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ECONOMIC DEMOGRAPHY AND DEVELOPMENT:

NEW DIRECTIONS IN AN OLD FIELD

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Abstract

Economic Demography and Development: New Directions in An Old Field

This paper surveys a literature on the economic determinants of household demographic and economic behavior, one that has contributed to a reappraisal of the consequences of rapid population growth on economic development. Guided by the theory of household demand and production, empirical studies have shown that fertility, family labor supply, market coordinated specialization of production, and investments in the productivity of humans are interrelated activities with common economic origins in the household economy. Differences in these forms of family behavior are partially explained by theoretically prescribed economic variables that can be taken as exogenous from the viewpoint of the individual household. These exogenous determinants of household production-demand behavior include lifetime wage rates, market prices, initial assets, public sector services and infrastructure, and programs that extend information to households that is useful in production, such as public health and family planning programs. Estimation of "structural" relationships among family choice variables are not generally identified, according to household demand framework, because the exogenous variables and constraints that condition one class of family behavior are also likely to condition other forms of family demographic and economic behavior. This inability to disentangle how endogenous family choice outcomes interact does not prevent consistent estimation of reduced forms. These reduced-form equations are useful for assessing how localized programs and policies affect household outcomes, and how the benefits of programs are distributed by exogenous population groups, such as by education, race, or sex.

ECONOMIC DEMOGRAPHY AND DEVELOPMENT: NEW DIRECTIONS IN AN OLD FIELD*

I. INTRODUCTION

Three decades ago economists lent their weight to the plausible conclusion that rapid population growth is an important deterrent to economic development in contemporary low income countries (Notestein, 1945; Coale and Hoover, 1958; National Academy of Sciences, 1971). In the last ten years the evidence for this conclusion has been reevaluated. A recent working group of the National Academy of Sciences (1986) came to the judgment that "On balance, we reach the qualitative conclusion that slower population growth would be beneficial to economic development for most developing countries. A rigorous quantitative assessment of these benefits is difficult and context dependent" (p. 90). Nonetheless, public subsidies to voluntary family planning were viewed by this working group as often justified, but not on the economic grounds of relieving society of the evident burdens of social externalities attributed to population growth. These program subsidies were rationalized because they enable "couples to have the number of children they desire" (p.93), that is, family planning

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was justified within the public sector on the same basis as public health and farm extension activities, because family planning diffused efficiently and equitably new and poorly understood productive knowledge and thereby helped private households achieve their own objectives. This paper takes stock of a recent literature on the economic determinants of household demographic and economic behavior, that has, I shall argue, contributed to this significant reappraisal of the linkages between modern economic growth and population growth.^{1/}

Reversals of this kind by economists are not uncommon, particularly when issues of public policy are involved. But such reversals can contain lessons. They may signal a fundamental advance in knowledge, or at least an alternative interpretation of accepted facts. They may represent the accumulation of new facts, due to the systematic cataloging of data to reveal empirical regularities where none were previously perceived. In this case, the reversal does not seem to be due to a fundamentally new economic insight, but rather to the proliferation of empirical studies increasingly guided by a common framework that suggests fertility, family labor supply, market coordinated specialization of production, and investment in humans are closely interrelated activities that have common economic origins. Differences in these forms of demographic and economic behavior of households diffuse through societies with the onset of modern economic growth and can be partially explained by economic variables such as prices, wages, assets, and public sector services and programs that extend information to households. These differences in behavior are evident across countries at one moment in time, and within countries over time, paralleling their demographic transitions from high to low rates of population growth. One interpretation of the evidence is, therefore, that fertility and family specialization between market and nonmarket production

activities are reflections of purposive behavior, and can be fruitfully modeled as outcomes of optimizing household production and consumption decision making, subject however to imperfect information and buffeted by many unexpected events that help to account for noticeable disequilibria.

Consequences of individual fertility decisions that bear on persons outside of the family have proven difficult to quantify, as in many cases where social external diseconomies are thought to be important. Problems of inefficient resource allocation that are often attributed to population growth are increasingly analyzed as originating from market failures, misguided policy interventions, and restricted property rights such as arise with common property resources (National Academy of Sciences, 1986). What remains unclear is precisely when Malthusian (1798) diminishing returns to labor constitute a serious social externality of population growth, and when, conversely, increasing returns to population density, as conjectured by Boserup (1965), are a dominant feature of economic development? With mounting evidence that fertility represents private optimizing behavior of couples, even in premodern societies, the task of assembling convincing empirical evidence on the magnitude of these Malthusian or Boserupian aggregate effects of population growth becomes substantially more complicated, as discussed below.

Recognition of the ambiguity of the existing evidence of macro economic consequences of population growth on development may also represent a broader intellectual trend in economics. Macroeconomic systems that lack clearly identified causal relationships have lost their credibility, and microeconomic models of optimizing agents such as individuals, families, farmers, or firms have gained ascendance. This shift in economic fashions may have given impetus to modeling the microeconomic foundations of behavior in the household sector. The next step is to apply these microeconomic models to understand aggregate

developments in a general equilibrium framework. But progress in this direction has been slow.

One research strategy is to describe the general equilibrium problem facing agents, and then specify from a literature review the likely functional form and possible empirical parameters to the component relationships. Simulation of the computable general equilibrium (CGE) framework that is thereby specified can then be used to show how counterfactual changes in conditioning variables might affect the evolution of the aggregate system. Although particular phenomena have been thoughtfully studied by means of CGE models of this form, such as urbanization in low income countries (Kelley and Williamson, 1984), these techniques have not been applied with much success to modern household demand models and economic development (Rodgers, et al., 1978). Economists have also estimated production functions, factor demand equations, and consumer expenditure systems to measure in a general equilibrium model the empirical importance of Malthusian and Boserupian macroeconomic effects of exogenous population growth on wages and welfare (Evenson, 1984). This innovative empirical strategy for assessing the consequences of population growth has not yet directly sought to incorporate fertility endogenously. That is clearly the next, but far from trivial, task facing economic demographers studying development.

This paper proceeds as follows. Section II reviews the empirical evidence for the most influential general equilibrium model of demographic development, that was originally proposed by Malthus. Section III states the current microeconomic framework for analyzing household demographic behavior, and Section IV illustrates the empirical implementation of this model. The concluding section reconsiders the capacity of empirical studies of household behavior to clarify the consequences of alternative development programs and policies.

II. MALTHUS'S MODEL AND THE EVIDENCE

For the last 25 years there has been almost a consensus among social scientists on the nature of the relationships between population growth and economic development. This shared view owes much to the ideas that Malthus (1798) articulated nearly two hundred years ago. In many quarters his conceptual framework continues to guide thinking about demographic change during the development process and sets the stage for related policy discussions. A review of the empirical evidence for this historically influential viewpoint is a useful introduction to modern microeconomic analysis of household demographic behavior. It may also clarify why our knowledge of some critical relationships remains so ambiguous.

