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ABSTRACT

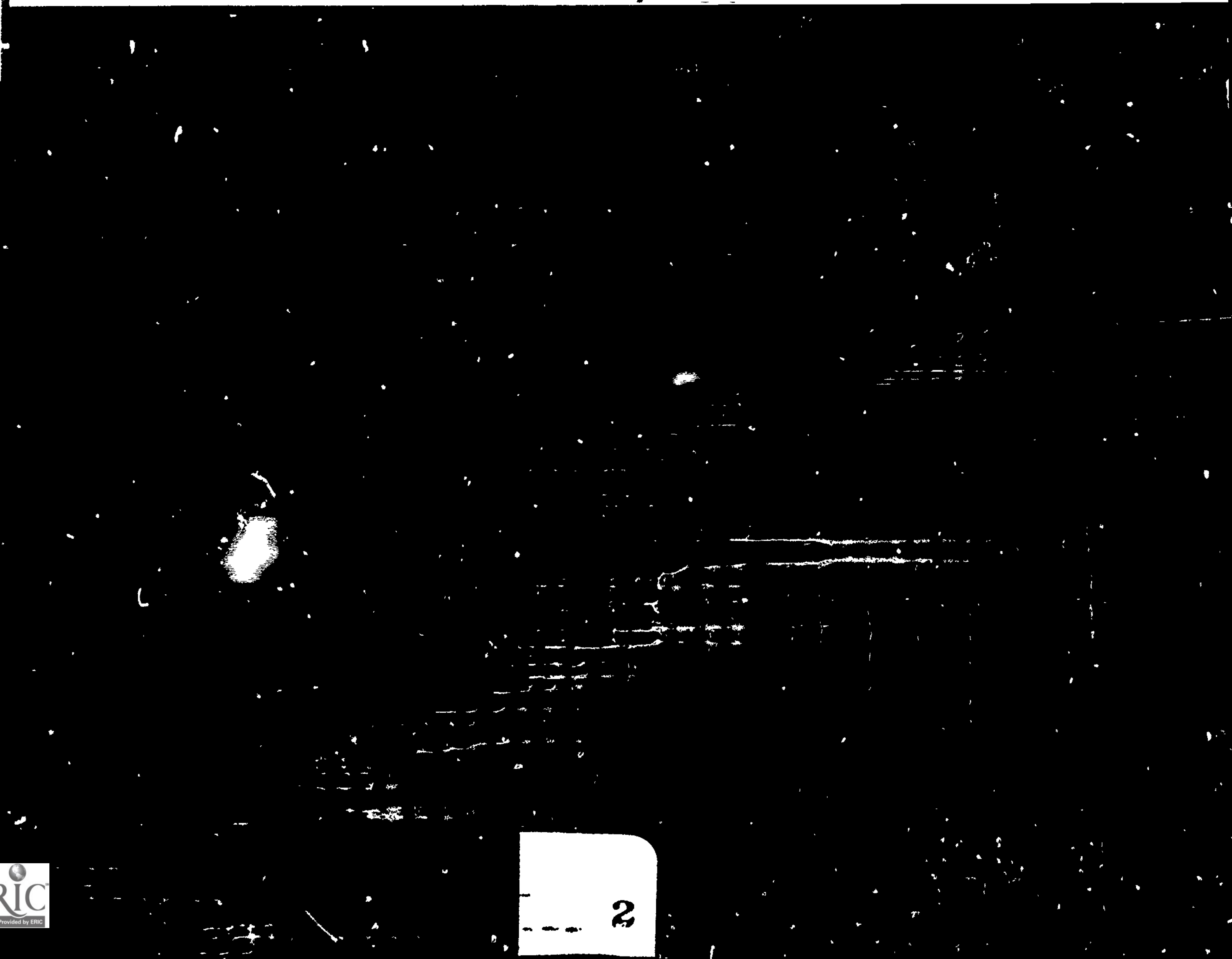
This report surveys the first generation of theoretical and empirical research on the determinants of parent "demand" for children. A large fraction of this literature was first published as Rand reports and papers. The pragmatic question discussed here is the strengths and shortcomings of the state of the art in economic analysis of fertility determinants. Efforts to view fertility as a response to time and resource constraints and market determined exchange prices have begun to yield a substantial and largely consistent literature of empirical investigations. Section 2 outlines the evaluation of this framework for analyzing fertility, and Section 4 evaluates the estimated magnitude and importance of several of the apparently causal relationships assumed by this framework. Section 3 briefly reviews the problems of statistically modeling reproductive behavior and estimating model parameters. In Section 5 it is argued that if the evaluation of population policy interventions is to become a more precise science, analysis should focus on fertility and not contraceptive services. Section 6 summarizes the empirical results from various evaluation studies of the Taiwan Family Planning Program. The final section considers how the demand approach to fertility determinants might help in the future to choose among broad types of policy interventions. (Author/JM)

FERTILITY DETERMINANTS: A THEORY, EVIDENCE, AND AN APPLICATION TO POLICY EVALUATION

PREPARED FOR THE ROCKEFELLER FOUNDATION AND THE AGENCY FOR INTERNATIONAL DEVELOPMENT

T. PAUL SCHULTZ

R-1016-RF/AID JANUARY 1974



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PREFACE

This report summarizes research completed for the Office of Population, Agency for International Development,[1] and related research supported by a grant from The Rockefeller Foundation for the study of the economics of fertility determination and family behavior.[2] For specific detail the reader may consult the six other reports prepared under the AID contract and other related Rand population studies. The report addresses two separable but related topics. The first four sections review some of the emerging elements of a theory of fertility determination and survey the growing body of empirical evidence bearing on this approach. The last three sections consider the techniques used to evaluate family planning programs, and indicate how a theory of fertility may be adapted to improve the evaluation of population policies.

This survey was initiated while the author was at The Rand Corporation. It draws on earlier research supported by The Rockefeller Foundation, contract NIH-71-2211 from the Center for Population Research, National Institute of Child Health and Human Development, and contracts

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[1] T. P. Schultz, *Evaluation of Population Policies: A Framework for Analysis and Its Application to Taiwan's Family Planning Program*, R-643-AID, June 1971; F. Sloan, *Survival of Progeny in Developing Countries*, R-773-AID, July 1971; J. DaVanzo, *The Determinants of Family Formation in Chile, 1960: An Econometric Study of Female Labor Force Participation, Marriage, and Fertility Decisions*, R-830-AID, December 1971; W. P. Butz, *Research and Information Strategies to Improve Population Policy in Less Developed Countries*, R-952-AID, February 1972; K. M. Maurer and T. P. Schultz, *A Population Projection Model: Description of a Computer Program and Illustrations for Its Policy Applications*, R-953-AID, June 1972; K. M. Maurer, R. Ratajczak and T. P. Schultz, *Marriage, Fertility and Labor Participation of Thai Women: An Econometric Study*, R-829-AID/RF, April 1973.

[2] Y. B. Porath and F. Welch, *Chance, Child Traits, and the Choice of Family Size*, R-1117-NIH/RF, April 1973. T. P. Schultz, *Disequilibrium and Variation in Birth Rates over Space and Time: Taiwan 1964-1969*, R-1079-RF, September 1972; D. N. DeTray, *The Interaction Between Parent Investment in Children and Family Size: An Economic Analysis*, R-1003-RF, April 1972; D. J. O'Hara, *Changes in Mortality Levels and Family Decisions Regarding Children*, R-914-RF, February 1972.

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SUMMARY

The past search for policy options to cope with rapid population growth mirrors a natural but nonetheless one-sided technocratic view of what is essentially a social problem. It seems far simpler to promote a better birth control technology than to learn why parents want the number of children they do and be prepared to promote the desirable social and economic changes that will modify those reproductive goals. For example, expenditures on family planning that seek to lower the *supply* price of modern birth control technology, reducing the cost (pecuniary and subjective) of restricting fertility, is a widely approved policy response. Alternatively, expenditures on, say, public health and nutrition programs that seek to reduce child death rates, contributing to a downward shift in parent *demand* for numbers of births, is thought to be a counterproductive or at best a controversial policy strategy. Both sets of policy options--the "supply" and "demand" sides--need further elaboration and quantitative study to enable decisionmakers to select an equitable and efficient mix of family planning and development policies for each social setting.

This report surveys the first generation of theoretical and empirical research on the determinants of parent *demand* for children. A large fraction of this literature was first published as Rand reports and papers. The pragmatic question discussed here is the strengths and shortcomings of the state of the art in economic analyses of fertility determinants. Efforts to view fertility as a response to time and resource constraints and market determined exchange prices have begun to yield a substantial and largely consistent literature of empirical investigations. Section II outlines the evolution of this framework for analyzing fertility, and Section IV evaluates the estimated magnitude and importance of several of the apparently causal relationships assumed by this framework. Section III briefly reviews the problems of statistically modeling reproductive behavior and estimating model parameters. In Section V it is argued that if the evaluation of population policy interventions is to become a more precise science, analysis should focus

on fertility and not contraceptive services, and that the adopted statistical models must allow for the concomitant changes in the society that are independently responsible for evolving patterns of reproductive behavior. One set of such changes that influence reproductive goals and performance are the fertility determinants stressed in the demand model of fertility reviewed here. Consequently, if family planning programs are evaluated only in terms of their capacity to provide contraceptive services, the record of program effectiveness may not accurately portray the program's impact on fertility. To show that this is a real possibility, Section VI summarizes the empirical results from a various evaluation studies of the Taiwan Family Planning Program. Significantly different policy recommendations follow from the different evaluation methodologies. This result is instructive for the future design of information systems and evaluation strategies in the field of family planning. The final section considers how the demand approach to fertility determinants might help in the future to choose among broad types of policy interventions to slow population growth as well as aid in evaluating their individual effectiveness.

ACKNOWLEDGMENTS

I have benefited greatly from the critical reading given this and earlier drafts by Y. Ben Porath, P. Berman, W. P. Butz, J. DaVanzo, D. N. DeTray, S. A. Hoenack, T. W. Schultz, J. Stein and F. Welch. Though they share no responsibility for this report, they have corrected and contributed much.

CONTENTS

I. INTRODUCTION

There are many explanations to describe why human fertility varies from one society to another and among different groups or individuals within the same society. Attempts to identify and measure the factors that affect fertility and hence to discriminate among competing causal hypotheses have not been notably successful. This lack of knowledge is both a source of embarrassment to social scientists and an obstacle to the strategic formulation and tactical evaluation of population policies throughout the world.

This report describes an economic framework for interpreting variation in reproductive behavior. The approach holds promise of accounting for factors affecting fertility, especially those that might be influenced by public policy, and of relating these factors consistently to other important forms of household decisionmaking such as labor force participation, marriage, and savings. Unlike many other areas of household nonmarket choice, the number of children a couple has is readily measured. Recent progress in extending economic analysis to the study of fertility has clarified many issues, but the field remains in a state of flux. For the economic approach to yield empirically refutable propositions, a number of specific assumptions must be imposed upon it. At this time, however, it is unclear which set of assumptions least impairs the model's realism.

In many fields of applied economics, the phenomena studied are simpler and more purely economic in nature, whereas the appropriate adaptation of the constrained decisionmaking model to the study of differential fertility is likely to rely more heavily on accumulating empirical evidence and the interdisciplinary exchange of ideas. But to have meaning, facts must be collected and studied within a coherent and appropriately designed framework. A satisfactory statistical methodology for studying fertility determinants is, therefore, almost as important as the conceptual framework that emphasizes the role of resource constrained choice.

Section II describes the central theoretical elements of a demand theory of fertility and discusses some of the as yet unsolved problems with this approach. Section III briefly discusses the statistical methods needed to verify and elaborate this framework. Empirical evidence from both cross-sectional and time series studies in low- and high-income countries is summarized in Section IV. [illegible]s V and VI discuss the application of a theory of fertility to evaluate population policies: first comes a review of the specific problems that arise when family planning program effectiveness is estimated without experimental data or a theory of fertility; and second, from studies of the Taiwan Family Planning Program, comes an indication of why different evaluation methods appear to produce significantly different policy recommendations. The final section considers the overall policy implications of the demand approach to fertility determinants.

II. OUTLINE OF A DEMAND THEORY OF FERTILITY

If variation in fertility across individuals and groups were a purely random phenomenon, a theory of fertility would have little point. But the widespread consensus is that two sources of systematic variation in fertility warrant a place in any theory of fertility determination--*biological factors* that constrain the reproductive process and determine fecundity or the potential supply of births, and conscious and inadvertent differences in *behavioral factors* that modify the extent to which the biological maximum is realized.

For the policymaker, the more interesting factors affecting fertility are those that can be influenced by administratively and politically feasible policies.[1] Factors that can be plausibly linked to policy instruments are very poorly understood, such as how public policy affects child mortality or the age at which children leave school and first enter the labor force. Any manageable and illuminating representation of the complex process determining fertility must neglect many facets of the problem. Hopefully, these omitted factors are not correlated with the analyzed factors nor with each other,[2] so that their

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[1]For example, more analytical attention might be given to the relationship between the educational attainment of parents and their fertility than to the relationship between desired family size and fertility. The former relation is subject to obvious policy instruments and can be projected accurately for a cohort as it ages; the latter relation is not yet reliably affected by policy options and has not, to my knowledge, been projected for a cohort with great precision.

[2]In formulating a simple statistical model from a complex conceptual model, it is often assumed that the many omitted and frequently unobserved factors are independent of each other and therefore their sum may be assumed to approach a normally distributed random disturbance in the model to be estimated statistically. It should not be surprising therefore that it is possible to account for a larger fraction of the differences in average reproductive behavior across groups because these stochastic elements cancel out and the systematic factors appear to "explain" more of the aggregate variation in fertility. Conversely, it is more difficult to account for the reproductive behavior of individual families, for a larger share of the variation in fertility will stem from purely random factors and the systematic factors will "explain" a smaller share of the observed variation in

neglect need not distort interpretation of empirical evidence on the responsiveness of fertility to observed group and individual characteristics implied by the economic framework as determining reproductive demands. Two broad classes of factors that are neglected in most economic analyses of fertility are systematic differences[1] in reproduction associated with fecundity and "tastes," discussed below.

BIOLOGICAL CONSTRAINTS ON FECUNDITY

In most contemporary societies most parents can have the number of children they desire without being constrained by the biological limitations of their fecundity. Undoubtedly there have been historical periods when a majority of parents failed to rear to maturity the number of children they wanted, perhaps because of severe child mortality. But in high-income countries and in most low-income countries as well these conditions no longer exist. Child mortality has been falling for two decades or more, and evidence from both anthropology and sociology suggests that most parents in these countries have for some time exercised individual choice or adopted social conventions to limit their reproductive performance. There are also historical instances when the spread or control of specific diseases may have affected fecundity, such as in certain of the Pacific Islands in the 19th and 20th centuries (Pirie, 1972). But such cases are always difficult to document, and are often transparent means for denying the importance of elusive

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fertility. Appropriate tests of statistical significance, therefore, are *not* explanatory power (i.e., R^2) but the magnitude and sign of estimated coefficients (i.e., effects) relative to their standard errors, or asymptotic standard errors where simultaneous equations or nonlinear estimation techniques are required to obtain consistent estimates.

[1]Systematic differences refers here to differences in fertility that could be predicted on the basis of obtainable information and estimable models. Certainly a substantial fraction of the variability in *individual* reproductive behavior is in no sense systematic or predictable, resulting from truly stochastic parameters to underlying biological processes, and perhaps equally random vagaries of individual human behavioral response to the same conditioning stimuli.

behavioral factors in the control of fertility.[1] Although the relative importance and effectiveness of individual and societal modes of reproduction control are as yet unclear, it is well established that biological constraints on fecundity are today relatively unimportant in accounting for systematic differences in fertility, except perhaps across societies with very different standards of living or endemic disease (Freedman, 1963; Ryder, 1967).

Moreover, it is extraordinarily difficult to separate empirically the biological and behavioral components of the reproductive process. For example, the biological capacity to give birth varies systematically with a woman's age. The proportion of women biologically *in*capable of childbearing appears to increase gradually from age 20 to 40, and increases sharply thereafter. By the time women reach age 50, virtually all are sterile. In studies of several cohorts of noncontracepting women of proven fecundity (i.e., they subsequently had children), intervals between births are observed to increase gradually from 24 months for women in the 20-24 age group to about 31 months for the 35-39 age group (Henry, 1966). Thus, both the probability of being *in*capable of bearing a child and the interval between births, on average, appear to increase with age.

The analytical problems of empirically separating the biological and behavioral components of the reproductive process arise because the onset of sterility and the spacing of births may also be influenced by diet, general health, prevalence of specific diseases, and prior childbearing and breast feeding patterns. It is widely believed that the time between a birth and the onset of ovulation depends on the duration and intensity of breast feeding. Since some of these secondary biological effects, holding age constant, can be *behaviorally* influenced by social custom or individual choice, observed differences in fecundity might partly reflect differences in desired fertility that

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[1]Farley (1970) is surely open to this interpretation, where the economic depression is played down as a possible cause for the drop in U.S. Negro fertility during the 1930s, whereas the spread of venereal disease is emphasized as the probable explanation (pp. 215-235).

could be accounted for within a behavioral framework.[1] The distinction between biological and behavioral determinants of fertility is thus a difficult one to draw, in practice, except where the conditioning factor is clearly exogenous, such as with age.

Although much work is under way characterizing the biological determinants of fecundity, there is, as yet, no consensus on how lactation practices, diet, or a mother's health affect the duration of sterility she experiences after a birth, her subsequent rate of conception, and fetal mortality. Moreover, the values of parameters used to describe the most interesting relationships in the reproductive process have often been based on small sample clinical studies that leave much to be desired. Only recently have such parameters as, for example, those linking lactation to intervals between births, been estimated satisfactorily within the context of an explicit stochastic framework. These findings have not yet been verified for different populations.[2]

The weak empirical foundation for fecundity models is undoubtedly related to the complexity of the pertinent biological processes, but it is also a function of the scarcity of longitudinal analyses of individual reproductive histories and the likelihood that these studies are contaminated by induced "behavioral" variation in reproductive performance.[3]

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[1]A mother can vary her lactation practices, depending upon her desired rate of conception. This decision may also influence the incidence of child mortality among her infants, for mortality is sometimes more frequent among those weaned before the second year of life (Wyon and Gordon, 1971). Also the incidence of pregnancy wastage is clearly affected by a woman's regime of work, diet, etc.; and differential spontaneous abortion, miscarriage, and stillbirth rates probably reflect more than purely stochastic variability (Freedman and Coombs, 1966; James, 1969).

[2]Jain's (1968) dissertation develops a stochastic model of human reproduction and estimates for a sample of Taiwanese women the effect on fecundity of socioeconomic factors, holding constant (approximately) for duration of lactation. (See also Jain et al., 1970; Schultz and DaVanzo, 1970.) Studies of child mortality have also begun to use individual survey data and more persuasive methods of multiple regression, for example, Shah and Abbey (1971).

[3]Unfortunately, longitudinal histories that include the necessary demographic, economic, and biological/nutrition/health information to estimate such a model are still uncommon (Butz, 1972; Butz and Schultz,

In sum, important differences in biological fecundity are associated with the aging process.[1] Within age-stratified groups in a given society, differences in a woman's fecundity can stem either from factors that are beyond her control, such as regional health conditions, or from factors over which she has greater control, such as prolonged lactation or induced abortion. If the former uncontrolled factors are independent of the environmental variables that will later be interpreted as the determinants of the demand for children, the neglect of these determinants should pose no statistical problem in analyzing fertility as a demand determined process. Moreover, as fecundity becomes an ever less frequently binding constraint on women having at least the number of children they want, and birth control technology reduces the cost and inconvenience of curbing excess fecundity, the demand framework should account for an increasing share of systematic variation in completed fertility.

DEMAND AND THE ROLE OF TASTES

Reproductive behavior is often associated with a parent's socioeconomic characteristics. These empirical regularities might be attributed to differences in the number of children preferred among

1972; Schultz and DaVanzo, 1970). Theoretical work in this direction is being undertaken by Robert Michael and Robert Willis at the National Bureau of Economic Research to gain a better understanding of the determinants of contraceptive behavior. Their investigation is proceeding in the tradition of Sheps and Perrin (1963), Sheps (1965), Henry (1972), and Mencken and Sheps (1973).

[1]Age in a cross section is also associated with birth cohort effects and will tend to capture time variant determinants of fertility that are omitted or measured with systematic error in a predictive model. Willis (1973), for example, includes a quadratic in age when he considers in one regression equation the number of children ever born to currently married U.S. white women in 1960 between the ages of 35 and 64 (Table 2, S50). The quadratic in age accounts for part of the cycle in cohort fertility associated with the baby boom. But what is more interesting, the inclusion of three "economic" determinants of desired fertility (measured contemporaneously) in the regression equation does not modify greatly the explanatory role of the quadratic in age. These results reinforce evidence from other sources that the broad aggregate time trends in fertility are not yet adequately explained by available evidence assembled in the microeconomic framework.

socioeconomic groups of parents. Parents derive intangible rewards and in some cases pecuniary transfers from their children, and differences in a parent's evaluation of these returns are undoubtedly responsible for a part of cross-sectional and time series variation in fertility. The importance of "tastes" in determining desired fertility is thus widely recognized (Easterlin, 1969), but the operational significance of this interpretation is rarely made explicit. To the economist, tastes differ if individuals behave differently when confronted by the same prices and endowed with the same resources and productive technology. If tastes are thus defined as behavioral differences that cannot be explained by economic variables, the concept of taste acquires substantive content only when the distribution of preferences across a population is related to observable phenomena, or more generally, when a model of taste-formation is postulated with refutable empirical implications.[1]

Lacking a psychological theory that specifies relationships between observable characteristics of parents and their tastes for children, this line of inquiry has not yet been notably productive.[2] Given

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[1]Such a model is verbally stated by Easterlin (1968) and Fuchs (1956). The hypothesis is essentially that when individuals are teenagers they develop their expectation for an acceptable material standard of living on the basis of the economic status of their parents. If the economic fortunes of the children are better than anticipated, these children feel they can "afford" somewhat more offspring than secular trends would predict, and vice versa. Children are essentially supernumerary expenditures that absorb the excess or shortfall of actual to anticipated incomes. The small cohort born and raised during the Great Depression, hence, contributed to the postwar baby boom, whereas the offspring of the baby boom are not faring as well as they expected, in part because of their cohort's relatively large size. Consequently, the cohort born in the 1950s is not contributing to the sharp decline in birth rates in the United States. Though this model may have considerable predictive power to account for cross-sectional and disaggregated time series variation in fertility in all high-income countries, it has been tested only to a limited extent against U.S. aggregate time series.

[2]To propose that unexplained differences in reproductive behavior among racial or religious groups reflect differences in tastes is, in my judgment, to mask our ignorance. An alternative approach to searching for the sources of ethnic group differences is evident in the observation that Catholic women with a college education have more children than non-Catholics with the same education, but that these

the nonpecuniary context in which parents obtain satisfactions from their children,[1] and the highly subjective and intangible nature of certain tastes for parenthood, there is presently no obvious way to integrate and analyze the role of tastes within a theory of fertility.

It is common, therefore, to assume that all individuals share the same utility function embodying their basic preferences. Differences among individuals in appraising specific goods are then attributed to environmental differences, some of which are assumed to be stochastic.[2] Specifically, people are assumed to prefer different amounts of a particular good, even when prices and resources appear to be the same because of a combination of unobserved taste factors, each independently normally distributed across populations. The sum of these specific taste-effects on fertility can be represented by a properly-behaved

differences are insignificant between women with lesser education. Implicitly two working hypotheses may be entertained. Is it the Catholic college experience that contributes to taste formation in the United States, or do those with such family-formed tastes elect to enroll in Catholic colleges? Empirical tests can be imagined to refine further one's understanding of the ultimate source of ethnic fertility differentials. It is also obvious that when one stops with distinguishing differences in behavior among ethnic groups, one has provided little useful knowledge to the policymaker that has no leverage on group identification.

[1]In most societies parents are encouraged to satisfy only their own demand for children. With an imperfect market for exchange, children represent a classic example of a nonmarket commodity that is produced only for the final consumer. Specialization in child production is uncommon, therefore, except under unusual circumstances (see S. Chueng, 1972).

[2]Alternatively, it may be assumed that parent tastes for children vary and are distributed across populations in a specific fashion. This representation of tastes is in some respects more appealing than the abstraction of a "representative individual," and in certain circumstances it implies different response estimates from the same empirical evidence. For example, when observations are obtained on only a portion of a population, the distribution of tastes may be estimated by analyzing both pieces of evidence: data on the observed population, and the proportion of the population observed with differing characteristics. Gronau (1973a, 1973b) has used this formulation to study the shadow price of a housewife's time, when market wages are observed for only the portion of the female population that is currently in the labor force. Knowledge of the covariance structure of errors across behavioral equations, such as in the equations determining fertility and labor force participation of women, might also provide one with an opportunity to identify the specific effects of "tastes." (See for example, Griliches, 1973).

disturbance term in a statistical model designed to analyze systematic sources of variation in reproductive behavior.[1]

THE DEMAND FOR CHILDREN

The family's choice of final consumption activities is limited by its market income and its members' time; and typically, market-determined wage opportunities provide the exchange rate between these two scarce household consumption inputs (Mincer, 1963; Becker, 1965). Because childbearing and rearing absorb a substantial fraction of the family's available time and market income, this approach to the determinants of household demand suggests that reproductive behavior is likely to be a significant determinant of parent welfare. Beyond some level of fertility, specified for a couple by its economic environment, wealth, and tastes, additional births are likely to diminish parental well-being, and lead them to search more diligently for ways to avert further births.

From this working hypothesis, a number of questions follow. Should one expect that differences in market prices, wages, and incomes will significantly affect reproductive behavior? Is the microeconomic framework of choice useful in structuring empirical research into the critical relationships between fertility and the features of the parents' environment and endowments that are predetermined for the individual (i.e., outside of his control), but which are ultimately subject to some social policy control? Answers to these questions are hard to come by, but recent empirical studies[2] have rather successfully interpreted

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[1]It is nonetheless important to probe beneath personal values and social norms to determine how they mold individual preferences and the related roles of culture and genetics. But measurable, variable, and potentially policy-manipulatable elements of the individual and his culture are difficult to discern. How important is it to the policy-maker (in contrast with the projector or planner) that Catholics want more children than Protestants? Yet, however conceptualized and quantified, the influence of these taste factors can be properly assessed only when the tangible pecuniary returns have also been isolated and taken into account.

[2]The bibiliography cites many of these studies. For example, see Becker, 1960; Mincer, 1963; Schultz, 1969, and a collection of studies

reproductive behavior as a response to the relative scarcity of resources available to the household and the associated costs of children. Nonetheless, important problems remain unresolved, which are discussed later.

Determinants of the *demand* for births will be explained in terms of this framework of household choice in a resource constrained environment. This is clearly a partial approach to the problem that should eventually incorporate the salient biological, technical, and behavioral features of the reproductive process that determine the *supply* of births. The economic framework of constrained choice appears to provide a general way of accommodating the environmental factors dictated to individuals that presumably motivate parents to want a smaller or larger number of births.

Ultimately, the test of the usefulness of the demand approach will be its predictive and integrative power in comparison with alternative frameworks. It would be premature to attempt such an evaluation at this time.[1] The remainder of this section describes some problems in restricting this formulation of the demand model of fertility to obtain refutable predictions, indicates how difficult it is to translate the relevant concepts into empirically observed variables, and discusses the theoretical and econometric problems of identifying and estimating the structure to the dynamic household behavioral system, of which

in "New Economic Approaches to Fertility," in T. W. Schultz (ed.), *Journal of Political Economy*, Vol. 81, No. 2, II Supplement (March/April 1973. A second conference volume will appear in a March/April 1974 supplement to the *Journal of Political Economy*.

[1]The most obvious reason to postpone such an evaluation is the absence of any comparable alternative structure of logical hypotheses with empirical implications against which the economic demand model might be judged. Also, the current interest of economists in this topic is hardly a decade old, and a consensus among economists would be hard to come by at this time. Moreover, most of the multivariate empirical testing of the demand model (see Tables 1 and 2) has been prudently focused on cross-sectional differences in fertility that are partially "explained" by almost any socioeconomic variables. The more severe test of the economic approach will be to predict time-series variation in completed reproductive performance. Whether economic theory has any interesting implications for the optimal timing of family formation (birth intervals, etc.) has not yet been established.

fertility is an integral part. A mathematical statement of the constrained maximization approach is presented in Appendix A for the simplified case in which it is assumed that the family chooses between only two final consumption commodities, children and all other commodities.

The resources that individuals allocate over their lifetime are ultimately their own time and their initial stock of nonhuman wealth. Time is assumed to be allocated between two classes of activities: (1) those that yield money, goods, or services which can be readily exchanged in a market, and (2) those that yield goods or services which cannot be exchanged in a market and are therefore valued by the producer solely for their own consumption. Since eating, sleeping, and virtually all forms of final consumption require the input of one's own time, all persons engage in the "production" of some nonmarket final consumption goods. It is also assumed that all persons allocate some time to producing goods and services exchanged in the marketplace.[1] In the latter case, if the net disutility associated with each class of activity is assumed identical, the net value of time expended at the margin in market and nonmarket activities is also equal. The market wage an individual receives equals the opportunity value of his time in nonmarket activities (Becker, 1965).

Income influences the demand for children within this framework differently according to which member of the family experiences the change in wage rates or whether the income comes from nonearned sources. Therefore, the lack of an invariant positive relationship between income and fertility *cannot* be interpreted as prima facie evidence that economic scarcity and individual choice are irrelevant to the fertility decision. If children required a fixed amount of their parents' time

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[1] It is conceivable that individuals whose spouses were sufficiently productive in the market or who owned sufficient nonhuman wealth might allocate *none* of their time to market activities. The occurrence of such a "corner solution" leaves the individual's nonmarket allocation of time and shadow price of time dependent upon the value of his marginal productivity in each nonmarket activity, which is ultimately dependent on his spouse's market-determined value of time, nonhuman wealth, and nonmarket production possibilities or technology. See Willis (1971, 1973) and Gronau (1973a, 1973b).

and market resources, one would anticipate that an increase in the parents' stock of *nonhuman* wealth would shift their demand schedule for children and other ordinary goods unambiguously to the right. However, the simplifying assumption implicit in this argument, that children can be treated as a homogeneous commodity, overlooks the important behavioral relationship between the number of children parents want and the "endowments" parents want to give each of their offspring.[1]

But increases in the household's stock of *human* wealth, as reflected by an increase in a parent's permanent (lifetime average discounted) wage rate, generate both a positive wealth effect and an offsetting price effect due to the increased opportunity cost of parents' time required in the care and enjoyment of their children. Since this framework is essentially based on comparative statics, these changes in the household's human and nonhuman wealth position are assumed to be *exogenous* to the individual decisionmaking unit.

For linear homogeneous separable household production functions (see Appendix A), the elasticity of demand for children with respect to either spouse's wage rate can be separated into a weighted combination of the compensated price elasticity and income elasticity of demand for children. The price elasticity is weighted by the value share of the respective spouse's time in the total cost of children minus the value share of the spouse's time in the cost of producing the composite commodity. The income elasticity is weighted by the value share of the spouse's market earnings in the household's full income (see Appendix A). Stronger assumptions are required to prescribe the sign of the wage elasticities, but plausible magnitudes for these weights suggest that the elasticity of fertility with respect to the wife's wage will be *algebraically* smaller than that with respect to the husband's wage, given the time intensity of children and the predominant role of mothers in child rearing.

In sum, economic analyses of fertility as a demand determined process lead to a few simple empirical predictions, if it is assumed that

[1]For an early statement of this problem see Becker (1960) or for theoretical and econometric methods for analyzing the quality/quantity dimensions of choice see Houthakker (1952), Theil (1952) and Becker and Lewis (1973).

the resource intensity of childbearing is not also a choice variable. Nonhuman wealth exerts only an income effect on the derived demand for children, increasing desired fertility. Increases in wage rates must have a smaller positive or perhaps even negative effect on the demand for children, due to the additional offsetting effect of the price of time. Plausible assumptions concerning sex roles and market rewards lead to the prediction that the elasticity of demand with respect to the wife's wage will probably be negative, but under most conditions it will be at least less positive (algebraically smaller) than the elasticity with respect to the husband's wage.

Cross-sectional studies of individual countries at all levels of economic development have confirmed the qualitative predictions of this rudimentary demand theory of fertility.[1] In part because of the difficulties of measuring a permanent wage rate, particularly for women not in the paid labor force, education has often been assumed to be a satisfactory proxy for lifetime wage rates. When fertility is then regressed on the educational level of men and women, the women's education coefficient tends to be negative, as anticipated, and several times its standard error, while the men's education coefficient is smaller in absolute magnitude and generally less significant statistically.[2] When regression analysis deals with average earnings for men

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[1]Cross-country comparisons of fertility and its determinants are excluded from this survey. Not only do the usual problems of relative prices and inconvertible exchange rates make international comparisons of income levels treacherous, but also most of the additional data required to test the propositions discussed here are not meaningfully culled from standard international compendiums. For example, no experienced demographer would accept registered birth and death rates as satisfactory evidence of fertility and mortality levels in most low-income countries, yet official or registered vital rates are the basis for many international cross-sectional regression analyses. Education statistics have their own problems; female labor force participation rates reflect local conventions; wage rates for men and women are rarely compiled and, when available, tend to represent only a small segment of the labor force, such as that in modern manufacturing. All of the criticisms raised later with reference to cross-sectional studies of regional populations within one country apply with greater force to cross-sectional studies, which span the even greater diversity of national institutions, statistical conventions, and cultures.

[2]See for example where both male and female education is considered: Ben-Porath (1970, 1973a) on Israel; DeTray (1973) U.S. countries;

and women within regional population aggregates, or earnings of individual couples in which the husband and wife are currently working, the estimated elasticity of fertility with respect to women's earnings is negative and with respect to men's earnings is either positive or small and negative.[1]

The predicted positive association between fertility and exogenous differences in nonhuman wealth is less often tested because of the scarcity of information on personal nonhuman wealth and the endogenous nature of related savings behavior. Although wage and wealth effects are a help in accounting for cross-sectional differences in fertility in high-income countries, mortality has been perhaps the most important factor affecting reproductive behavior in low-income countries. This demographic variable, whose recent and sudden change is the proximate cause for the population explosion in much of the world, affects the structure of incentives for reproduction in many complex ways. Current efforts to incorporate this factor into the economic model of fertility determination are discussed below.

CHILD MORTALITY

If we assume that parents are motivated to bear children to accrue benefits from their mature surviving offspring, the effects of child mortality on desired fertility can be divided into two partially offsetting effects: (1) the demand for survivors and (2) the derived demand for births. Child mortality decreases the number of *survivors* demanded by increasing the expected cost per survivor; it increases the

Gardner (1972), 1973) rural U.S.; Hashimoto (1973) Japan; Maurer et al. (1973) Thailand; Michael (1971) suburban U.S.; and Schultz (1973) Taiwan (see Tables 1 and 2).

[1]See for example where income, earnings or wage rates of males and females are considered: Cain and Weininger (1971), U.S. SMSAs; DaVanzo (1972), Chile; DeTray (1973), U.S. countries; Gardner (1973), rural North Carolina; and Hashimoto (1973), Japan. Male income and female education are analyzed for the U.S. by Sanderson and Willis (1971), Simon (1972), and Willis (1971, 1973). (See Tables 1 and 2). Because simultaneous equation bias is probably severe when both education and wages are included as explanatory variables in ordinary regressions on fertility, the empirical results of such studies are difficult to interpret and are not reported here.

derived demand for *births* by increasing the number of births required to obtain a survivor. The final derived demand for births will respond positively to the incidence of child mortality only if the product of the relative change in expected cost per survivor and the price elasticity of demand per survivor is less than unity (in absolute value). In the event that the family reduces its completed fertility (i.e., births) as the incidence of child mortality declines, this tendency toward demographic stability within the family may be interpreted as evidence that parents' demand for surviving children is relatively price inelastic (O'Hara, 1972; Ben-Porath and Welch, 1972).[1]

No one can doubt that parenthood is one of the most risky undertakings that economists have proposed to study, yet the above formulation implicitly assumes that parents are risk neutral, that is, it assumes that parents consider only the expected value of outcomes and ignore the variance (or higher moments) and covariance effects. The potential importance of uncertainty for understanding shifts in fertility has been stressed in the context of low-income countries where child mortality has declined sharply (Schultz, 1969), but theoretical analysis of the relationship between uncertainty and reproductive behavior is of recent origin (O'Hara, 1972; Ben-Porath and Welch, 1972), and I know of no empirical evidence that separates the effect on fertility of the mean value of mortality in the family or region from the

[1]The elasticity of demand for births, B, with respect to the probability of a child's survival to maturity, P, can be expressed as follows:

$$\eta_{BP} = \eta_{SC}\eta_{CP} - 1,$$

where S is the number of births that survive from which parents are assumed to derive utility under risk neutral assumptions, and C is the expected cost of a surviving child which is assumed to depend inversely on P and be independent of family size. Since it is known that η_{SC} and η_{CP} are both less than zero, if their product is less than unity, the elasticity of demand for births with respect to the probability of survival will be negative. Ben-Porath and Welch (1972) illustratively assume that $\eta_{CP} = -1$, whereas O'Hara indicates why it might exceed unity in absolute value. The positive relationship observed between child mortality and fertility is therefore suggestive of an inelastic demand for surviving children, i.e. $|\eta_{SC}| < 1$.

effect due to some subjective measure of the uncertainty attached to that mortality level.[1]

Multiple regression analyses based on both individual and grouped data indicate that the relationship between fertility and child mortality is positive and statistically significant in such varied environments and periods as Bangladesh (1951-1961), Puerto Rico (1950-1960), Taiwan (1964-1969), Chile (1960), and the Philippines (1968). In these studies, the explanation of birth rates on the probability of birth is improved by lagging the incidence of child mortality two to four years. This is, of course, roughly the average time required for a mother to bear another child. There is reason, moreover, to anticipate that older mothers with nearly completed families will weigh heavily the survival or death of earlier children in their decision to have an additional (marginal) child. Consistent with this sequential and adaptive view of reproductive behavior, the estimated responsiveness of births to child deaths is greater and more significant statistically for women over 30 years of age (DaVanzo, 1972; Schultz and DaVanzo, 1970; Schultz, 1971, 1972). Among these older women, the response of birth rates is also more pronounced to male child deaths than to female child deaths (Schultz and DaVanzo, 1970; Schultz, 1972), presumably reflecting preferences for family sex composition.

The death of a young child may also stimulate a *biologically* independent feedback mechanism that will increase the mother's fecundity. If the child was still breast fed at the time of his death, the termination of lactation may shorten the mother's period of postpartum sterility and increase her subsequent fecundity and consequent fertility. But this biological mechanism can play only a relatively small role in the

[1]If parent preferences with regard to the number of surviving children they have are sufficiently asymmetric about some preferred number, changes in uncertainty (i.e., dispersion of anticipated family size outcomes that symmetrically preserve the expected mean) can change the desired level of fertility. For example, where parents want [illegible] a specified number of surviving children but do not regard a larger number as a large sacrifice, increases in uncertainty can increase desired fertility. Alternatively, if preferences are s[illegible]tric, as implicitly assumed in the text, the effect of changes in ri[illegible] on desired fertility will depend upon the price elasticity of demand for children.

widely noted robust relationship between birth rates and prior child deaths, for the *behavioral* factors, such as the mother's age and the sex of the child that died, continue to explain a statistically significant share of the variation in birth rates.

This evidence implies that birth rates of older mothers adapt promptly to offset some of the increase in population growth rates that occurs because of increased survival of children in low-income countries. But in the two- to five-year periods studied in these investigations, the overall birth rate response does not appear to be large enough to prevent the population growth rate from increasing. Longitudinal studies of cohort fertility are now needed to appraise the longer-run adjustment of fertility to changing child mortality levels. Future population growth rates in much of the world hinge on the magnitude of these adjustments in reproductive behavior and on the rate at which they occur.

Reduced death rates at all ages also increase the returns to parents of such long-term investments as those in child schooling and vocational training relative to the returns from having more children. If child "quality" investments and the quantity of children are close substitutes to parents, this shift in the relative returns to these two activities may motivate parents to seek fewer children in order to augment the resources they have available to invest in each child (O'Hara, 1972). Increased life expectancy for parents may also contribute to their greater valuation of long gestation investments such as child quality, since they have an increasing chance of being alive at any future date to enjoy these distant returns.

In sum, mortality exerts diverse influences on the family formation process and the incentives for associated savings and investment behavior in the household sector. Although the dramatic postwar change in mortality constitutes a significant and pervasive shift in the intertemporal constraints on household behavior in low-income countries, economists, unfortunately, have as yet paid scant attention to this phenomenon.

The consistent effects on fertility of (1) the shadow price (wage) of husband's and wife's time and (2) child mortality account for a statistically significant share of cross-sectional variation in aggregate and individual reproductive behavior. Encouraging though these empirical results may seem, there still are ambiguities in and limitations of this conceptual approach and its current empirical application. A few of the unresolved problems are discussed below.

RESOURCE INTENSITY OF CHILD REARING

It was suggested earlier that viewing children as a homogeneous commodity from which parents obtain a uniform flow of "child services" neglects the qualitative dimensions of child-rearing over which parents exercise some choice. Reproductive motivations are closely related to the amount of time, energy, and resources parents want to invest in each offspring (Becker, 1960). Widely observed empirical regularities suggest that parents tend to trade off resource intensity per child for numbers of children (e.g. Schultz, 1969, 1970, 1971; DaVanzo, 1972).[1] Understanding the determinants of this tradeoff promises to account for much systematic variability in fertility in both high- and low-income countries.

Progress in this direction, however, has been slow for at least two reasons. Unrealistic restrictions must be posited, apparently, to obtain refutable predictions from models of family choice in which both parents may contribute through their market earnings and own-time to the production of *three* final consumption commodities: the number

[1]Child schooling rates are often more highly (negatively) correlated with fertility than are educational attainments of mothers. Conversely, a positive partial correlation is generally observed between fertility and the rate at which young children enter the labor force in low-income countries. See for example Schultz (1969, 1970, 1971), Nerlove and Schultz (1970), DaVanzo (1972), Maurer et al. (1973). One might conjecture that parents in some poor populations borrow, on balance, from their children over their lifetime rather than invest in them (Schultz, 1971). Increased attention to the implicitly producer good (capital) attributes of children may yield additional insights into the determinants of fertility in low-income countries. I have not seen any evidence of a theoretical or empirical nature that might distinguish whether children should be treated as a consumer or producer durable good in the refinement of a demand theory of fertility.

of children, child quality, and other commodities.[1] Second, and more obvious, the lack of agreement on how to quantify the resource cost or consumer value of child "quality" has deterred relevant empirical research.

The most interesting theoretical effort to restrict the general three-good model to obtain an analytical reduced-form expression for the derived demand for numbers of children is by Willis (1971). He assumes that the husband does not contribute to household production, holding fixed his full-time labor force participation. With standard assumptions regarding linear, homogeneous, separable production functions and nonreversal of factor intensities, the derived demand for numbers of children is analytically deduced for (1) households in which the wife works in the labor force and (2) for households in which she does not.

Two novel implications follow: An increase in the husband's lifetime wage increases the demand for children by a greater amount if the wife engages in market work; an increase in the wife's education (i.e., market-specific human capital) reduces demand for children *only* if she is engaged in market work.

Further extensions of this work (Willis, 1973) treat the wife's labor force participation decision as endogenous and jointly determined with desired fertility, but this important step toward greater realism is achieved with a serious loss of refutable predictions.

The merit of this model for empirical work rests on the degree to which wives who are out of the labor force are engaged solely in producing nonmarket (untradable) consumption commodities in Becker's (1965)

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[1]Without additional restrictions, the only qualitative prediction is the positive sign of the effect of nonhuman wealth on the demand for both quality and quantity. DeTray (1973) estimated a special form of this model with U.S. county aggregate data and found that the wealth elasticity of demand for quality per child was not significantly different from zero.

Becker and Lewis (1973) and Willis (1973) have also explored the implications for demand analysis of the multiplicative interaction between child quality and quantity that enters the household's budget constraint if it is assumed that to change child quality marginally a parent must also change the quality investments in all intramarginal children.

sense of the word. If, instead, wives who are outside of the labor force are, nonetheless, producing at home some substitutes for market goods and services as well as final consumption commodities, then the process of factor price equalization and the determinants of derived demands are identical for the two classes of households.

In high-income societies the analogy between labor force activity and home production and Becker's market goods and nonmarket commodities has some appeal. But it is hazardous to extend this formulation to low-income societies where handicrafts, cottage industries, and local barter markets provide many points of contact between relative market prices and the allocation of a housewife's time. In the low-income environment where market specialization is less developed, it is hardly surprising that both spouses will typically produce at home some goods that the household will also purchase or sell in the market. The converse hypothesis might also warrant investigation in high-income countries; namely, as market specialization proceeds, husbands will increasingly have a comparative advantage to contribute their time to producing more nonmarket consumption commodities, including perhaps children. The realism of the Willis model for high-income countries is, therefore, also conjectural.

If further refinement of the three-good model is not to rely entirely on corner solutions, empirical research may have to provide sharper guidance on how theoretical restrictions are to be imposed. What are the economies of scale in the production of numbers of children and child quality? How are these outputs interrelated to other household consumption activities? Can production tradeoffs be estimated from changes in the relative prices of these other, more nearly marketed, household activities? Can one infer, directly or indirectly, more about the manner in which parents assess quality in their offspring, which ultimately must motivate their transmission to children of genetic potential, inherited wealth, educational advantage, economic opportunity, and culture? Perhaps an entirely new approach to the quality-quantity conundrum will be required.

PROBLEMS OF EMPIRICAL INFERENCE AND MODEL SPECIFICATION

As the framework of constrained choice has been adapted to analyze a growing body of data on reproductive behavior, it has become clear that it is difficult to infer the direction, magnitude, and timing of causality from partial correlations among the seemingly relevant variables in a cross section. Elements of the approach require reformulation, the distinction in each specific context between endogenous and exogenous variables requires more explicit consideration, and, finally, improved statistical techniques appear necessary to estimate the underlying structural relations without substantial bias.

Observations on exogenous differences in wage rates and nonearned income, from which price and income effects might be estimated without simultaneous equation bias, are hard to come by. Virtually all of the decisions parents make over their lifetime affect the subsequent structure of incentives bearing on fertility, and most individuals recognize that their current choices modify these future options. Therefore, many attributes of the household and its members that reflect past or current choices cannot be treated as exogenous to lifetime fertility decisions.[1] Proxies that appear initially useful as measures of the opportunity cost of children or of given resource constraints must ultimately be treated as endogenous variables in a broader simultaneous system of behavioral relations.

[1]Ordinary least squares estimates of the structural relationship determining fertility will not be statistically "consistent" unless all explanatory variables are uncorrelated with the disturbance in the fertility equation. Nor can lagged values of endogenous variables be treated as independent of the disturbance in relationships accounting for the same or related forms of current behavior, for well-known reasons (Nerlove, 1965). For example, the probability that a woman works in the paid labor force will in general not be independent of the disturbance in the relation accounting for her fertility. Labor force participation patterns earlier in her life cycle are also influenced by observed and unobserved features of her environment that will be highly serially correlated, and that will continue to affect not only her labor force participation but also her reproductive behavior. Clearly, individual tastes for children and, more generally, tastes for a wider array of market and nonmarket goods may be such an unobserved variable influencing both forms of behavior. In such a dynamic system of household behavioral relations, simultaneous equation estimators would appear generally appropriate for studying structural equations determining fertility.

Mate selection, the life cycle timing of marriage, and the allocation of both spouses' time between market and nonmarket activities are decisions that are intimately related to similar price and income variables as well as underlying tastes.[1] The extension of fertility models to encompass additional areas of jointly and simultaneously determined household choices has confirmed the importance of interactions among at least three forms of behavior: reproduction, the incidence of marriage (legal and consensual, where distinguished), and the sex division of labor market participation (DaVanzo, 1972; Frieden, 1972; Harman, 1970; Maurer et al., 1973; Nerlove and Schultz, 1970; Schultz, 1970). Beyond this core, models of household decisionmaking might be reasonably extended to incorporate additional allocative choices that are also probably endogenous to fertility determination, such as savings and nonhuman capital formation, migration and, as emphasized above, the resource intensity of the child-rearing process.

But these simultaneous-equation models tend to be formulated in static terms and tested, most often, against cross-sectional data from one point in time. Though this abstraction has proven a powerful generalizing device, little attention has been given to the question of what economic theory and statistical techniques can say about dynamic behavior models. Reproduction occurs sequentially, and the constraints on childbearing affect many other areas of economic and demographic decisionmaking in the household and are influenced themselves by past reproductive behavior.[2]

In cross-sectional studies, explanatory variables are at best discretely lagged a few years, as noted with regard to child death rates, to represent the time required for reproduction to respond and for

[1]For example, the educational attainment of the wife, considered here as an exogenous determinant of the opportunity cost of her time in childbearing, is *not* an exogenous variable with respect to her husband's wage rate, education, or tastes for children. The selection of mates is undoubtedly responsible for the high simple correlation between educational attainments of spouses.

[2]Sanderson and Willis (1971) use numerical simulation and dynamic programming techniques to explore this sequential family formation process, but unfortunately there is no empirical foundation for most of their specifications.

birth control information to take effect (Schultz, 1971). But the stochastic biological nature of the reproductive process and the numerous neglected features of the individual that could affect reaction times suggest that a distributed lag would be more appropriate for studying changes in fertility. Identification and estimation of these lag structures are, nonetheless, difficult because of the limited availability of time-series information and the strong positive serial correlation (over time) of relevant characteristics of regional populations or individuals, such as wages, nonhuman wealth, industrial structure, and schooling.

There is as yet little evidence on the magnitude of parameter bias introduced by misspecifying the dynamic process determining fertility by static approximations estimated from a single cross section of observations. A demand model for birth rates in Taiwan was estimated first on the basis of cross-sectional data, and then reestimated on the basis of a dynamic formulation using a combined time-series of cross sections (Schultz, 1972). Parameter estimates shift substantially between the static pooled cross-sectional formulation and the dynamic specification that utilizes both dimensions of the time series of cross sections. The changes in parameter estimates conform to those predicted by theory when appropriate weight is ascribed to time series variation in the estimation procedure. Cross-sectional estimates of the impact on birth rates of slowly changing environmental constraints, such as child mortality[1] and wage rates, tend to be biased upward or distorted

[1]For example, the systematic portion of the regime of mortality is determined by such slowly changing factors as long-term investments in public health, sanitation, water supplies and transportation, geography and climate, and socioeconomic characteristics of the population, and thus interregional differences in child mortality contain a relatively stable component over time. High positive serial correlation in regional differences in mortality implies that cross-sectional observations on mortality in any single period contain substantial information about the interregional differences that existed, 5, 10, and perhaps even 20 years earlier. If the factors increasing mortality over the long term were associated with higher fertility levels in the cross section, the positive observed relationship between child mortality and fertility would overestimate the direct short-run influence of a change in child mortality on fertility. If the association between the long-term determinants of mortality and fertility were causal,

(see Table 1, this report, columns 8a and 8b). Conversely, the influence of factors that are less highly correlated serially over time, such as recent family planning activities, tend to be underestimated. According to this study, estimates of the parameters to a dynamic behavioral process, such as fertility determination, may be seriously biased if they rely only on the information contained in a single cross section.

Finally, the character of family size suggests that *linear* demand models are too restrictive for the study of fertility. Both theoretical arguments (Willis, 1973) and empirical evidence (Ben-Porath, 1973; Hashimoto, 1973; Simon, 1972) have been presented for nonlinearity between explanatory variables and fertility. But at a more fundamental level, there is the question of how to specify the utility function with regard to numbers of children, and how the production function for children changes with scale.[1] Linear demand models presuppose that the desirability of *all* increments to family size are affected identically by shifts in economic constraints. It seems reasonable to study the sequential binary choices made in the family formation process separately; this approach would in fact determine whether price and income effects differ by birth order.

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then the observed cross-sectional relationship between child mortality and fertility would also spuriously overstate the long-run influence of mortality on fertility.

[1]Recently Leibenstein (1973) proposed a new economic framework within which to interpret fertility declines that stresses the benefits and costs of having children of a *specific order*. He suggests that the marginal cost declines with additions to the family, and the marginal benefit may increase before it ultimately declines. But the principal thesis of the paper is the importance of "status goods" which, it is asserted, claim an increasing share of expenditures in a given status group as development compresses the social structure of personal incomes. Until further theoretical elaboration of his approach is set forth, or empirical proxies and methods of application are proposed, I do not see how the framework could be challenged (or illuminated) by obvious sources of data.

III. PROBLEMS OF STATISTICAL INFERENCE

It is beyond the scope of this report to examine critically the statistical models and estimation techniques that have been used in the past, and might be productively used in the future, to study fertility determinants. New knowledge about the associations among fertility, parent characteristics, and their socioeconomic environment has increased awareness of how difficult it is to attach causal interpretations to evidence of intercorrelations. For those simple and partial correlations typically refer to interdependent choices that may be made sequentially over the life cycle, but which nonetheless are dependent on common lifetime goals, aspirations, and constraints, and are affected jointly by unanticipated outcomes. Clearly, it is not a simple task to infer from nonexperimental data the magnitude of the underlying causal relationships linking fertility to policy instruments or to exogenous features of parent endowments and environment. Since the collection and analysis of empirical evidence must continue to play a crucial role in further advances of the conceptual framework and in the choice of appropriate restrictions on the general demand model, relatively sophisticated statistical analysis of reproductive behavior will be increasingly called for. This subject has been emphasized in earlier Rand studies and will therefore be treated here briefly.[1]

Direct and indirect influences on fertility can be estimated from a complete and correctly specified model of the causal system within which fertility is determined, given accurately measured information on fertility and its potential determinants. The specification of a parsimonious but relatively complete model of fertility determination is, of course, still a matter of controversy, but certain rules for formulating alternative models and their statistical estimation should improve our ability to discriminate among them in terms of predictive power and

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[1]These guidelines are discussed at greater length in Schultz (1971a, 1971b) and Butz (1972a). The statistical nature of these problems is treated thoroughly in econometric literature, but it is not often translated into the problems of inference in economic demography.

specific sources of estimation bias. Adherence to these elementary methodological guidelines should also facilitate comparisons across empirical studies of fertility and aid in choosing among theories or restrictions on general models that predict different configurations among the numerous variables related to fertility.

More is known about biological and socioeconomic constraints affecting fertility and their appropriate measurement than is exploited in most studies of fertility differentials. Fertility models should be formulated in terms as comprehensive as possible if statistical analysis based on nonexperimental data is intended. Simple bivariate relationships and correlations of any particular factor and fertility are only descriptive statistics, and have little meaning for causal analysis, since many socioeconomic determinants of fertility are highly intercorrelated, and even biological constraints on fertility, such as lactation, may be causally related to socioeconomic determinants of fertility (Jain, 1968).

In the context of a specific decisionmaking situation, two classes of explanatory variables must be distinguished: those that are determined outside the model,[1] and those that are subject to choice by the decisionmaker or are jointly dependent on such choices. Technically, the distinction between exogenous and endogenous variables is clear cut; but in practice, given the interrelated nature of household status and behavior, this distinction may often be relatively arbitrary. The former are factors the *individual* decisionmaker cannot change: one's age, sex, and race, or competitively determined market prices including the lifetime (average discounted) wage received for labor and the returns obtained on endowments of nonhuman capital. The latter are factors the individual can influence: one's attitudes, labor force

[1]Exogenous variables are technically defined with respect to a specific context (behavioral relation) as a variable that is uncorrelated with the purely stochastic disturbance term in the specific structural relationship. An explanatory variable is not exogenous but endogenous when it is affected by the dependent variable (the feedback effect transmits the disturbance into the explanatory variable), or when the explanatory variable is affected by stochastic shocks (or omitted variables) that also influence the disturbance term in the structural equation under study.

participation, migration, age at marriage, acceptance of contraception, and the efficacy of its use. Both types are schematically portrayed in Fig. 1.

This distinction within a fertility model is important to obtain consistent estimates (i.e., unbiased in the probability limit) of the lines of causal influence. For example, if strong negative partial correlation is noted between age-at-marriage and completed fertility among women aged 40 to 44, would this reflect the importance of the causal relationship? Possibly not, because the exogenous factors included in the analysis may influence a woman's age at marriage and, in all likelihood, also exert an independent effect on her completed fertility. Moreover, some unobserved factors may influence both marriage and fertility. Both sources of bias would tend to overstate the direct "causal" influence of age at marriage on fertility and understate the direct (and indirect) influence of exogenous factors on fertility, whether or not they were included in the multiple correlation with fertility.[1]

Also, a policymaker needs to know the relationship between his policy instruments and fertility. Knowing that fertility is related to age at marriage is not particularly helpful without evidence about how policy instruments might influence the age at which people marry. Thus, a theory of fertility for policymaking application should emphasize exogenous factors that are logically related to actual or practicable policy choices. As the conceptual framework is gradually broadened to include closely related aspects of family decisionmaking such as age at marriage, women's role in the labor force, child schooling investments, and migration, additional theories (explanations) for these forms of behavior are also needed, unavoidably increasing the complexity of the household behavioral model.[2]

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[1] The bias could be attributed to misspecification of the complete model or, in the context of a single equation framework, to simultaneous equation bias of parameter estimates.

[2] A partial exception to this statement is discussed later. When consistent estimators are sought for an endogenous factor for which a firm theory is not at hand, instrumental variable (IV) techniques yield consistent estimates. Generally, however, the less theoretical guidance one has in the choice of instruments, the less efficient the IV estimates (that is, the greater are their standard errors).

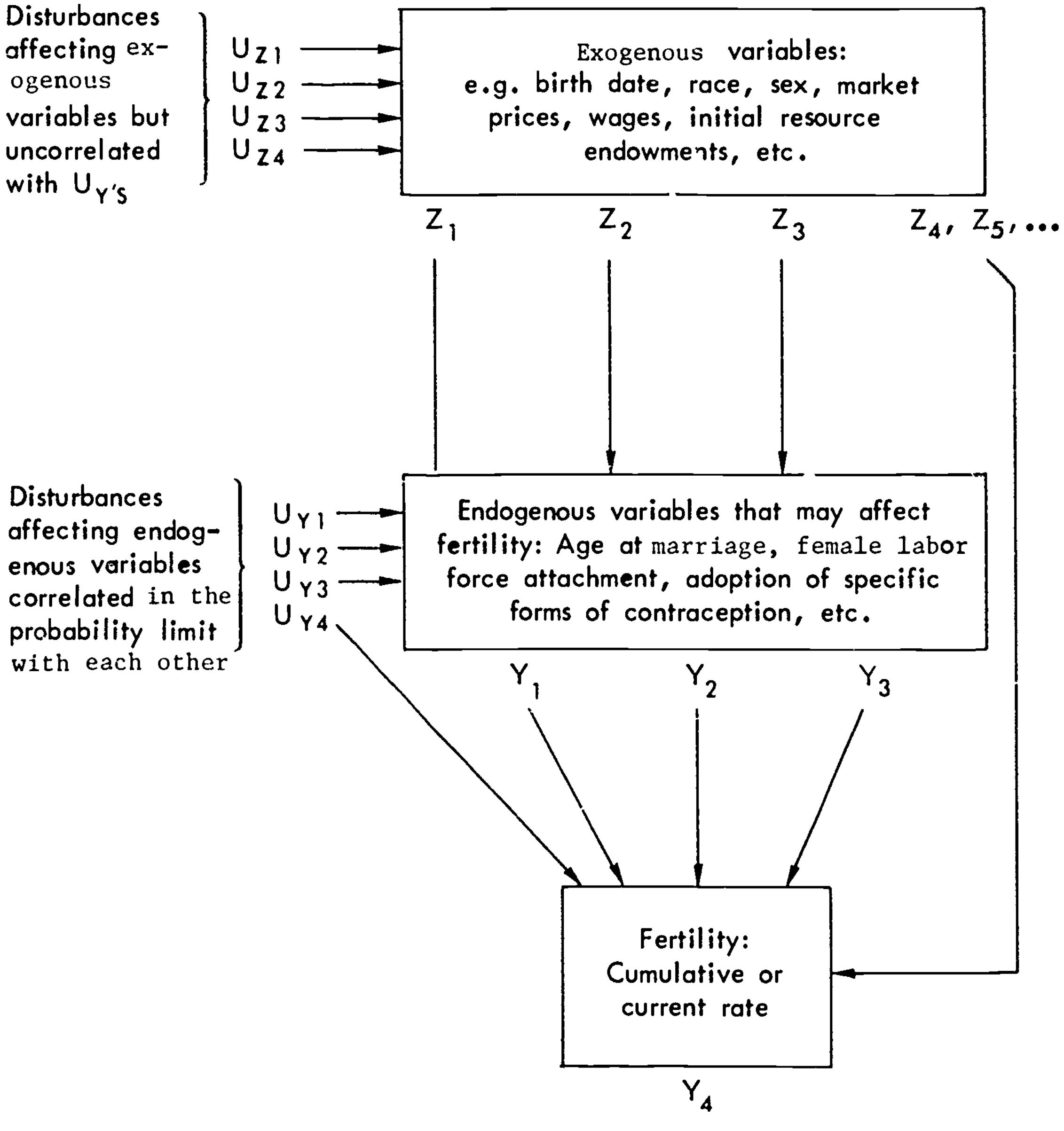

Fig. 1—General causal framework for statistical analysis of factors affecting fertility

Therefore, theory formulation begins by identifying the *exogenous* factors that affect fertility. Empirical confirmation or refutation of the theory can then be based initially on ordinary least-squares regression techniques. Additional restrictions on the model can then be considered and empirically tested. Finally, additional areas of jointly dependent family decisionmaking can be explored. Specifically, it may seem necessary to include the study of marriage and women's participation in extra-family labor force activities, which are integrally related to fertility decisions. A stepwise strategy for empirical research on fertility is proposed, given the complexity of the system of simultaneous behavioral relations in which the fertility decision must be imbedded. Appendix B outlines this approach in greater technical detail.

Section II proposed a framework for interpreting factors affecting the demand for children. This section has reiterated two guidelines for estimating the nature and magnitude of these effects empirically. First, relatively complete specification of potential fertility determinants is needed because the relevant socioeconomic variables tend to be highly intercorrelated. Second, exogenous and endogenous variables must be carefully distinguished.

Explanatory endogenous variables should generally be estimated by simultaneous equation techniques which are, under these circumstances, the only consistent estimators. Conversely, ordinary least-squares regressions or path analyses produce biased estimators in these instances. The econometric problem known as simultaneous equation bias is a serious impediment to drawing causal insights from many studies of fertility differentials because exogenous and endogenous explanatory variables are combined indiscriminately in multiple regression analyses. Identifying and measuring the effect of socioeconomic factors on fertility is hazardous using ordinary least squares unless consideration is restricted to exogenous explanatory variables. When "intervening" or jointly and simultaneously determined variables, such as attitudes, are added as possible explanatory variables in a structural relationship determining fertility, simultaneous-equation techniques are appropriate. Their actual use in statistical studies of fertility is all too rare.[1]

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[1] See Goldberger and Duncan (1973) for other examples of how structural equation models are being used in the social sciences.

IV. SOME EMPIRICAL EVIDENCE

This section does not review the extensive literature on fertility differentials.[1] Although many of these studies are a useful source of working hypotheses and insights into potential mechanisms affecting fertility, most do not help in testing directly the conceptual framework outlined in Section II. This is because they consider only a few of the more significant factors thought to be affecting fertility, or they do not distinguish statistically between what would appear to be exogenous and endogenous factors in multiple regressions on fertility, or they exhibit both of these shortcomings.[2] Consequently, only a few relatively recent empirical investigations are discussed here that have sought to account either for differences in fertility across populations or individuals at one point in time or for changes in fertility over time. Each study attempts to measure several of the factors distinguished as belonging to the core of constraints on the household allocation of resources;[3] each factor has a presumed effect on desired and actual fertility levels.

Though the models underlying the cross-sectional studies differ in terms of analytical detail and econometric complexity, their empirical implications are nonetheless similar. Whether a specifically restricted general equilibrium model of household choice is posited from which a reduced-form fertility equation is derived (DeTray, 1972; Michael, 1971; Willis, 1971), or a partial equilibrium model of fertility choice is specified in which the household is viewed as allocating its time and nonhuman capital over an interrelated set of life cycle

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[1]See for example the relatively exhaustive presentation of studies of differential fertility by Mason et al. (1971).

[2]Omission of important causal variables that are correlated with those included biases the estimates, and failure to use simultaneous equation estimation techniques when endogenous explanatory variables are analyzed generates additional sources of bias.

[3]The standard linear regression model may be applied with continuous variables, or dummy variable techniques may be used in the standard regression mode to permit nonlinearities and interactions among qualitative or grouped explanatory variables.

activities (Ben-Porath, 1970; Cain and Weininger, 1973; Gardner, 1971; Nerlove and Schultz, 1970; Schultz, 1969a, 1971b), parent derived demand for children is related to market and nonmarket productivities of husband and wife and other exogenously observed prices or constraints on the family formation process, as, of course, modified by the assumed functional forms of the equation determining fertility.

CROSS-SECTIONAL ANALYSES

Regardless of differences and inadequacies in the analytical frameworks used in studying fertility, the same economic variables or their proxies appear to account for a substantial share of the variation in cross-sectional aggregates or individual fertility, whether fertility is measured by (1) the number of children ever born per woman (Cain and Weininger, 1973; DaVanzo, 1971; DeTray, 1972; Gardner, 1971; Harman, 1970; Maurer et al., 1972; Schultz, 1972b; Willis, 1971; Sanderson and Willis, 1971); (2) crude, age-adjusted, or age-specific birth rates (Ben-Porath, 1970; Nerlove and Schultz, 1970; Schultz, 1969a, 1971a, 1972a); (3) child/woman ratios (DaVanzo, 1971; Schultz, 1969b, 1970); or (4) other proxies for fertility (Michael, 1971; Schultz, 1972c).

Tables 1 and 2 summarize some of the salient empirical findings from nineteen recent investigations into the determinants of fertility that have been guided by the demand model of constrained choice. Table 1 refers to studies of countries with relatively low per capita income levels, and Table 2 refers to studies in high-income countries. Unfortunately, most of the studies in Table 2 pertain to segments of the U.S. population, but several different data sets were employed. The third case (1c) in Table 2 should probably be reclassified with the low-income country studies, since the non-Jewish population of Israel appears to have more in common with these populations.[1]

Caution should be exercised in interpreting these results, for analytical detail and the questions addressed by the respective authors differ. Since no consensus has yet emerged on the "appropriate" specification of the demand model of fertility, investigators have made do

[1] See note to Table 3.

Table 1

SUMMARY OF EMPIRICAL FINDING ON FERTILITY DETERMINANTS FOR LOW-INCOME COUNTRIES

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8a)	(8b)
Author (year, page)	Schultz (1969; 171)	Schultz (1970; 43)	Nerlove-Schultz (1970; 45)	Harman (1970, 29-30)	Schultz (1971; 61)	DaVanzo (1972; 80)	Maurer et al. (1973: 20-29)	Schultz (1972; 36)	Schultz (1972; 38)
Population (time)	Puerto Rico (1951-1957)	Egypt (1960)	Puerto Rico (1950-1960)	Philippines (1968)	Taiwan (1964-1968)	Chile (1960)	Thailand (1960)	Taiwan (1964-1969)	Taiwan (1964-1969)
Observations (number)	Regions (75*7)	Regions (41)	Regions (78*11)	Individuals (250)	Regions (361)	Regions (50)	Regions (71)	Regions (361*7)	Regions (361*7)
Equation (estimators)[a]	Reduced form (GLS)	Reduced form (OLS)	Structural (TSLS/GLS)	Structural (TSLS)	Reduced form (OLS)	Structural (TSLS)	Solved reduced form (TSLS)	Reduced form (OLS)	Reduced form (GLS)
Dependent variable	Births per 1000 population	Children (0-4) per women 15-49	Births per 1000 population	Children ever born per women aged 35-39	Normalized births per 1000 women aged 35-39	Children ever born per 1000 women aged 35-39	Children ever born per women aged 35-39	Births per 1000 women aged 35-39	Births per 1000 women aged 35-39
Explanatory variables[b]									
1. Adult education	-1.58 (5.3) [0.15]	--	-1.95 (3.2) [0.20]	--	--	--	--	--	--
2. Women's education	--	-65.2 (4.0) [0.087]	--	-0.092 (1.6) [0.094]	0.422 (1.97) [1.8][f]	--	-0.0926 [0.13][h]	98.2 (9.2) [0.37]	-45.4 (2.78) [0.17]
3. Women's wage	--	--	--	--	--	-1589 (1.84) [0.35][g]	-22.6 [0.16][h]	--	--
4. Men's education	--	--	--	--	--	--	0.526 [0.55][h]	-274 (16.0) [1.4]	-174 (7.9) [0.98]
5. Men's wage	--	--	--	--	--	170 (0.33) [0.054]	--	--	--
6. Death rate	1.18 (3.5) [0.27][d]	--	0.302 (1.6) [0.082][d]	5.76 (3.9) [1.0] [0.048][e]	5.61 (9.3) [5.5][f] [0.41][e]	7.65 (2.72) [0.28]	--	432 (17.9) [3.9] [0.28][e]	172 (8.2) [1.5] [0.11][e]
R^2 (F;df)[c]	0.46	0.537	(27.3)	(3.5)	0.33[f]	(14.4; 6.3)	(13.9, 7.4)	0.461	0.809

NOTE: After each regression coefficient the absolute value of the t ratio is reported in parentheses, and elasticity at regression means is in brackets.

[a]Form of estimation equation such as reduced-form equations (only exogenous explanatory variables) which may be estimated by ordinary least squares (OLS); structural equations (including endogenous explanatory variables) estimated perhaps by an instrumental variable technique such as two-stage least squares (TSLS); solved reduced-form equations, derived from the simultaneous equations estimates of the related structural equations (generally without t statistics); and when a time series of cross sections are pooled for either a reduced form or a structural equation, estimates may be reported using a generalized least-squares procedure (GLS) that assumes a Nerlovian two-component stochastic structure to the disturbances. For instrumental variable estimates, asymptotic t statistics are reported.

[b]For definition of explanatory variables, including those not reported in table, see original studies.

[c]Asymptotic significance of entire equation can be evaluated with the F ratio when TSLS estimates are computed. See Dhrymes (1969). For OLS and GLS of reduced form equations, R^2 can be used to test the equation's overall statistical significance.

[d]Arithmetic sum of lagged coefficients, and averaged t statistics.

[e]Child death rate entered regression as the reciprocal of child survival rate. For comparability and ease of interpretation, the second elasticity estimates are with respect to the child death rate.

[f]Arithmetic average of regression coefficients, t statistics, elasticities, and R^2 from five annual cross-sectional regressions.

[g]The women's potential wage was estimated as a function of variables such as women's education, residence, and husband's occupation.

[h]The solved reduced-form equations are reported without asymptotic standard error estimates. The elasticity estimates for education variables incorporate also the effect of an additional nonlinear variable in male and female education--namely, the relative educational attainment of women to that of men.

Table 2

SUMMARY OF EMPIRICAL FINDING ON FERTILITY DETERMINANTS FOR HIGH-INCOME COUNTRIES

	(1a)	(1b)	(1c)	(2)	(3)	(4a)	(4b)	(4c)	(5)
Author (year: page)	Ben-Porath (1970 & 1973; S210-211)	Same	Same	Cain & Weininger (1973; Table 3)	Willis (1971; 61a)	Sanderson & Willis (1971 Table 1)	Same	Same	Michael (1971 26)
Population (time)	Israel (1961)	Same	Same	U.S., urban white census (1960)	U.S., white census (1960)	U.S., white married once husband present, census (1960)	Same	Same	U.S., suburban survey (1968)
Observations (number)	Regions: Jewish towns and Moshevim (42)	Non-Jewish (133)	Kibbutzim (180)	Major cities SMSA (100)	Aggregated cells (1920)	Husband occupation by wife's education categories (101)	Same (98)	Same (98)	Micro-households (513)
Equation (estimators)[a]	Reduced form (OLS)	Same	Same	Reduced form (OLS)	Reduced form (OLS)	Reduced form (OLS)	Same	Same	Reduced form (OLS)
Dependent variable	Age normalized birth rate	Same	Same	Children ever born per 1000 women ever married aged 35-44	Children ever born per women aged 35-44, married 22 years or more	Children ever born per women aged 35-44	Children ever born per women aged 44-54	Children ever born per women aged 55-64	Number of children in household per women aged 35-39
Explanatory Variables[b]									
1. Women's education	-0.132 (10.0) [1.1]	-0.089 (4.2) [0.06]	0.046 (1.5) [0.5]	-53.9[d] (5.4) [0.04]	--	-0.175 (4.67)	-0.192 (7.04)	-0.155 (4.43)	-0.0617 (2.18) [0.29]
2. Women's wage	--	--	--	-27.2 (3.97) [0.33]	-1.99[e] (3.38)	--	--	--	--
3. Men's education	-0.0[illegible] (2.6) [0.[illegible]]	0.022 (1.8) [0.11]	0.009 (0.4) [0.1]	--	--	--	--	--	-0.0124 (0.47) [0.064]
4. Men's wage	--	--	--	9.7 (1.84) [0.23]	-0.0289[ef] (1.17)	-1.77 (2.25)	-0.192 (3.27)	-1.65 (2.47)	--
5. Interaction (1*3)	--	--	--	--	--	0.151 (2.66)	0.150 (3.62)	0.084 (1.58)	--
6. Family income/consumption	--	--	--	--	0.4968 (284)	--	--	--	0.160 (1.80) [0 086]
R^2 (F;df)[c]	0.533	0.120	0.017	0.52	n.a.	0.253	0.437	0.448	0.018

For footnotes, see page 36.

Table 2--continued

	(6a)	(6b)	(7a)	(7b)	(8)	(9)	(10a)	(10b)	(10c)	(11)
Author (year; page)	Gardner (1972; 522)	Same	Ben-Porath (1973; 221)	Same	DeTray (1973; S97)	Frieden (1973; Table 4)	Gardner (1973; S10)	Same	Gardner (1973; S112)	Willis (1973; S50-552)
Population (time)	U.S., urban census (1960)	U.S., rural farm census (1960)	Israel (1963/1964)	Same	U.S. census (1960)	U.S. census (1960)	Rural North Carolina families, where wife reported some earnings (1967-1970)	Rural North Carolina families (1967-1970)	Rural North Carolina families (1967-1970)	U.S. census (1960
Observations (number)	States (48)	Same	Urban families of wage earners married in Israel (182)	Same	County (516)	County	Families (240)	Families (511)	Families (511)	Individual urban white once married women living with husband (9169)
Equation (estimators)[a]	Reduced form (OLS)	Same	Reduced form (OLS)	Same	Reduced form (OLS)	Structural (TSLS)	Reduced form (OLS)	Same	Reduced form (OLS)	Reduced form (OLS)
Dependent variable	Children ever born per women aged 40-44	Same	Children ever born per married women aged 40 or over	Same	Children ever born per 1000 married women aged 35-44[e]	Births per 1000 women aged 15-45	Children ever born per currently married women aged 30-49	Same	Children ever born per currently married women aged 30-49	Children ever born per currently married women aged 35-44
Explanatory variables[b]										
1. Women's education	-6.5 (0.5)	-17.0 (2.3)	-47.2[i] (1.44) [0.17]	-223.0[i] (1.96) [0.33]	-0.030 (3.19) [0.32]	-1.15 (2.95) [0.19]	-0.15 (2.7) [0.5]	-0.14 (3.7) [0.5]	-0.17 (4.0) [0.6]	-0.176 (14.0) 0.41
2. Women's wage	-40.0 (5.6)	-39.0 (4.0)	--	--	-0.30[e] (12.5) [0.30]	-7.0 (7.0) [0.26]	-0.43[k] (2.0) [0.2]	--	-0.020[k] (3.0) [0.6]	--
3. Men's education	1.6 (0.4)	26.0 (2.6)	--	--	0.0077 (0.74) [0.08]	--	-0.05 (0.9)	-0.09 (2.5) 0.3	-0.09 (2.2) [0.3]	--
4. Men's wage	--	--	-26.8 (1.38) [0.11]	-2.44 (0.41) [0.06]	0.074[e] (2.12) [0.07]	--	-0.06 (0.6)	--	-0.17 (2.2)	-0.248 (7.35) 0.067
5. Interaction (1*4)	--	--	548.0 (1.28)	2632[j] (1.89)	--	--	--	--	--	0.0202 (7.33)
6. Family income/consumption	3.6 (3.0)	2.5 (1.4)	--	--	0.065[eh] (2.73) [0.07]	1.1[h] (5.5) [0.22]	21.0 (3.2) [0.32]	0.16 (4.1) 0.28	0.26 (4.8) [0.38]	--
R^2 (F;df)[c]	0.70	0.76	0.306	0.313	0.75	(11.7;7, 3)	0.23	0.19	0.25	0.047

NOTE: After each regression coefficient, the absolute value of the t ratio is reported in parenthesis, and elasticity at regression means is in brackets.

[a, b, c]Refer to corresponding footnotes (a, b, c) in Table 1.

[d]Women's education variable expressed as percentage of females with less than five years of schooling. Variable is thus an inverse measure of educational attainment among the lower tail of the distribution, and the regression coefficient has the opposite sign from the other studies that use average or median years of schooling. Its sign has been reversed here to facilitate comparisons.

[e]Variables expressed in logarithms.

[f]Wife's potential market wage was constructed from 1960 data on the earnings of employed wives adjusted for hours worked per week and weeks worked last year to obtain a full-time yearly earnings potential of wives cross-classified by urban/rural residence, and the education or occupation of the husband (Willis, p. 54).

[g]This coefficient is obtained from a supplemental regression of the occupation/education dummy variable estimates from the fertility equation against mean income of husbands in these 24 occupation/education categories, which is assumed to be a satisfactory proxy for the husband's permanent income.

[h]Median value of owner occupied housing which is interpreted as a proxy for the wealth or consumption level of families in the county. In Frieden's study, housing value also affects (negatively) the proportion married, and therefore its net (reduced form) impact on births is about ten percent less than that reported here.

[i]The schooling variable is transformed according to five steps into an approximation of the monthly full-time wage rate for women.

[j]The women's schooling (wage rate) variable is squared to capture the non-linearity in the relationship between the woman's wage rate and her fertility. The interaction term (variable 5) also approximates this quadratic term since husband and wife educational attainment (and wage rates) are highly correlated.

[k]In study 10a the wife's wage is directly observed for the sample of North Carolina families where the wife reported some labor earnings, whereas in 10c for the entire sample of families the wife's wage is approximated by the county wage rate for off-farm employment to others than the farm head. The county wage should be a better approximation for an exogenous measure of the value of time that will not be systematically related to the woman's past labor force experience and consequently jointly determined with her family planning and fertility.

with very different sources of data, different proxies for essential economic variables, and different "control" variables. Nonetheless, the collected tableau suggests patterns as mentioned in Section II, and provides a convenient set of references to an otherwise scattered literature. Table 3 reports the range across studies of elasticity estimates of fertility with respect to the variables that are consistently emphasized in the economic view of the fertility determination process.

Table 3

RANGE OF ESTIMATES OF THE ELASTICITY OF FERTILITY WITH RESPECT TO THE CENTRAL VARIABLES IN DEMAND MODEL

Explanatory Variable	Per Capita Income Level	
	Low (Table 1)	High (Table 2)
Women's education	-0.17 to -0.06	-1.1 to -0.19
Men's education	-0.98 to +0.55	-0.4 to -0.06
Women's wage	-0.35 to -0.16	-0.6 to -0.17
Men's wage	+0.05	-0.11 to +0.23
Family income	--	+0.09 to +0.38
Mortality	+0.05 to +0.28	--

NOTE: Different measures of fertility are treated as the dependent variables, as indicated in Tables 1 and 2. Certain estimates apparently are not comparable because of the functional form of model estimated or the nature of proxy variables analyzed. The Willis (1971) and DeTray (1972) studies fit a model partially in logarithms. Willis obtains an unusually large elasticity of fertility with respect to his proxy for female full-time potential market earnings of -1.99. DeTray obtains elasticity estimates that are within the ranges reported. The interaction model estimated by Sanderson and Willis (1971) is reported without elasticities or variable means, and hence is not represented in the table. Cain and Weininger's (1973) female education variable is not comparable with the other average or median years of schooling variables (see note d, Table 2). The Kibbutzim case (Ben-Porath case 1c) is excluded as noncomparable. Although they are reported in Table 2, the non-Jewish communities in Israel are classified with the studies of low-income countries. Median years of schooling in these communities is 4.9 for males and 0.7 for females, contrasted with between 8 and 10 for both sexes in Israel's Jewish settlements.

WAGE AND WEALTH EFFECTS

The predicted effects of husband and wife wage rates or the shadow price of their time have not yet been adequately estimated, because current wages are a poor proxy for permanent lifetime wage rates, and market wages are not observed for wives who are currently out of the paid labor force. If education is regarded as a sufficiently good proxy for permanent wage rates, however, a linear relationship between fertility and the educational level of husbands and wives has been estimated from aggregate and individual data for many populations, as noted earlier.[1]

With respect to women's years of schooling, the elasticity of fertility appears to be about -0.1 in several low-income countries, but may be a substantially larger negative magnitude in high-income countries where a larger proportion of women are in the paid labor force. With respect to men's schooling, the elasticity of fertility does not appear to be uniformly defined across low-income countries, but is negative and about half the magnitude of the women's schooling elasticity in high-income countries. Inclusion of wage variables along with educational variables in several of these studies, without allowing for the indirect effect of education on market productivity and wage offers, probably understates the actual effect of women's schooling on fertility while overstating the negative effect of men's schooling.

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[1]Exceptions can also be instructive. Ben-Porath (1970) found across Kibbutzim no statistically significant partial association between women's education (proxy for the value of time) and fertility, whereas the associations across other Jewish and non-Jewish Israeli communities were all significantly negative. The institutionalization of communal child rearing in the Kibbutz reduces the mother's discretionary input of her own time into her own children, weakening the substitution effect embodied in the women's education (time value) variable. Clearly, many additional factors in the Kibbutz need to be evaluated to conclude much of anything from this preliminary aggregate analysis. Nonetheless, where the household time-allocation model is least applicable to the determination of child costs, the model's predictions are also rejected.

Another instance in which women's education was attributed a perverse positive effect on fertility was in cross-sectional studies of Taiwan (Schultz, 1972a). As discussed later, when the single cross section of observations is expanded to include a time series of cross sections, the puzzling association between women's education and birth rates reverses.

The relationship between years of schooling completed by the wife and her fertility appears to be nonlinear in a number of countries where it has been studied. In particular, the greatest absolute declines in fertility are associated with obtaining the primary and early years of secondary schooling. This nonlinearity can be explained in terms of the changing weights attached to income and price elasticities in the expression reported earlier for the elasticity of demand with respect to wages (see Appendix A). As women become better educated, they earn a larger share of household income. They also increase the market-good intensity of their child care. Other explanations for the behavioral pattern have also been proposed (Willis, 1973; Ben-Porath, 1973a).

Fertility studies that have analyzed actual male and female wage rates for regional population aggregates or that have (structurally) imputed wage rates to men and women regardless of labor force status, have also obtained regression coefficients for the female wage rate that are more significant statistically than those for the male wage rate (DaVanzo, 1971; DeTray, 1973; Gardner, 1973). Comparisons across studies suggest that the elasticities of fertility with respect to women's wage rates range between -0.2 to -0.5, perhaps somewhat larger in high-income than in low-income countries. The elasticity of fertility with respect to male wages has been estimated in only one low-income country as +0.05, whereas in high-income countries it varies from -0.1 to +0.2.

The predicted positive relationship between exogenous differences in nonhuman wealth and fertility is rarely estimated, particularly in low-income countries. Several demographic studies of relatively homogeneous peasant societies have noted a positive simple relationship between size of landholding and fertility, particularly when fertility is measured not as children ever born but as the number of children *living* when the parents reached middle age (Prachuabmoh, 1967; Stys, 1958). These studies might be interpreted as evidence of a positive nonhuman wealth effect, but the pattern might also be explained by the greater value of child labor for the larger landowner. As a proxy for wealth across U.S. county aggregates, DeTray (1972) and Frieden

(1973) used median value of housing and obtained a positive regression coefficient for the wealth proxy, holding average male and female wages and education constant. From the studies surveyed here, the elasticity of fertility with respect to family income, consumption or wealth in high-income countries has been estimated to be between +0.1 and +0.4.

MORTALITY

Although the theory of household choice does not qualitatively prescribe the relationship between fertility and child mortality, empirical evidence from low-income countries indicates the cross-sectional relationship is positive and very significant statistically, both at the aggregate and individual level (DaVanzo, 1971; Harman, 1970; Nerlove and Schultz, 1970; Rutstein, 1971; Schultz, 1969, 1971a). Estimates of the elasticity of fertility with respect to death rates for all persons or only for children range from +0.09 to +0.38. From the analysis of a time series of cross sections (Schultz, 1972), it appears that aggregate cross-sectional estimates of the responsiveness of fertility to mortality may be biased upward, but the magnitude of the response is nonetheless important.

CHILD SCHOOLING INVESTMENTS

A more difficult to interpret relationship found repeatedly in low-income countries is the strong partial association between child schooling rates and lower fertility (DaVanzo, 1971; Maurer et al., 1972; Nerlove and Schultz, 1970; Schultz, 1969a, 1969b, 1970, 1971a). But because this pattern could be due to politically motivated public investment (supply) or to private choice (demand), or both, it cannot yet be firmly attributed to either. A factor strongly related to child investments in schooling is child labor practices (Schultz, 1970; DaVanzo, 1971); also fertility, especially among older women, tends to be significantly higher in communities where young children are often in the labor force (DaVanzo, 1971; Maurer et al., 1972; Nerlove and Schultz, 1970; and Schultz, 1969a, 1970).

In addition to human capital formation associated with schooling and training, the consciously and culturally determined regime of lactation and maternal-child nutrition may be responsible for substantial differences in morbidity, mortality, and subsequent mental and physical capabilities of the human agent (Butz, 1972b; Selowsky and Taylor, 1971; Sloan, 1971). Work has only begun to evaluate the repercussions of this behavioral complex on fertility and to attribute them to choice or chance.

Economic theories of fertility determination generally presuppose an equilibrium relationship between permanent or lifetime conditions and completed fertility, whereas empirical verification is often based on observations of either conditions prevailing sometime after the arrival of the last child, or current conditions in conjunction with an incomplete stock or rate of addition to an unobserved stock of children. Moreover, unbiased estimates of cause and effect relations are difficult to obtain from a single cross section in which most economic and demographic aspects of the household are jointly dependent on prior conditions that have also influenced fertility. Thus, relatively little is learned from these cross-sectional studies about the time required for reproductive behavior to adapt to unanticipated change in environmental constraints (for example, how parents react to policy measures that seek to provide family planning information and reduce the costs of modern birth control). To cope intelligently with rapid population growth rates occurring in most low-income countries, one needs an understanding of precisely this process of behavioral adjustment to demographic and economic change and the resulting disequilibrium that it introduces into the family formation process.

TIME SERIES OF CROSS SECTIONS[1]

A statistical accounting of changes in fertility over time is less common than studies of cross-sectional variation. Because the historical record is generated by so many interrelated and unobserved factors, aggregate trends for nations and peoples do not generally provide enough information to isolate readily how slowly changing demographic trends

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[1]This section draws on T. P. Schultz, *Variation in Birth Rates Over Space and Time in Taiwan, 1964-1969*, R-1079-RF, November 1972.

affect the rate and structure of economic growth, and vice versa. In the sweep of historical time, marriage, fertility, and population growth rates have often responded positively in periods of prosperity. At other times, the pace of population growth has undoubtedly influenced for better or for worse the prospects for economic development. How then should concurrent broad cycles of growth in *both* per capita income and population, as widely noted by Kuznets (1966, 1967), Boserup (1965), and Clark (1967), be interpreted? Should this be construed as evidence that the elasticity of economic output with respect to population size is greater than one, or that the elasticity of parent demand for numbers of surviving children is positive with respect to per capita wealth, holding unchanged the relative structure of prices and wages? Since causation may operate in both directions simultaneously, at the macro and micro levels, and feedback cycles are rarely separated distinctly in time, historical trends in demographic and economic time series have not yet divulged their message regarding the strength or even sign of these underlying structural relationships. More sophisticated analysis of aggregate time series is now getting under way (e.g., Kelly and Williamson, 1972; Lee, 1972) and promising avenues for research are also being opened up at individual levels, where historical demographers are reconstructing longitudinal life histories for entire communities (Eversley, 1966). In the interim, the puzzle that Kuznets has posed is still with us.

A number of historians have constructed annual time series on harvest cycles and birth rates at the local and national level (Thomas, 1941; Gille, 1949) to explore the Malthusian link between the economic and demographic variables; the modern counterpart is found in high-income countries where study has focused on the association between business cycles and birth and marriage rates (Ben-Porath, 1973; Galbraith and Thomas, 1941; Hyrenius, 1946; Kirk, 1960; Silver, 1966, 1967). But these short-run associations between prosperity and birth rates would seem to be largely an effect on the timing of family formation and not necessarily an effect on completed family size. Yet as Easterlin (1961, 1968) has shown for the United States, certain swings in *cohort* fertility can also be accounted for by intergenerational disparities in living standards. Time series studies of birth rates or cohort completed fertility are even more scarce and less suitable for drawing policy insights. Weaknesses and bias inherent in the study of only cross-sectional evidence, particularly as relevant to evaluating new policy interventions, were stressed earlier (Schultz, 1972).

Therefore, cross-sectional findings must be interpreted with caution as estimates of the impact of slowly changing environmental constraints on birth rates during a specific discrete interval.[1] Discretely lagged variables present several problems for interpretation. Since these lagged variables approximate poorly the continuous distributed lag functions, errors in measurement contribute to downward bias in the estimated coefficients (Theil, 1971), understating the true long-run effect of the variable on fertility. Conversely, a discrete short-term lag may overstate the true short-run response, because of substantial positive serial correlation in variable levels over time.

To improve the temporal specification and estimation of dynamic behavioral relationships accounting for variation in reproductive behavior, it may be essential to incorporate information from a time series of cross sections. Individual specific but time-invariant effects might then be isolated, and the overall disturbance separated into its stochastic components. Estimates of the stochastic structure to disturbances from pooled time series of cross sections may then be used to obtain more efficient and unbiased estimates of the effects of specified and observed factors on individual fertility.

Another issue that may be explored in studying time series is how to approach disequilibrium in reproductive behavior analytically. The existing static theory of the determinants of fertility may help to isolate communities where birth rates are atypically high, given the configuration of environmental constraints confronting parents. In Taiwan, family planning field personnel were found to have exerted twice the effect in reducing birth rates among older women in such atypically-high birth rate communities than they did in the atypically-low birth rate communities (Schultz, 1972). Evidence of "disequilibrium"

[1] See footnote p. 24.

in reproductive behavior derived by analyzing residuals from a regression model could become a useful method for stratifying and studying changes in fertility over time. The technique might also provide an additional guide for efficiently allocating policy resources.

The static equilibrium theory of household time allocation and decisionmaking must now be modified to incorporate dynamic elements of innovation, search, and information costs. The longitudinal complexities of intergenerational savings, transfers, and bequests require conceptual and empirical study as they relate to reproductive behavior.

RELATED HOUSEHOLD BEHAVIOR

In addition to estimating a fertility equation, structural equations have also been estimated accounting for several classes of household behavior that are closely related to fertility. Most of these investigations use simultaneous equation estimation techniques. Only the briefest outline of these studies, largely done at Rand over the last five years, can be presented here.

Marriage has been most frequently analyzed in conjunction with fertility to answer the important demographic question of whether fertility responds to a specific stimulus by means of variation in the timing and duration of marriage or by variation in marital birth rates (see DaVanzo, 1971; Frieden, 1972; Harman, 1970; Maurer et al., 1972; Nerlove and Schultz, 1970; Schultz, 1970, 1971b). