form of widely marketed contraception is positive, but only about .05.

5.6.4 Time Series Changes within Countries

Data are available on all variables except the "price" of contraceptives and child immunization for 66 low-income countries in 1972, 1982, 1988, and 1989, a period during which the total fertility rates declined on average by .78, or 13 percent. The same model may, therefore, be estimated from the cross-country or within-country variation in this panel and based on a more

Table 7

Cross Country Regressions for 1988, with Child Immunization for
Diphtheria/pertussis/tetanus (dpt) and Prices of Oral Contraceptives^a

Dependent Variable: Estimation Method:	(1) Child Mortality (CMR) OLS	(2) Fertility (TFR) 2SLS ^c	(3) Fertility (TFR) OLS	(4) Means (Standard Deviations)
Explanatory Variables:				
Years of Female Education ^b	-12.1 (3.34)	-.249 (1.28)	-5.00 (3.82)	4.53 (2.29)
Years of Male Education ^b	.263 (.11)	.231 (2.35)	.237 (2.79)	6.30 (2.44)
Log of GDP per Adult (1988\$, Purchasing Power Parity)	-12.2 (1.14)	.608 (1.21)	.354 (.92)	8.08 (.794)
Urban Percent of Population	-.012 (.05)	-.0134 (1.23)	-.0135 (1.41)	45.6 (22.4)
Percent Male Labor Force in Agriculture	.251 (1.02)	.0087 (.84)	.0139 (1.57)	44.0 (26.6)
Catholic Percent of Population	.325 (2.54)	.005 (.89)	.012 (2.64)	39.2 (38.6)
Protestant Percent of Population	.810 (2.50)	.014 (.94)	.031 (2.67)	8.50 (12.4)
Muslim Percent of Population	.548 (3.25)	-.000 (.02)	.011 (1.87)	24.4 (35.7)
Calories consumed per capita per day	-.282 (2.29)	-	-.0054 (1.22)	2475. (398.)
Calories per capita squared $\times 10^{-3}$.0489 (2.04)	-	.00093 (1.08)	6281. (2004)
Percent Children age one immunized for dpt (1990)	-.282 (2.29)	-	-.0149 (1.69)	75.2 (17.0)
Price of Oral Contraceptives (\$/year)	-.0663 (.68)	.0066 (1.70)	.0533 (1.51)	40.4 (39.7)
Child Mortality Rate to age five (CMR)		.0207* (2.37)		107. (65.9)
Intercept	661. (4.20)	-2.97 (.63)	10.2 (1.81)	4.86 ^d (1.63)
R ²	.895	-	.779	
F	32.0	11.8	13.2	

Notes: See Table 5. Sample size is 58.

realistic specification of the stochastic term. In shifting from cross sectional estimates of a behavioral relationship to estimates based on time series variation, dynamic model limitations tend to become more salient (Kuh, 1959; Nerlove, 1965; Hausman and Taylor, 1981). Assume that fertility of country i at time t , F_{it} , is a linear function of a set of concurrent conditioning variables, X_{it} , and a family planning program variable, P_{it} :

$$F_{it} = \alpha_0 + \alpha_1 P_{it} + \sum_{j=2}^n \alpha_j X_{jit} + u_i + e_{it}, \quad (1)$$

where it is now assumed that the error has two components, one associated with the country, u_i , either random or persistent over time, and another independently distributed error, uncorrelated across time or countries, e_{it} .

If in equation (1) u_i is fixed and correlated with the regressors P_i and X_{ji} , then the α 's can be consistently estimated by introducing fixed effects (FE) for countries. This is equivalent to expressing all of the variables as deviations from their average over the time of the panel (T) within countries, whereby the confounding of regressors with each country's fixed effect is swept out, and one obtains:

$$F_{it} - F_{iT} = \alpha_1(P_{it} - P_{iT}) + \sum_{j=2}^n \alpha_j(X_{jit} - X_{jiT}) + (e_{it} - e_{iT}). \quad (2)$$

It is commonly assumed that the errors, e_{it} , are normal and independently and identically distributed, and then the differences in errors over time are also normal and iid. If the conditioning variables do not change in the panel, such as with religion, their coefficients cannot be estimated within the fixed effects framework. The intercept, α_0 , vanishes if there is no time trend, or if there is a time trend, it is estimated as an intercept in equation (2).

The fixed-effect specification draws attention to the rudimentary dynamics in the "static" fertility behavioral model represented by equation (1). Fertility at time t is assumed to be only a function of P and X 's at t ,

rather than depending on a more complex history of these variables which may be incorporated into expectations about the future. In the cross section one may be approximating long-run equilibrium tendencies in behavior (Kuh, 1959), but from the first differences it becomes obvious that the "dynamic" adjustment process places inordinate weight on one episode of change in the conditioning variables to explain the concurrent movement of fertility to what is presumably a new equilibrium.³⁴ By extending the length of time between the observations to 6-10 years, the fixed-effect approach may be more plausible, despite the inadequacies of the implied static framework. However, the task of endogenizing child mortality rates and family planning program activity is now more difficult to implement. The cautious approach adopted here is to interpret only the reduced-form specification based on fixed effects, which is less dependent on knowledge of the dynamics of the full structural model.³⁵

In Table 8, Generalized Least Squares (GLS) estimates are reported that allow for random country effects. Only single-equation models that do not contain endogenous explanatory variables are reported. The Lagrange multiplier (LM) test is performed to assess whether ordinary least squares (OLS) estimates based on the pooling of the panel data are consistent, or whether the country specific components are significant and should be

³⁴If one maintained this hypothesis it would also imply the desirability of measuring fertility and conditioning variables for cohorts. Rather than relying on period measures of fertility, such as the total fertility rate, cohort measures of children ever born should be analyzed in the future, with possible corrections for censoring of completed fertility by age for cohorts under age 45. Unfortunately, there are few countries for which these more suitable cohort data on fertility exist, and if one also required child mortality and education by sex and income by cohort, there might not be any low-income countries left in the working sample.

³⁵Some studies of changes in TFRs (e.g., Bongaarts, et al., 1990) have regressed current fertility on lagged values of fertility and reported ordinary least squares (OLS) estimates. Clearly, country-specific unobserved factors affecting fertility will persist to some degree over the period of analysis, and such serial correlation in errors embodied in fertility violates the assumptions under which OLS estimates are unbiased. Therefore, lagged fertility must be generally treated as endogenous and the model estimated by simultaneous equation methods (see above section 3.8).

Table 8

Generalized Least Squares Estimates from the Panel of
1972, 1978 and 1988 Assuming Random Error Structure

Dependent Variable: Estimation Method:	(1) Fertility (FPA Endogenous) (TFR)	(2) Fertility (FPA Exogenous) (TFR)	(3) Child Mortality (CMR)	(4) Family Planning (FPA)
Explanatory Variables: Years of Female Education ^b	-.454 (6.51) ^a	-.456 (6.78)	-3.21 (1.25)	-.378 (.26)
Years of Male Education ^b	.180 (3.43)	.204 (4.12)	-3.40 (1.68)	3.97 (3.52)
Log of GDP per Adult (1988\$, Purchasing Power Parity)	.118 (.86)	.265 (1.91)	-16.8 (3.38)	6.50 (2.41)
Urban Percent of Population	-.0017 (.30)	-.0049 (.93)	-.282 (1.35)	-.139 (1.17)
Percent of Male Labor Force in Agriculture	.0210 (4.70)	.0190 (4.39)	.817 (4.99)	.0540 (.57)
Percent of Catholic Population	.0127 (3.86)	.0104 (3.56)	.269 (2.02)	-.204 (2.79)
Percent of Protestant Population	.0256 (3.35)	.0217 (3.26)	.561 (1.82)	-.377 (2.20)
Percent of Islam Population	.0165 (4.25)	.0134 (3.88)	.794 (5.09)	-.216 (2.51)
Calories Consumed per capita per day ($\times 10^3$)	-.742 (3.89)	-.815 (4.13)	-12.2 (1.80)	-4.35 (1.10)
IPPF expenditures	-.0113 (.14)	-	-	.100 (5.83)
Family Planning Activity (FPA)	-	-.0101 (3.67)	-.212 (2.17)	-
1982 Year Dummy	-.0417 (.47)	.0078 (.09)	-12.0 (3.85)	5.61 (3.06)
1988 Year Dummy	.0230 (.21)	.231 (1.92)	-14.9 (3.42)	19.9 (8.52)
Constant	4.66 (3.91)	4.23 (1.71)	278. (6.39)	-17.0 (.68)
Pseudo-R ²	.704	.753	.775	.458
Lagrange Multiplier (LM) test rejecting OLS pooled for GLS or fixed effects model specification (confidence level)	85.02 (.0000)	49.78 (.0000)	96.69 (.0000)	70.09 (.0000)

incorporated into the estimation by a suitable procedure, such as GLS or FE.³⁶ The next to the last row in Table 8 reports this specification test indicating that the OLS estimates should be rejected in favor of either a random-effects or a time invariant model of u_i .

The GLS coefficients on the core variables are similar to the pooled cross section reduced-form OLS regression (4) in Table 5, except that income and urbanization have lost their explanatory effect. Regression (2) is based on the assumption that family planning activity is exogenous, in which case the GLS estimates suggest a standard deviation increase in FPA is associated with a total five percent decline in fertility, which is about half the size implied by regression (3) in Table 6. Regression (3) in Table 8 explaining child mortality assigns different weights to women's and men's education in lowering child mortality than in the OLS pooled results reported in regression (1) Table 6. Finally, regression (4) for family planning activity differs from OLS estimates in regression (5) in Table 6.

The Hausman and Taylor (1981) specification test is reported in the bottom row of Table 8 for the null hypothesis that the X_{ji} and fixed u_i are uncorrelated. If the null is rejected, both OLS and GLS estimates are inconsistent, and fixed-effect estimates are preferred. If family planning is endogenous and only IPPF expenditures are included (regression 1), the GLS estimates are accepted and preferred because of their efficiency. But if FPA is exogenous (regression 2), the GLS estimates are rejected in favor of the FE estimates. The Hausman test also rejects the GLS estimates for the child mortality equation, but accepts them for family planning activities.

Given the mixed outcomes of the specification tests, Table 9 reports, with qualifications, the fixed-effect model estimates based solely on changes over time within countries. The estimated effects of female and male

³⁶Missing data from the panel are assumed to be randomly missing; in which case including single observations in the GLS estimates is possible and the entire sample of 217 country-year observations is retained for GLS, but only 198 observations are used for FE estimates (Hsiao, 1986).

Table 9

Regressions on Changes Within Countries from 1972 to 1988
or Fixed Effect Estimates^a

Dependent Variable:	(1) Fertility (FPA Endogenous) Reduced Form OLS ^c -FE	(2) Fertility (FPA Exogenous) Reduced Form OLS-FE	(3) Child Mortality (CMR) OLS-FE	(4) Fertility (TFR) 2SLS ^c -FE	(5) Family Planning Activity (FPA) OLS-FE	(6) Fertility (TFR) 2SLS-FE
Estimation Method:						
Explanatory Variables:						
Years of Female Education ^b	-.447 (3.91) ^a	-.478 (4.26)	13.8 (4.71)	-2.35 (.95) ^a	-3.89 (1.50)	-1.72 (1.09)
Years of Male Education ^b	.259 (2.75)	.291 (2.97)	-11.8 (4.40)	1.82 (.90)	7.20 (3.35)	1.20 (.98)
Log of GDP per Adult (1988\$, Purchasing Power Parity)	-.0811 (.41)	-.0545 (.28)	3.60 (.70)	-.541 (.60)	6.51 (1.46)	-.707 (.81)
Urban Percent of Population	-.00215 (.20)	-.00248 (.23)	.0610 (.21)	-.0107 (.26)	-.310 (1.23)	-.00191 (.05)
Percent of Male Labor Force in Agriculture	.0274 (3.95)	.0278 (4.03)	.342 (1.89)	-.0185 (.26)	.0654 (.42)	.0127 (.23)
Calories consumed per capita per day ($\times 10^{-3}$)	-.652 (2.79)	-.668 (2.87)	-4.94 (.81)	-	-2.32 (.44)	-
IPPF expenditures per woman in (1988\$)	.0316 (.27)	-	-	-	.110 (4.19)	-
Child Mortality to age five (CMR)	-	-	-	.135* (.77)	-	.108* (.87)
Family Planning Activity Score (FPA)	-	-.00323 (.89)	.0505 (.53)	-.0107 (.62)	-	.0271* (.69)
1982 Intercept	-.0866 (.62)	-.0662 (.47)	-31.3 (8.48)	4.17 (.75)	6.90 (2.18)	3.07 (.81)
1988 Intercept	-.719 (.36)	.310 (.01)	-48.0 (8.45)	6.50 (.76)	22.5 (4.58)	4.36 (.80)
F (80, 129)	25.9	26.1	99.5	38.3	13.6	1.17

Notes: See Table 5. Sample size is 210, but minus 72 country fixed effects the actual degrees of freedom is only 139.

*Endogenous variable.

education and agricultural employment remain similar to those originally obtained by OLS from pooled levels, whereas the estimated effects of income and urbanization lose statistical significance and decline in magnitude as they did in the GLS random effects estimates.³⁷ Family planning activity, even when assumed to be exogenous, now exerts no significant effect on fertility in the fixed-effect specification, and the magnitude of the point estimate declines by two-thirds. A standard deviation increase in the family planning score of 25 is associated over time with less than a two percent decline in fertility. Only the reduced-form FE estimates in regression (1) appear to provide a plausible interpretation of fertility changes: the effort to include child mortality or family planning as endogenous does not yield convincing FE estimates of the implied dynamic structural models.

Evaluating the effects of social intervention programs, such as family planning, is rarely possible with country level data, though such data may appear useful for testing general hypotheses about the consequences of different patterns of development and suggest linkages that warrant further study at the microeconomic level. Family planning, health, and education programs often differ substantially within a national population and this variation can provide scope to estimate the behavioral impact of various mixes of program activities. Controlling for demand determinants of fertility may improve efforts to evaluate family planning programs in such a quasi-experimental setting, because the demand factors and program activities may themselves be intercorrelated and the omission of one factor will bias estimates of the effect of the other (Schultz, 1988). Studies of Bangladesh, Indonesia, Taiwan, Thailand and China have used statistical methods to

³⁷ That the effect of urbanization is insignificant in the first-differenced specification is not surprising, since these changes are probably dominated by projections of trends and are probably not greatly affected by actual current rates of rural-urban migration which might contain some information relevant to the fertility demands of parents. Income effects in short periods are obviously noisy sources of signals on the lifetime constraints relevant to a couple's fertility goals and behavior.

estimate the effects of family planning activity on birth rates (Foster and Roy, 1992; Gertler and Molyneaux, 1992; Schultz, 1974, 1980, 1992a; Montgomery and Casterline, 1993; Schultz and Zeng, 1992). The distribution of program benefits are inferred from coefficients on interaction variables, defined as the product of the program's regional inputs and each distinguished individual exogenous group identifier (Schultz, 1992a). The distribution of the program's benefits by socioeconomic groups in the population is thus assessed, defined by age, ethnicity, education, and region of residence. The failure in the analysis in this section to document from country level data the impact of family planning on fertility should not be interpreted to imply that there is no effect. Rather, information at a more disaggregated level is a more promising basis for evaluating such social programs.

5.6.5 Summary of Country Comparisons

Previous studies have found that both family planning and development are associated across low-income countries with lower levels of fertility. These regularities have also been noted here. What distinguishes my approach and how do these findings differ from those of earlier studies?

First, simple static theory is used to conceptualize the constraints imposed on (not chosen by) individuals that may influence their demand for children. Development may involve a different mix of changes in these constraints in each country, some associated with declines in fertility and others with increases. Unless one gets beyond the search for a single "index of development" and focuses on measuring the dimensions of modern economic growth that have theoretically distinct effects on fertility, the search for empirical regularities between development and fertility is unlikely to be informative. Fertility should be statistically understood in terms of these multiple theoretical constraints, allowing their independent effects to be possibly nonlinear and to interact. Procedures that collapse the diversity of

development into a single index seem archaic and counterproductive but are still common to this field of study.³⁸

Second, most prior studies have included education as a demand or development indicator, but none has distinguished between the education of men and women. This practice continues despite the clear prediction of the earliest economic models of fertility that the effect of female education will be more negative than the effect of male education (Schultz, 1973). Distinguishing between the effects of the adult education of women and men is absolutely essential to test the relevance of the microeconomic model of fertility. This is not to suggest that other interpretations of female education as empowering women and thereby contributing to fertility declines, or Caldwell's (1982) view that mass education provides women with the capacity for decisionmaking in the family, are not also viable interpretations of why gender differences in education are critical for understanding the demographic transition in low income countries.

Third, child mortality is arguably not exogenous to the economic endowments, preferences, and conditions of the family, despite the likely importance of some community health measures and local disease environments in determining child deaths. But the family's resources are also important, such as the educational attainment of a mother that helps to explain empirically the probability of survival for her children. Consequently, either child mortality should itself be studied jointly within the same conceptual

³⁸The United Nations (1987) proposed that an index of development be constructed as the average of four series: GNP per capita, gross school enrollment ratio, infant mortality rate, and per capita number of radios, TVs, and cars. Bongaarts et al. (1990) use this index for their portrayal of the demographic effect of family planning. As with Mauldin and Berelson (1978), and Lapham and Mauldin (1985) countries are displayed on a two way grid of the development index and the family planning effort index. The most recent Bongaarts et al. (1990) paper concludes that the absence of family planning programs worldwide would have led to a total fertility rate for low-income countries that would be 1.2 children higher in 1980-85, or the TFR would have been 5.4 rather than 4.2. As a comparison, the pooled cross sections (Table 6, regression (2)) suggest that if the mean level of family planning score had not been 34 but zero, the associated TFR would have been .3 lower (34* (-.0089)).

framework with fertility or a reduced-form equation for fertility should be estimated where child mortality has been implicitly solved out of this relationship. The supply of calories per capita is specified here as a determinant of child mortality, but excluded from the fertility equation. The estimated effect of endogenous child mortality on fertility based on this identification restriction appears to be several times larger than when child mortality is viewed, as in prior studies, as if it were exogenous and measured without error. According to the estimates confirmed by exogeneity specification tests, declines in the level of child mortality in developing countries are not associated with increases in population growth, because coordinated fertility declines fully offset this demographic effect of improvements in child nutrition and survival. In this time period, improvements in child health are associated with slower population growth.

Fourth, countries that have higher permanent incomes in the cross section, given their human resource base, have higher fertility. This is not unexpected from the demand model of fertility. If the level of income is due to physical capital and natural resources, such as petroleum, which may have only a modest short run effect on the productivity of the time of men and women, then an increment in income will not be offset by an increase in the opportunity cost of the time of parents in childbearing. A higher level of GDP per adult that is not associated with higher male and female education or lower child mortality can be expected to increase demands for children.

Fifth, the effects of gender-specific education and income on fertility are strengthened when several control variables for religion are included, such as Christianity and Islam. For example, the relatively high levels of fertility in Islamic countries are explained here in terms of the underlying economic constraints on the population, including past educational investments in women. One does not have to resort to ad hoc cultural variables to explain most of the variation in fertility across low-income countries.

Sixth, family planning programs are summarized by an index used in a series of influential articles buttressing the idea that family planning is responsible for much of the reduction in fertility in low-income countries. If this family planning were an experimental treatment administered randomly to different countries, it could be argued that these programs are, as implicitly claimed, exogenous to the preexisting development and demand factors in these countries. Under this working hypothesis, family planning as an exogenous conditioning variable is indeed related to lower levels of fertility in the cross section. A standard deviation increase in the family planning score from 34 to 59 is associated with a modest five percent decline in fertility. But if family planning effort is explained within the model and endogenized, the relationship between it and fertility becomes statistically insignificant. Nevertheless, when the price of oral contraceptives is treated as an exogenous price of birth control, this more defensible exogenous family planning variable accounts for a significant, though small, share of the variance in fertility, with a doubling of the price of birth control being associated with fertility being five percent higher.

Seventh, when the fertility analysis shifts from cross sectional levels to the more difficult to explain changes over time within countries, from 1972 to 1988, it is possible to estimate with confidence only a reduced-form specification of the fertility model. Based on fixed effect estimates where family planning is treated as exogenous, the impact of family planning on fertility is insignificant and only one-third as large as when estimated by OLS or GLS. It is notable that female and male education, agricultural employment, and caloric availability exhibit significant estimated effects on fertility of roughly the same magnitude whether estimated by OLS, GLS or fixed effects.

Eighth, the Bucharest World Population Conference in 1974 first asked whether fertility declines are promoted by development or by organized family planning activities? This question is, of course, poorly framed, for both are

certainly relevant. But the thrust of this analysis is that the level and sex composition of human capital, the decline of agricultural employment, and the basic nutrition of the population explain most of the variation in the levels of total fertility rates and much of their changes over time, whereas family planning explains relatively little of either cross sectional or time series variation in fertility. Some changes associated generally with modern economic growth, such as increased male education or returns to nonhuman capital, raise fertility, whereas other changes, such as improvements in female education, urbanization, declines in the share of employment in agriculture, increases in availability of food, and a resulting decline in child mortality, lower fertility. The specific mix of these sources of growth and development in any particular country will then influence whether its development is pronatal or antinatal.

The education of women is the dominant empirical factor associated with the decline in fertility in the cross section and over time. But since male education has a weaker but countervailing effect on fertility, a critical dimension of development is likely to be the investment in schooling of females relative to males. Growth in income alone lowers child mortality, but has little total (reduced-form) effect on fertility. Raising calorie availability at very low levels appears to be strongly related to lowering child mortality and thereby contributes to fertility declines at early stages in the development process.

In the changes over time, family planning effort does not emerge as an important determinant of fertility. Because of the complexity of the policy formation process, and the lags between changes in the constraints on individuals and dynamic adjustments in their fertility, intercountry comparisons are not well suited to provide definitive answers on the cost effectiveness of social welfare programs, such as family planning. Program evaluation studies are more promising when conducted within individual countries, in those cases where administrative regions have implemented

distinctively different policy packages without regard to socioeconomic development of the regions. When individual household survey data are then combined with administrative information on program expenditures or activities by small service regions, convincing evidence can be constructed on the contribution to fertility declines by family planning programs (or lack of it), holding constant for the principal household demand factors emphasized here. Even in these cases, the first differencing of data by region helps to purge from the analysis potentially misleading correlations between region fixed effects and program inputs (Foster and Roy, 1992; Gertler et al., 1992). Aggregate data for countries may not provide a credible answer to the question: how much difference has organized family planning made? But models that seek to explain cross-country differences and changes within countries may still shed light on the connections between the underlying sources of modern economic growth and their consequences for the decline in child mortality, fertility, and population growth that distinguish this century.

6. Conclusions

Applications of microeconomics to understand the demand for children emphasize several special aspects of children. Their cost to parents is heavily affected by the opportunity cost of the time of mothers, who in most societies contribute a disproportionate share of their time to child rearing. Demand models, consequently, predict and empirical studies confirm that increases in women's wages and education have a more negative impact on fertility than do increases in men's wages and education, or, for that matter, than does nonhuman capital income, which is indeed often associated with increased fertility in low-income agricultural settings. The changing composition of income, between labor and nonhuman capital, and between male and female productivity, are as important for the decline in fertility as the overall level of national income.

Children are also important vehicles for human capital investment that parents apparently treat as a substitute for their numbers of children. Thus, when the returns to human capital investment in the education of children increase, parents are expected to provide their children with more schooling, and will also reduce their own fertility. It is not clear from theory or empirical studies whether parents are motivated to make these child investments out of altruism or in exchange for the care and resources they expect their children to provide them in old age and in other unfavorable states of the world.

Other factors in the environment of families also appear to affect the demand for children and are reasonably subsumed within the demand model as affecting the relative cost or productivity of children. A plentiful supply of land owned by farm operators is conducive to relatively high fertility because the parents recoup more of the costs of childbearing by using children to replace costly hired farm labor. In cities, the net costs of children are thought to be higher because there is less productive work there for children within the family, and the costs of food, shelter, and vocational training are greater. Fertility clearly tends to be higher in rural-agricultural than in urban-industrial areas, holding many other factors constant.

The decline in mortality is the critical factor behind the acceleration in population growth that emerged in Europe about 1700 and spreads to low-income countries in the twentieth century. Our knowledge about the precise causes for and mechanisms producing the decline in mortality either in high- or low-income countries is fragmentary. The competing hypotheses are that nutrition improved, increases in income allowed other forms of healthy consumption to increase, public and private technologies controlled infectious diseases, or the organisms causing some (primarily childhood) diseases became less often fatal and were not immediately replaced by others. Whatever the cause of the mortality decline, the response of parents has been to reduce their births. This response of parents to the decline in child mortality can

be explained within an economic demand model by the diminished need to replace children not dying, by the decreased need to use children as an insurance against uncertain mortality, and by the increased expected returns the family earns on investments that take the form of longer gestating child human capital. Although the empirical and theoretical pattern is clear, there remains ambiguity on how to allocate econometrically the substantial positive covariation between child mortality rates and fertility. Part is undoubtedly due to a response of parents to exogenous change in the health environment and part to endogenous household mediated control of family health and survival.

Finally, changes in the family are associated with changes in the state. Schools replace the family as training grounds for children and are almost everywhere publicly subsidized. Old age support and health care are provided by many state insurance schemes, which reduces the incentive to rear children to perform these functions within the family. Unfortunately, it is hard to measure with any confidence the effect of these institutional changes on fertility, but intuition tells us that they could be substantial. For many low-income countries these forms of social welfare legislation are not a realistic option to lower fertility because their cost exceeds publicly available resources. However, there are an increasing number of studies that suggest programs increasing the schooling of women, improving child health and nutrition, and diffusing family planning methods have all contributed significantly to the declines in child mortality, fertility, and population growth rates in low-income developing countries. These human resource programs certainly help to explain the puzzling variations in the world's demographic and economic development which were reviewed at the outset of this chapter. Economic models of the demand for children assist in providing an integrated framework for the study of these programs and their consequences on family behavior.

Data Appendix Table A-1

<u>Variable Definition</u>	<u>Sources</u>
1. Total Fertility Rate	United Nations, 1990, <u>World Development Prospects and Demographic Yearbook</u> .
2. Child Mortality Rate per thousand births	United Nations, 1988, <u>Mortality of Children Under Age 5, 1980</u> .
3. Years of Schooling Completed by Adult Population by Sex. (Wage = exp (years * .15))	World Bank, diskette <u>Source data</u> , 1992. UNESCO, <u>Statistical Yearbooks</u> .
4.a Real GDP per adult in U.S. 1988 \$ using foreign exchange rates (in logarithms).	World Bank, 1991, <u>World Tables</u> , WDR 1990, <u>UN Statistical Yearbook</u> and IMF <u>International Financial Statistics Yearbook</u> .
4.b Real GDP per adult in 1985 international prices (PWT5) or purchasing power parity (in logarithms)	R. Summer and A. Heston, 1991, Expanded Set of International Comparisons 1950-1988, " <u>Quarterly Journal of Economics</u> 104:2 (May) 327-368.
5. Urban Population Share (percent)	UN <u>Demographic Yearbook</u> , 1991, <u>World Tables</u> , 1990 <u>World Urbanization Prospects</u> .
6. Religious composition as of 1980 (percent).	D. Barrett, 1982, <u>World Christian Encyclopedia</u> .
7. Calories per capita per day	Food and Agricultural Organization, 1976, <u>FAO Production Yearbook</u> , 1985 and 1991 WDR.
8. Family Planning Effort score	1972 scores in B. Berelson and W.P. Mauldin, 1978, "Conditions of Fertility Decline in Developing Countries, 1965-1975," <u>Studies in Family Planning</u> 9:5, 84-148. 1982 and 1989 scores in Ross et al., 1991, <u>Family Planning and Child Survival Programs</u> .
9. International Planned Parenthood Federation Expenditures in U.S. \$ 1988 per woman age 15-45.	1989-90, <u>IPPF Annual Report</u> ; 1973/74, 1983/84, 1988/89 <u>Inventory of Population Projects</u> , UN Population Fund.
10. Oral Contraceptive Price 13 cycles (one year) in U.S. \$ 1990.	<u>Access to Affordable Contraception</u> , 1991, Report on World Progress toward Population Stabilization, Population Crisis Committee, Washington, D.C.

Data Appendix Table A-2

Countries and Years in Sample

1. Algeria	1972, 1982, 1988	41. Liberia	1972, 1982, 1988
2.* Argentina	1988	42. Libya	1972, 1982
3. Bangladesh	1972, 1982, 1988	43. Madagascar	1972, 1982, 1988
4.* Barbados	1972	44. Malawi	1972, 1982, 1988
5. Benin	1972, 1982, 1988	45. Malaysia	1972, 1982, 1988
6. Bolivia	1972, 1982, 1988	46. Mali	1972, 1982, 1988
7. Botswana	1982, 1988	47. Mauritania	1972, 1982, 1988
8. Brazil	1972, 1982, 1988	48. Mauritius	1972, 1982, 1988
9. Burkina Faso	1972, 1982, 1988	49. Mexico	1972, 1982, 1988
10. Burundi	1972, 1982, 1988	50. Morocco	1972, 1982, 1988
11. Cameroon	1972, 1982, 1988	51. Myanmar	1972, 1982, 1988
12. Central African Republic	1982, 1988	52. Nepal	1972, 1982, 1988
13. Chile	1972, 1982, 1988	53. Nicaragua	1972, 1982
14. China	1972, 1982, 1988	54. Nigeria	1972, 1982, 1988
15. Columbia	1972, 1982, 1988	55. Pakistan	1972, 1982, 1988
16. Congo	1972, 1982, 1988	56. Panama	1972, 1982, 1988
17. Costa Rica	1972, 1982, 1988	57. Papua	1972, 1982, 1988
18. Cuba	1972, 1982	58. New Guinea	1972, 1982, 1988
19.*Cyprus	1982	59. Paraguay	1972, 1982, 1988
20. Dominican Republic	1972, 1982, 1988	60. Peru	1972, 1982, 1988
21. Ecuador	1972, 1982, 1988	61. Philippines	1972, 1982, 1988
22. Egypt	1972, 1982, 1988	62. Republic of Korea	1972, 1982, 1988
23. El Salvador	1972, 1982, 1988	63. Rwanda	1972, 1982, 1988
24. Ethiopia	1972, 1982, 1988	64. Senegal	1972, 1982, 1988
25. Fiji	1972, 1982	65. Singapore	1972, 1982, 1988
26.*Gabon	1988	66.*South Africa	1988
27. Ghana	1972, 1982, 1988	67. Sri Lanka	1972, 1982, 1988
28. Guatemala	1972, 1982, 1988	68. Sudan	1972, 1982, 1988
29. Guyana	1982, 1988	69. Syria	1972, 1982, 1988
30. Haiti	1972, 1982, 1988	70. Tanzania	1972, 1982, 1988
31. Honduras	1972, 1982, 1988	71. Thailand	1972, 1982, 1988
32.*Hong Kong	1982	72. Togo	1972, 1982, 1988
33. India	1972, 1982, 1988	73. Trinidad & Tobago	1972, 1982, 1988
34. Indonesia	1972, 1982, 1988	74. Tunisia	1972, 1982, 1988
35. Iran	1972, 1982, 1988	75. Turkey	1972, 1982, 1988
36. Iraq	1972, 1982, 1988	76. Uganda	1972, 1982, 1988
37. Ivory Coast	1972, 1982, 1988	77.*Uruguay	1988
38. Jamaica	1972, 1982, 1988	78. Venezuela	1972, 1982, 1988
39. Kenya	1972, 1982, 1988	79. Zaire	1972, 1982, 1988
40. Kuwait	1972, 1982, 1988	80. Zambia	1972, 1982, 1988
41. Lesotho	1972, 1982, 1988	81. Zimbabwe	1982, 1988

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