The Model

Three economic relationships constitute the core of Malthus's equilibrium model of economic and demographic development. On the one hand, when real wages fall below some subsistence level mortality increases. On the other hand, when real wages increase, marriage is encouraged at an earlier age, with a predictable positive effect on lifetime cumulative fertility and thus on population growth. Consequently, there is a dual microeconomic direct dependence of population growth on the wage rate, operating through an economic-biological mortality function and an economic-institutional marriage-fertility function. Malthus assigns greater weight to the former "positive check" than to the latter "preventive check" as a long run mechanism governing population growth. The third relationship Malthus relied on was a classical macroeconomic production function in which population growth led to an increase in the labor force and a decrease in the marginal product of labor

and hence of real wages. This three-equation system is homeostatic: when shocked from equilibrium, it has a tendency to converge over time to a "natural" or subsistence wage at which there is no population growth, or alternatively, at which population grows, but at an exogenously fixed long-run rate of factor neutral productivity growth.

Mortality: Evidence

What is the empirical basis for these three relationships underlying the Malthusian framework? Death rates in preindustrial Europe appear to increase in years when real wages are very depressed (Lee, 1981; Eckstein, et al., 1984). It is less certain, however, whether the response of death rates to short run fluctuations in real wages cumulates or represents primarily a time displacement of deaths.^{2/} Periods of increased mortality are also often periods of food shortage and hence inflation in food prices that is not reflected in nominal wages (Sen, 1981). Interregional and rural-urban migration during these crisis periods add further uncertainty as to the independent effect of real wage variation on mortality, for the movement of people in search of employment and food observed during crises may be a major factor associated with epidemic and endemic disease and may explain the special age and sex patterns observed in crisis mortality (Galloway, 1985; Watkins and Menken, 1985).

If historical times series data lend only weak support to Malthus's conjecture that mortality responds to variation in real wages, modern time series data provide little additional evidence that this connection is quantitatively large in contemporary settings. For one reason, the evidence is generally flawed, because those societies with sufficiently low wage levels to exhibit potentially the Malthusian sensitivity of mortality to wages tend to

have the least adequate registration of deaths. Moreover, periods of low real wages continue to be associated with other events--natural disasters, wars, vast movements of population--that leave in their own wake additional consequences as well as below-normal levels of mortality registration.

There are also long phases of industrialization and economic development during which increased wages can be associated with increased mortality. Urbanization, until at least the 20th century, was often purchased at a social cost in terms of degradation of the health environment. Williamson (1982) argues that the higher wages paid urban English workers compensated them for their loss of longevity in the 18th and 19th centuries. Increases in wages in the 20th century in developed countries have supported consumption patterns, such as smoking, alcohol and drug abuse, that have weakened and sometimes even reversed the traditional positive cross sectional correlation between income and longevity (Fuchs, 1984). In low income countries, however, mortality remains inversely related to income and occupational status (United Nations, 1980), though education is a far better predictor of lower mortality than is wealth, suggesting that knowledge of hygiene and health practices may today be as important to health as the economic resources to pay for food and health services. The strongest cross-sectional correlate of mortality is the consistent linkage between child mortality and the mother's education, where an additional year's education of the mother is associated with a 5 to 9 percent reduction in child mortality (Schultz, 1980; Cochrane et al., 1982; Schultz and Rosenzweig, 1982; Farah and Preston, 1982; United Nations, 1985). The lack of convincing contemporary or historical evidence on the empirical magnitude of the relationship from real wages to long-run mortality levels suggests that this plausible link is weak at today's wage levels or attenuated by current public sector capacities and commitment to alleviate extreme poverty and moderate fluctuations in food prices.

Fertility: Evidence

Birth rates in Europe before the industrial revolution appear to respond positively to wage rates, with a one to two year lag rationalized by the requirements of conception and gestation (e.g. Lee, 1977; Eckstein et al., 1984). Good weather and harvests lead predictably to increases in real wages, to increases in marriage, and, in due course, to an increase in fertility (Heckscher, 1954). These preindustrial behavioral patterns that Malthus captured in his agrarian theory are also evident in industrial societies. Covariation between the business cycle, marriage rates, and birth rates is documented in the later 19th and 20th century for several industrializing countries. The business cycle relationship is statistically more significant if birth rates are again lagged one to two years (Thomas, 1927; Silver, 1965, 1966). Malthus may again have correctly perceived the short-run responsiveness of births to wage rates, but the cumulative effects of fertility induced by persisting wage changes are less clearly established in existing analyses of time series from England, Sweden or France (Lee, 1981; Bengtsson, 1984; Eckstein, et al., 1984; Richards, 1984).

The major shortcoming of Malthus's framework is not in its failure to provide an adequate explanation for fluctuations in birth and death rates in preindustrial European societies. Its failure was rather to provide no inkling of the secular decline in fertility that occurred shortly after Malthus's death, more or less simultaneously in most industrially advanced countries of Europe (Coale, 1983). To explain this decline in fertility in the face of rising real wages, it is necessary to identify binding constraints on fertility that Malthus overlooked. This has led to the assumption of individual optimizing behavior inclusive of fertility, and then the proposition that one

or another change in the environment has motivated individuals to want fewer births. Fertility may respond to an increase in the relative cost of children, or to an increase in the return to investments in the schooling of children, or to a decrease in the frequency of child mortality. These and other hypotheses are discussed elsewhere (e.g. Schultz, 1976, 1985b).

Revising Malthus on Microeconomics

This brief review of the empirical evidence provides several clues as to how the Malthusian framework should be revised. First, in preindustrial periods of the now industrialized countries, the relative emphasis Malthus ascribed to the wage responsiveness of death rates should probably be weakened. Large variations in mortality did occur, but for reasons other than short-run variations in wage rates. Death rates responded only moderately in the short-run to wage rates, while birth rates may have varied more substantially to economic conditions. Variation in age-at-marriage was one means by which this occurred. But birth rates within marriage also exhibited positive responsiveness to short-run wage and price variation.^{3/} As with mortality, the uncertainty as to the magnitude of these relationships increases as we seek evidence on the longer-run wage effects on cumulative mortality and fertility (Fogel, 1986). These patterns in historical time series suggest that some measure of voluntary control of fertility within marriage may have existed to avoid births in particularly bad times, even before the onset of the pattern of stopping births according to accumulated family size. This latter form of parity-specific application of birth control became, of course, the dominant means of fertility control during and after the demographic transition (Henry, 1961).

Thus, even in preindustrial periods the "preventive check" on population growth via fertility occupied a central place, while the role of mortality as a "positive check" on population growth operated relatively independently of wage rates (Lee, 1973). This is more than a minor shift in emphasis between the two reinforcing microeconomic relationships in Malthus's framework; it implies that fertility is not exogenous from the individual's standpoint but is an endogenous variable with an economic life of its own. Making individuals partially responsible for their numbers complicates, as we will see, the interpretation of long swings in population size, which might otherwise provide a clear basis for measuring the third critical Malthusian relationship, that between population size and the marginal product paid to labor in the aggregate economy.

Diminishing Returns: Evidence

Demographic and economic evidence is broadly consistent with diminishing returns to labor for England from about 1250 to 1700, as illustrated in a variety of general and partial equilibrium models by Lee (1973, 1980). During this period inputs that complement labor grew sufficiently fast to absorb at a more or less constant wage a gradual growth of population of about .4 percent per year (Lee, 1980). After 1650, as the industrial revolution took hold of England, the capacity of the economy to absorb labor may have increased, population growth accelerated, and wages nonetheless continued to increase until the end of the 19th century, when birth rates finally declined. In other European countries, reliable long time series on population size, wages, and prices from preindustrial periods have not been as thoroughly reconstructed and studied. By the 19th century when data are available for countries such as Sweden, population increases do not appear to be associated with wage declines

(Schultz, 1985b). One interpretation of this evidence is that improvements in production technique and nonlabor factors of production grew more rapidly than did population, despite the acceleration in the growth of population to about one percent per year in the 18th and 19th centuries.

By the 1950s and 1960s the gap between crude birth and crude death rates in the low income countries had widened, and population growth in these countries increased to two to four percent per year. These rates of population growth were several times larger than those ever recorded in Europe during its transition in the 19th century. It is remarkable, in retrospect, that the accumulation of nonlabor resources, human capital, and productive knowledge somehow caught up to this very rapid rate of population growth, for real wages in virtually all regions of the world increased, except recently in subSaharan Africa and Bangladesh. Diminishing returns to labor induced by rapid population growth must have been fully offset by capital formation and growth in productive knowledge. Although the forecast of a Malthusian trap which would drive wages back to a subsistence level does not fit the historical facts, neither does the available data contradict a tendency for rapid population growth, other things equal, to reduce real wages. The other things which have not remained equal since 1750 in Europe and since 1950 in the low income world may be viewed two ways. They may be interpreted as economies of output scale in nations and world markets, and as economies of population density in providing transportation, communication, and irrigation infrastructures (Boserup, 1965, 1981; Simon, 1977), or they may be seen as due to investment activities that occurred relatively independently of population growth, such as expenditures on mass education, scientific research, and application of new knowledge to productive technology (T. W. Schultz, 1961; Denison, 1962; Kuznets, 1966).

If the former viewpoint of Boserup (1965) is adopted, then the economies of population density may today outweigh the diminishing returns to labor, and Malthus's long run conclusion must be stood on its head; population growth may trigger economic development as conventionally measured in terms of an increase in per capita income. Alternatively, population pressures on the fixed stock of land may have been offset by the accumulating returns from independent investments in clearing marginal land, draining and improving the fertility of existing land, investing in reproducible physical capital, adding to the average skill level of workers, and producing more knowledge for workers to use. In this latter case, population growth may remain a Malthusian drag on economic growth per head, but apparently not an insurmountable barrier to modern economic growth in the recent, and possibly exceptional, historical period.

Distinguishing between these two different interpretations of our era is complicated further if fertility is an endogenous choice of families. In particular, if fertility responds appreciably to changes in opportunities and adapts to the constraints faced by the individual, this microeconomic adjustment of fertility must be treated simultaneously in a modified macroeconomic Malthusian model of population growth and economic development. To estimate the role of Malthus's diminishing returns to labor or the effect of Boserup's economies of population density, a methodology is required that will hold constant the individual's optimizing behavior that is likely to affect fertility and thereby influence population growth. Assume, for example, that individuals "demand" fewer children when wages rise. Aggregate time series may then reveal that in periods of slow population growth wages increase relatively rapidly, as they did in England from 1250 to 1650 (Lee, 1980). Is this evidence to be viewed as consistent with Malthus's macroeconomics diminishing

returns to labor, or is it confirmation of the microeconomic hypothesis that desired fertility is a negative function of wages? To disentangle the critical micro and macro mechanisms on which the Malthusian model rests requires the specification of a more complete microeconomic model of the determinants of fertility (and perhaps mortality) whose parameters can be identified separately from the aggregate consequences of diminishing returns to population growth and increasing returns to population density. The next section reviews more comprehensive microeconomic models of household production and demand that are used today to account empirically for variation in demographic behavior in developing countries.

III. MICRO FOUNDATIONS FOR HOUSEHOLD DEMOGRAPHIC BEHAVIOR

Economic and demographic behavior of families and households are increasingly studied by economists. Their models of allocational choice are diverse, emphasizing particular conceptual or econometric problems, often at the cost of neglecting other issues. Yet there are common features of these investigations. First, the traditional money income budget constraint is replaced by a time budget constraint, endogenizing the allocation of time between market labor supply and nonmarket activity, especially for women. Second, demographic and economic behavior is assumed to depend on a disaggregated reckoning of the household's stocks of human and physical capital. Labor supply is particularly heterogeneous in its productive attributes and alternative uses, and must be valued distinctly for each family member by its marginal opportunity cost. Physical and human capital are costly to transform from one function to another, but, nonetheless, these barriers to adjustment of the asset portfolio of the household are gradually overcome, and adjustments toward equalizing returns across assets occur with time and as new

productive opportunities are realized. Separate labor supply equations for husband, wife, and children are a minimum accommodation to the existence of the multiperson family where the nuclear family coordinates individual interests. Yet the family takes on a variety of extensive forms and many models may be needed 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).

Third, the long-term nature of life-cycle commitments in labor market training, migration, marriage, children, and savings for retirement focuses economic analysis primarily on permanent and potentially foreseen life cycle conditions, in contrast to transitory and unexpected developments. 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 realistic to view these life cycle outcomes as occurring simultaneously. In other words, the unexplained deviations in specific outcomes will tend to be correlated across outcomes within households. These outcomes are most simply represented as a static single-period life cycle choice processes, and then complications added as they seem to clarify particular phenomena. Occasionally observations on entirely unforeseen events are exploited to understand dynamic adjustment behavior, but even in these special situations it is not generally possible to delineate how a sequence of decisions and outcomes feed back on themselves. An eventual goal of research in this field of economics, as in many others, is to integrate both evidence on long run tendencies for households to optimize their behavior and information on the stimuli to and constraints on short run adjustment to unexpected realizations. In the current household context, these

unexpected stochastic shocks may arise from either the salient biological processes, such as those culminating in births and deaths, or the unforeseen and hence exogenous changes in other more traditional economic constraints, such as prices, wages, and weather.

Estimation of household demand systems were first based on the assumption that a block recursive stochastic structure represented adequately time-ordered behavior of the individual and household (Wold, 1964). Path analysis was analogously justified in the sociological study of the unfolding of life cycle ordered events (Duncan, 1966): But this simplifying assumption--that errors are independent across demand equations--is not generally justified in the study of long-run household life cycle behavior. For example, how tenable is the assumption that the number of children a woman has is an exogenous determinant of her labor supply behavior, even though the fertility decision occurred in the past and the labor supply decision continues to accommodate current developments. Preferences of consumers and biological traits relevant to household production possibilities, such as fertility, are persistent and imperfectly measured. They are, therefore, impounded in statistical errors to equations accounting for many forms of demographic and economic behavior over the life cycle. Identification of recursive structures are thus far from trivial in the household demand framework. Even when plausibly approached as a simultaneous equation system or a multistate duration model, it is very often impossible to identify the structural parameters that in principle may relate one endogenous outcome of the household sector to another endogenous outcome, such as the presumed effect of fertility on a mother's market labor supply.

Fourth, as studies increasingly adopt a common specification of endogenous choice variables determined in the household sector, parallel reduced-form

equations are estimated to explain each of these household economic and demographic outcomes in terms of the same list of household endowments, skills, knowledge, and local input and output prices, wages, public sector services, and environmental factors such as climate. Thus, an empirical body of knowledge is accumulating on which to generalize about the size of specific reduced-form parameters. Estimates of the parameters describing household production technology may also exhibit sufficient stability in such areas as reproduction, nutrition or health to encourage replication efforts (Rosenzweig and Schultz, 1986). Progress in the systematic accumulation of knowledge on the regularities of these response and technology parameters over time and across societies can be expected in the future, now that a common analytical framework is being more widely adopted.

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, this form of analytical outline helps to focus subsequent discussion, and illustrate how empirical research has progressed by simplifying and restricting the characteristics of the consumer's utility function (i.e. preferences) or the household production relations (i.e. technology), and where empirical regularities can be relied upon despite the inability of theory alone to prescribe those regularities.

The General Household Demand Framework

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

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

Each of these arguments of the utility function may be thought of as produced in the home with market goods and the nonmarket time, potentially that of husband, wife, and children:

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

where $i = C, E, H, L_h, L_w, L_c$ and S , and μ_i represents a couple-specific trait that influences production possibilities and is partially known to the couple, though it is not controlled by them. An example might be exogenous genetic or environmental factors that affect the family's production of child health, or fecundity that affects the capacity of a couple to bear children (Rosenzweig and Schultz, 1983b, 1985a).

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 later be relaxed with little added complexity (Rosenzweig and Schultz, 1983). Together with time supplied to the market labor force, t_{jm} , the alternative uses of time sum to an exogenously given time budget constraint:

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

where $j = h, w, c$ and $i = C, E, H, L_h, L_w, L_c, S$. Market income is equal to the lifetime or permanent wage rate, w_j , received by each member of the family, times their market labor supply, plus income from nonhuman capital endowments

of husband and wife, V_h and V_w . For simplicity, children are assumed to acquire property only as adults.

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

If the household production functions (2) exhibit constant returns to scale, all family member work some time in the market, i.e. $t_{jm} > 0$, full income can be viewed as an exogenous budget constraint, and the shadow prices of the household commodities (i.e. the opportunity value of the market goods and household member's time inputs used to produce a unit of the commodity) are then fixed by the market 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).^{4/} If family members withdraw entirely from the market labor force, an interior solution does not occur, and the model takes on added complexity (Heckman, 1987). Because market income in this framework is clearly endogenous, reflecting the family market labor supply decisions, full income is designed to replace market income by a new exogenous resource constraint. But even in this case, the number of children or the composition of the family is endogenous, for it reflects past demographic behavior. The concept of full income, F , thus contains ambiguities for empirical analyses of life cycle behavior (Gronau, 1984, 1985), but is nonetheless heuristically valuable:

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

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, 1984; Smith, 1980).^{5/} This reliance on a well-behaved nuclear family utility function appears to many social scientists to be a limitation of the conceptual framework. In practice, however, economic demographers can always reframe the decision problem 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). 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." Implementing these individualistic approaches to family behavior underscores the desirability, whenever possible, to know customs 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 empirically V_h and V_w influence family demands in the same way, then there is no empirical case for the distinction, and the family utility maximizing model that generally combines V_w and V_h is the more parsimonious representation of household demand behavior (McElroy and Horney, 1978, 1987).

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

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

where P is a vector of prices of market goods and public services available to the household, M is the vector of exogenous household-specific traits, μ 's, that affect household's production of Z 's, and e_i are random disturbances that embody the effects of the couple's preferences and serially uncorrelated errors in measurement, specification and technology.

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

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

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

where f_i and g_{ij} are also serially 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. The inability of the researcher to observe typically the productive traits of the couple, M , 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 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).

IV. Empirical Applications of the Household Demand Framework

To proceed further in the analysis of such a general household demand model restrictions and simplifications must be adopted. The objective is to direct attention on the more important constraints on choice in a particular setting and 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 in a variety of directions. Rosenzweig and Evenson (1977) focus on three outcomes that can be measured from the 1961 Indian census; surviving fertility (children age 5 to 9 per woman of child bearing age), child school enrollment rates, and child labor force participation rates. These outcomes 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 considerable guidance. For example, the number of children is widely assumed to be a substitute for child schooling and child leisure, while schooling and child leisure are themselves often viewed as complements. Women are generally assumed to contribute time to the "production" of children and the other home commodity (S), whereas children allocate their own time among schooling, labor force work, and leisure. Since only uncompensated price and wage effects are ultimately observed, it is assumed by Rosenzweig and Evenson 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 assure that the own-wage effects are reinforced by cross-wage effects, and that income effects do not outweigh the predictable compensated wage effects. Exogenously higher women's wages should then be associated theoretically 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. Further more controversial restrictions are 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 child work and schooling decisions is that they can be analyzed in most data separately for boys and girls, thereby shedding light on substitution possibilities among these types of family labor and intrahousehold resource allocations (see also Rosenzweig and Schultz, 1982).

Confirmation of reduced-form partial associations is complicated if data refer only to regional level averages, where the aggregate supply of child and female labor is likely to respond to, and dampen (or reverse), observed variation in wages induced by demand factors. In other words, aggregate labor supply responses can be treated as exogenous when analysis occurs at the household or individual level, and life cycle market wages are thus exogenous. But at the aggregate regional level, wages also become endogenous. Consequently, Rosenzweig and Evenson (1977) instrumented their child wage series by rainfall, irrigation, and nonfarm employment opportunities, but persist in treating their female wage series as exogenous.^{6/} Many of the behavioral patterns implied 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 are empirically found to be positively associated in rural India with surviving fertility and negatively associated with child schooling levels. Most of these patterns are obtained in other studies of fertility in low income agricultural populations (Schultz, 1976; Mueller, 1984).

Wage rates of individual family members play an important role as the opportunity cost of time in explaining many forms of household economic and demographic behavior. Life cycle wages, as an exogenous constraint on life time choices, are difficult to measure, however, because current wages become endogenous over the life cycle as they reflect prior investments in specialized skills, and because current wages are not available for all persons if they currently work only in the home or work as a self-employed or family worker without knowing precisely the marginal product of their labor. Both problems appear to be more serious for inferring the wage of women rather 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 distinctly productive in market work. A standard 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 past time allocation, career, and fertility decisions, etc. The specification of these instrumental wage equations relies heavily on the human capital earnings function pioneered by Mincer (1974), except that the dependent variable is the logarithm of the wage rate and measures of labor supply, such as weeks worked, are strictly excluded from the instruments because they are 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, holding post schooling experience artificially constant at, say, ten years to approximate the overtaking point (Mincer, 1974, p. 93).

However, the instrumental wage equation may nonetheless be biased by the limitation of the estimation to a sample of wage earners and not all those for whom wages must be imputed. This potential sample selection bias can be appraised and corrected by methods described by Heckman (1979) and illustrated with clarity for men (Anderson, 1982) and women (Griffin, 1986) in the context of understanding household demand systems in low income countries. There are many econometric issues that arise with such wage imputation schemes. Multiple sources of sample selection may be present, such as nonreporting among wage earners, (see Behrman and Wolfe, forthcoming), and if the researcher understands what causes the different types of selection, each selection rule can be identified by distinct variables and estimated and corrected. But reliance on functional form alone (i.e. the distribution of the error terms) to achieve identification in such selection problems may not be sufficient to improve empirical results. Economic or institutional knowledge of the selection mechanisms is helpful in dealing with this ever present econometric problem in survey research.

Interdependencies among Endogenous Variables

A series of earlier studies at the Rand Corporation of interregional variation in household demographic and economic behavior analyzed jointly household outcomes such as age at marriage, proportion legally and consensually married, cumulative fertility, child-woman ratios, female and child labor force

participation rates, internal migration, the sex ratio of the adult population, and, finally family market income (DaVanzo, 1971; Maurer et al., 1973; Nerlove and Schultz, 1970; Schultz, 1971, 1972, 1981). These studies provided the first econometric evidence in low income countries that increased women's education and wage rates helped to account for women's increased participation in the modern labor force, decreased or delayed marriage, and reduced fertility. Census and survey data from Puerto Rico, Taiwan, Egypt, Philippines, Chile and Thailand were analyzed. These investigations also sought to go beyond reduced-form estimates, and to measure how various endogenous variables (Z 's and t 's) affect each other. A priori identification restrictions were exploited across structural behavioral relationships. It has become increasingly clear that the timing of marriage, fertility, and family labor supply behavior are jointly determined, but it remains difficult to justify the exclusion restrictions needed to identify statistically how one of these outcomes may affect the others. Hence, the growing reticence of economists to assess the consequences of population growth or the benefits of a fertility decline.

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, such as the effect of a decline in fertility on the average level of child schooling. Any of the reduced-form determinants of one outcome in equation (6) may be an important determinant in other reduced-form equations. 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 is the occurrence of twins, which can then be related to other adjustments in the household's pattern of consumption and behavior.^{1/} 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 demand response to an exogenous fertility supply shock (i.e. twins) can be interpreted as the following:

$$\partial E / \partial \bar{C} = (\partial E / \partial \pi_c)_{\bar{u}} / (\partial C / \partial \pi_c)_{\bar{u}} \quad (9)$$

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 (see Rosenzweig and Wolpin, 1980a). Since the compensated own-price effect is negative, the negative sign observed in India for $\partial E / \partial \bar{C}$ from twins implies that children and child schooling are substitutes, i.e. $(\partial E / \partial \pi_c)_{\bar{u}} > 0$. Without further restrictions on the cofactors of the general demand model, it is not possible to discriminate between the interaction of child quality (schooling) and quantity in the full income constraint, as proposed by Becker and Lewis (1974), and the conventional interpretation that child quality and quantity are viewed by parents in their utility function (1) as substitutes.

A parallel analysis of the effect of twins on mother's market labor supply behavior in the U.S. is also reported by Rosenzweig and Wolpin (1980b). Again the occurrence of this natural experiment, twins, identifies the consequences of an exogenous supply shock to fertility as it impacts on other household demand (i.e. labor supply) behavior. It should be noted, however, that these "twin" based estimates of fertility effects do not provide an appropriate measure of how other demands would adjust to general changes in fertility, because general changes in fertility embody the demands of couples adjusting to changes in prices, wages and technology that will be correlated with their other demands. The occurrence of twins is presumably independent of parent preferences or these changing constraints that affect household demands.

One major demographic trend is often interpreted as primarily due 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, 1985). 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 unanticipated shift in the biological "supply" of children (Schultz, 1980). The behavioral adjustment of parents to this development may then be analogous to that measured in the twin statistical studies.

It is more realistic to recognize that much of a decline in child mortality over time and variation in child mortality in the cross section is explained by the 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. To estimate only the response of parent fertility to exogenous child mortality, an identifying restriction must be imposed. The critical issue is what exogenous factor affects child mortality but does not have a direct influence on parent reproductive goals? The choice of such identification restrictions may in some circumstances be dictated by a well founded theory or knowledge of the technology of the relevant processes, but more often the identifying restriction statistically imposed is relatively

arbitrary. Consequently, the estimates thus obtained are likely to be misleading.^{8/}

In an analysis of fertility based on the 1973 Colombian Census public use sample, Rosenzweig and Schultz (1982) exploit municipal variation in climate, transportation infrastructure, and malaria control programs to account for exogenous regional differences in only child mortality. Based on these identifying restrictions, they estimate that the fertility response of parents offsets about one-third of the climate and malaria related variation in child mortality among urban women.^{9/} Olsen (1980) employing a different statistical methodology found replacement responses to exogenous child mortality in Colombia in 1973 on the order of .2, but this is a lower bound to the total parental response to mortality, because he could not distinguish what portion of the residual correlation might be attributable to an insurance effect of parent "hoarding" or having more births than wanted (in a mortality-free environment) in anticipation of regional levels of child mortality. In a subsequent study, he estimated the hoarding effect of about .14, implying a total response of Colombian fertility to child mortality on the order of .35 (Olsen, 1987).

Estimating Household Production Functions

Another methodological approach for measuring the responsiveness of household demands to exogenous variation in demographic variables involves explicitly estimating more of the structure of the general model to isolate variation in these demographic outcomes that cannot be attributed to behavior and therefore can be viewed as exogenous. First, the reduced-form demand equations, (7) and (8), are estimated for the inputs to the household production function. Individual predictions of input demands based on these

estimated equations then permit the estimation of the household production functions (2) parameters by instrumental variable techniques. These estimates are consistent, because the instruments--prices, programs, wages, and family wealth--can be assumed independent of the production trait, μ . Based on the estimates of the technical production parameters to (2), expected outcomes, Z_i^e , are calculated, given the couples's actual input behavior. The deviation of the actual behavioral outcome from that which is expected, $Z_i - Z_i^e$, is then a measure, albeit with error, of the couple-specific trait, μ_i . Data on individual outcomes over time should facilitate more precise 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 infant mortality, can then be employed to explain subsequent fertility (Rosenzweig and Schultz, 1983a). This roundabout procedure provides another way to estimate the reproductive replacement response of parents to exogenous variation in child mortality, i.e. a biological shock to child health.

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, 1985a). Technically unexplained deviations in a couple's reproductive performance over time 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 (Rosenzweig and Schultz, 1985a, 1985b).

The primary conclusion drawn from these estimations of household production models is that a priori structure must be imposed on the household demand model

to get behind the reduced-form equations (7), (8), and (9). To estimate the underlying household production-demand structure requires a method to remove the bias caused by heterogeneity in the couple-specific traits, μ_i . 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 household production processes, such as those underlying 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 readily observed endogenous factor determining conception rates in modern societies, the estimation of reproduction functions is a promising approach to integrate biological and behavioral factors in the study of fertility, a frequently noted goal of demographers (Easterlin, Pollak, and Wachter, 1980).^{10/}

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 investment, insurance arrangements, 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 from the vagaries of agriculture or urban business cycles. Little empirical analysis at the household level has yet been undertaken to test the implications of these theories.

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 and 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 size (World Bank, 1984). Here again to evaluate the consequences of fertility, one must 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 retirement at the end of the life cycle? What would be the consequence for household savings, if the increase in surviving fertility were due to exogenous eradication of endemic and epidemic childhood diseases that left more children living? These are hard questions to answer that will require unusually detailed economic and demographic information at the extended household level. But given the centrality of the savings relationship in hypothesized models of demographic and economic development, I would anticipate more research in the future within the household demand framework will analyze the composition and level of savings.

Another way to approach these changes in investments in children, fertility, and savings is to construct a general equilibrium system in which prices are determined endogenously within the model. A general equilibrium approach to the macro economic problems of growth, investment and consumption over time has been formulated around a microeconomic theory of exchange between overlapping generations. Although the general framework dates from Samuelson (1958), the redirection of this model from monetary phenomena to the analysis

of the demographic-economic transition is recent. This general equilibrium growth framework provides a suitable, if simplified, setting in which to also treat the fertility decision as endogenous. Eckstein and Wolpin (1982) show that as capital accumulates and wage rates increase, there is a substitution 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, of course, 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 and might plausibly first increase and then decrease as the labor share of output increases with the onset of modern economic growth. Thus, Malthus's 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.

Even though economic theory cannot tell us much about the tradeoff in parent preferences between these central dimensions of the family formation process, empirical analysis of various public policies, wage developments, and price changes that are relatively important to the family unit should inform us of certain tradeoffs in demand behavior, at least in those cases where income effects are small and can therefore be neglected.^{11/} Cross-price effects would be more influential when the forms of family behavior are closely related. For example, subsidized birth control programs are observed to reduce fertility because they raise the effective cost of children, and they also may increase the schooling (or quality) of children. More accessible or lower priced schools increase school enrollments (quality) and may also be associated with reduced fertility. Reinforcing cross-program effects of this type have been confirmed in several countries and are reviewed in the next section. Measures of the

effectiveness of any one of these programs based only on its direct objective would, in this case, overlook synergistic side effects that may be appropriately attributed to these reinforcing family-oriented welfare programs.

Policy Analysis

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 in a manner that is independent of individual preferences or unobserved environmental factors (Schultz, 1971). Program services may substitute for or complement other consumption and investment activities which are distinct from those targeted by the program. Thus, cross-program effects may be important to the extent that a variety of household commodities are highly complementary or close substitutes for one another. As noted above, the household demand literature has confirmed that child health services, schooling services, and family planning services often exert reinforcing cross-price effects on child health, child educational attainment, and decreased fertility. For example, Rosenzweig and Schultz (1982) report the local availability of clinics and hospital beds and family planning expenditures per capita are partially associated with both 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 in rural India cross-program effects on fertility, child mortality and schooling, and find reinforcing program effects from family planning clinics, dispensaries, hospitals, and secondary schools.

Rosenzweig and Wolpin (1984) 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 have access to cross-sectional information from repeated rounds of the Laguna Survey. Alternative estimates of the effects of programs on these stock-like measures of child health (viz. age standardized height and weight) are based on three statistical specifications of the same reduced-form equation. When community fixed-effects and child fixed-effects are introduced, bias due to omitted time-invariant community and individual variables is thereby eliminated. But the fixed-effect estimates are also very unstable and imprecise, probably because the fixed-effect specification relies heavily on 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". Although the promise of longitudinal data to illuminate the behavioral effects of changes in economic constraints and program interventions is indeed great, means must be found to exploit the panel features of such powerful data without sacrificing the valid 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 (Nerlove and Schultz, 1970). The problems and promise of panel data remain at the top of the agenda of research in economic demography (Ashenfelter, Deaton, and Solon, 1986).

V. PERSPECTIVES ON POPULATION POLICY

The purpose of this paper is to assess how microeconomic research on household behavior has in the last twenty years changed our understanding of demographic and economic factors associated with the development process. On the one hand, we are not much closer to knowing under what conditions the "grand dynamics" of Malthus' model of aggregate economic and demographic change

are applicable to low income countries and when these countries therefore sacrifice growth in per capita income by not expending public resources to slow their rate of population growth. Because fertility is increasingly viewed as a household decision variable that responds to changing private opportunities and endowments, a policy to slow population growth beyond what private decisions would otherwise accomplish deprives some individuals of an important benefit--their own children. There is scant evidence of the aggregate gains from slowing of population growth that could be used to compensate individuals whose demands for children would thereby be rationed.

On the other hand, the new economic demography has established a coherent agenda for research that is sufficiently guided by economic theory and econometric tools that the collection in low income countries of household and community data and its analysis has accelerated. Among the apparent determinants of fertility and mortality are family planning and child health programs, local schools, and infrastructural investments that increase the population's access to these services. There is reason to believe that public extension programs in family planning, child and maternal health, and the schooling of girls can affect substantially fertility and child mortality levels in many parts of the world. There is a strong rationale for more public extension activity in these areas, including at least initially heavy subsidies for contraceptive and health supplies and services, targeted to those populations with the least capacity, both economic and educational, to seek out and use the new technologies available in these fields. As with public sector support for agricultural extension programs to hasten the spread of new productive technologies among the many small farmers of the world, new birth control and public health technologies need to be disseminated widely in a variety of forms and combined with education, not propaganda, if the social

barriers erected by past educational policies are not to distort the diffusion of these techniques among all classes of society.

A serious misapprehension of the empirical record of the demographic transition and concurrent developments is that fertility and population growth rates mechanically decline as per capita income increases (Chenery and Syrquin, 1975 p. 47). A principal insight of the economic model of household production and consumption is that where children require substantial time of parents, and particularly of females, it is to be expected that the opportunity cost of children will increase and fertility will decrease as the market wage opportunities available to women improve. Increases in men's wages will not have a comparable effect depressing fertility, and may in fact add to the private demands for children in a traditional agricultural society. In these settings income and substitution effects may even pull together to increase birth rates. Correspondingly, increasing the value and productivity of land and nonhuman capital can add to fertility demands, unless concurrent technological changes and labor mobility increase the returns to parents of investing in their children's schooling and migration. It is not reasonable to assume that economic development must promote a decline in fertility; this widely held view ignores the theoretical logic of the household demand framework and the growing body of supporting empirical evidence that it is not merely the level of per capita income that affects fertility, but the structure of increases in personal income that occurs with development that determines desired fertility. Achieving more equal educational investments in girls and boys is one obvious route to facilitate a more rapid decline in fertility, because it is associated with lower child mortality and decreased demands for fertility. Investments that augment private returns on human capital are also likely to raise incomes and lower birth rates. Investments in land development

and irrigation projects are less likely to be associated with the same fertility reducing consequences, though these investments may be fully warranted in terms of their social rates of return. The point that has escaped the attention of some policymakers is that the broader structure of development investments can affect the rate of decline of fertility for a given increase in per capita income. Libya and Hong Kong, for example, might illustrate this distinction, if data were available.

Finally, the new economic demography has clarified the innate problems of measuring the effects of one family choice or behavioral outcome on another. For example, when the inverse association between family size and average child education is discussed in population surveys (World Bank, 1984; National Academy of Sciences, 1986), insufficient emphasis is given to the fact that this salient pattern is not a causal relationship on which policy can operate. It is rather an association between jointly determined family decisions that may reflect bidirectional causation, unobserved variables, and probably heterogeneity in preferences of the population. Unable to use economic theory to justify identifying restrictions that are required to estimate these structural relationships among family choice variables, and rarely able to trace out responses to random shocks from natural experiments, such as is possible with twins, many household researchers have refocused their analysis on unrestricted reduced form equations from the household production-demand system. In other words, they no longer try to disentangle how endogenous family choice outcomes interact, such as fertility and child education. The reduced form equations for household demographic and economic behavior can still provide a consistent basis for evaluating many programs and policy interventions. Indeed, reduced form estimates can also assess how the distribution of benefits from these programs differ by exogenous population groups, such as by education or by race (Schultz, 1984).

In sum, microeconomic demand studies of household behavior provide a framework that has not yet provided general measures of the aggregate or individual consequences of population growth, but this framework has provided a rationale for voluntary family planning as a technology extension activity that is justifiably undertaken by the public sector. The framework also provides a sophisticated statistical basis for evaluating the effectiveness of family planning and other family welfare programs.

VI. CONCLUSIONS

Several developments have recently led economists to qualify their views that the benefits of slowing population growth clearly outweigh the costs. Fertility is no longer seen as a natural force that is out of control in the world. Though it is a biologically constrained outcome, fertility is also widely regulated by traditional and increasingly modern means of birth control to advance the private interests of individuals and families. Reproductive goals of couples in low income societies are less rigid than feared by the demographers and economists who first fathomed the magnitude of the contemporary acceleration in population growth (Notestein, 1945). Marriage patterns and marital birth rates can both change rapidly and voluntarily, with the implication that private demands for modern, more effective means of birth control can also expand rapidly. These changes in fertility goals need not occur so as to offset precisely the decrease in mortality. Homeostatic tendencies of fertility to adjust to child mortality appear to be present, but they are difficult to quantify precisely because both outcomes are endogenous within the family production-consumption system. The family demand model implies that certain price, life cycle wage, and program variables are likely to play a pivotal role in modifying levels of reproductive demands, because

these variables change the opportunity cost of time and goods needed to rear children, or affect the productive benefits of child labor versus more educated adult labor, or influence the cost and inconvenience of available technologies of birth control. But the economic model cannot generally prescribe how parents ultimately view children, nor which production and consumption activities compete with children for parent time and other resources. Empirical studies of household demographic and economic behavior confirm that these exogenous conditioning variables not only appear to influence fertility as anticipated, but they also appear to affect parent investments in their children's schooling and health and many other coordinated allocational choices in the household sector. From these empirical regularities, it should be possible to discern whether particular commodities and activities subsidized through public sector programs tend to complement large families or substitute for additional children. If a society determines that it wishes to encourage or discourage fertility, this information may be considered in the formulation of public policy.

At the macroeconomic level much less research has quantified the aggregate consequences of variation in population growth. The expectations of Malthus that rapid population growth would depress real wages and increase income inequalities are not confirmed by a casual inspection of the recent historical record (Kuznets, 1967). Nor have quantitative estimates of Boserup's economies of population density been confirmed by widely accepted methods. This leaves policy makers unarmed with empirical economic evidence to support their general endorsements of population control policies as a means to accelerate economic development.

Most of the evidence cited in the past to demonstrate the negative consequences of rapid population growth is, with hindsight, simple statistical

associations between unfavorable family welfare outcomes and fertility, both of which tend to be endogenous variables determined jointly within the household demand model. For instance, large families have more malnutrition, more mortality, less schooled children, etc. (National Academy of Sciences, 1971). The covariation of such endogenous household variables does not provide a satisfactory basis for inferring causal influence in either direction. The empirical analysis that would clarify the benefits of slowing population growth must be derived within the broader perspective of the family household demand framework outlined above.

Having set aside the global question of the consequences of population growth as not yet answered, development economists can still proceed to seek answers to more appropriately framed questions, such as the effectiveness of public programs and market developments to change the health, education and fertility of people. Empirical estimates can be calculated representing how local public investments in the number and quality of schools, public health programs, family planning programs, agricultural research and extension programs influence a host of household behavioral outcomes, including, but not limited to, fertility and mortality. It is the synergistic potential of some of these family-oriented human capital investment and development programs that needs to be quantitatively assessed further. The methods as illustrated above are available for this type of research, although they have certain limitations.^{12/}

An increasing number of low income countries are investing in the collection of a broad range of economic and demographic survey data collected from households and matched to local information on average prices, wages, and public programs. These data can be directed to answering important policy questions of program effectiveness and the personal distribution of benefits

from these public sector activities. Only as these facts are assembled from a sufficient range of environments throughout the world will it be appropriate to venture generalizations. I suspect, however, that the empirical regularities that these investigations will uncover will be no less remarkable than those Engel (1895) found in his early studies of the expenditure shares of workers that established the subsequent direction for research on consumer demands.

NOTES

1/I shall survey more closely the work I know better. This may give special prominence to the research of economists associated with the Yale Economic Growth Center. Such an imbalance may perhaps be overlooked for a conference marking the Center's 25th anniversary. Regardless, there is a continuity and consistency to the research agenda pursued in economic demography at the Center that provides the focus for this survey.

2/Changes in real wages are due to two underlying series: nominal wage rates and on prices of basic foodgrains. Most of the time series variation is in food prices, and therefore in settings where both are available, analysis of the price series alone or real wages yields similar estimates of their effect on vital rates. Here I refer to studies that focus on either food prices or real wages. English mortality appears to have been more responsive to food prices in 1544-1640 than it was in subsequent years viz. 1641-1745 and 1746-1834 (Lee, 1981). This may have reflected the tendency for English wages to increase over time above subsistence or for other institutions to partially shelter the poor from the life threatening force of food shortages (Fogel, 1986). Smaller response rates are estimated by Richards (1984) for France, 1740-1909, using approximately the same distributed lag methodology as followed by Lee. Bengtsson (1984) found a closer relationship between harvest-price cycles and mortality in Southern Sweden in the early 19th century than he did in the 18th century. The reason offered for the increased sensitivity is the diminished importance of epidemic disease in the 19th century. A study by Eckstein et al. (1984) of Swedish national data from 1750 to 1860, based on auto vector regression, found strong evidence of wage induced fluctuations in mortality, particularly among persons over the age of one.

3/Carlsson (1970) illustrated this point with aggregate time series during the 19th century. Ohlin's (1955) thesis found similar evidence much earlier in Sweden and Finland. Lee (1981) shows in England from 1548-1834 that less than half of the incremental births associated with swings in marriage rates must be due to changes in marital fertility rates among women already married. In fact, in southern Sweden at the end of the 18th century marriages are not strongly related to harvest cycles. Marital fertility and the harvest cycle are, however, highly correlated in 19th century Sweden (Bengtsson, 1984).

4/Criticism of the household production approach often notes the fact that in a less specialized home production environment, time is frequently employed to advance several activities at one time, such as the mother's capacity to care for her children while doing some housework, or tending some own account business pursuits. Variable returns to scale are also noted in the household. The properties of household technology that Becker postulated are required to preserve the "adding up" character of full income and the exogeneity of shadow prices. But neither shadow prices or full income are generally observed or analytically needed except to compare welfare in the latter case, which we know is ambiguous anyway with variation in family composition (Gronau, 1985; Deaton and Muellbauer, 1985). Another feature ignored is the public-good aspect of some commodities. Children may be enjoyed by both parents without reducing either's pleasure. How these restrictions on technology actually distort analysis has not been demonstrated, though instances can certainly be found (Schultz, 1981; Gronau, 1984).

⁵/Aside 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. 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, the standard household model for this reason 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. This restriction of the family demand theory could not be empirically rejected with U.S. data by McElroy and Horney (1987) who developed a bargaining model of the family designed to explain consumption behavior of U.S. couples. They nest within this bargaining model the neoclassical family demand model. Even if one were to reject the family or household integrated demand model, individual consumption and time allocation behavior would nonetheless depend on the same reduced-form arguments (equations 6 and 7 below). See Rosenzweig and Schultz, 1984.

⁶/A cross regional analysis of Sweden from 1850 to 1910 identifies aggregate demand induced changes in adult female and male agricultural wages that help to explain the decline in fertility. The exogenous instruments for the wage series are regional relative output prices and nonfarm employment opportunities.

Female wage opportunities are associated with a fourth of the decline in fertility, and another fourth is associated with the decline in child mortality. Increases in male wages shift the age-pattern of fertility toward an earlier age, but do not noticeably affect the level of fertility across all ages combined (Schultz, 1985).

7/ The distribution of births by sex is another biologically exogenous outcome that may in turn influence subsequent fertility and other household demand choices to the extent that parents do not regard boys and girls as perfect substitutes.

8/ An even more distressing practice is for the same researcher in companion studies, often on the same data, to change core working assumptions, such as to shift without explanation from treating one household variable as endogenous in one study to being an exogenous instrument in another study. Such practices make the sum of research add up to less than the parts.

9/ The net reproduction rate (NRR) is the average number of female offspring per woman who themselves reach the mean age of childbearing T . In the long-run, such a stable population increases at the annual rate of r :

$$r = \log(\text{NRR})/T.$$

The empirical question is how does the number of births respond to a change in the death rate for children (to say age 25). If the adjustment were fully offsetting, then $dC/dD = 1$, and NRR would not vary with the decline in child deaths, D . Estimates of this derivative from intercountry comparisons for

women of various ages yields estimates of about unity, but this ignores covariates that influence both fertility and child mortality, such as mother's education, so it is undoubtedly upward biased (Schultz, 1981). Within countries, controlling for household economic characteristics, family estimates of response patterns range from .5 to 1.0. But as the text discusses, there is still likely to be an upward bias in these estimates from unobservables that will tend to have parallel effects on birth and death rates in the cross section. Thus, the need to specify a convincing exclusionary restriction to identify the effect of child mortality on fertility. These more restrictive exercises yield response rates on the order of 1/4 to 1/3.

10/Easterlin and Crimmins (1985) also propose a statistical methodology for disentangling biological and behavioral factors determining fertility, but their procedures can be quite misleading as elaborated elsewhere (see Schultz, 1986).

11/For example, if a family planning clinic lowers fertility and child mortality and raises school enrollment rates in a locality, then a school should increase school enrollment rates and symmetrically lower fertility and child mortality, while child health clinics would lower child mortality and fertility while raising school enrollment rates. Income effects in these cases would raise schooling and lower mortality, but might work to increase fertility, weakening some of the above anticipated program effects on fertility.

12/A limitation of the framework outlined in this paper is that it is static and treats the life cycle as a single period. It is desirable to characterize

the choice problem as one of dynamic optimization in an uncertain environment. Births and deaths are uncertain events and their timing may be important to understand some forms of household behavior. To model these features within the household life cycle fertility framework, in a general but estimable form, is attractive. It tends to impose, however, other limitations such as restricting the number of variables that can be treated as endogenous. The computational burden of the estimation methods also effectively restricts the number of conditioning variables that can be considered and the size of sample consulted. Nonetheless, with the decreasing cost of computation this area of research is active and innovative (Wolpin, 1984). Studies have analyzed fertility and child mortality in Malaysia (Olsen and Wolpin, 1983; Wolpin, 1984) and Costa Rica (Newman, 1983), and fertility and female labor supply in the United States (Vijverberg, 1984).

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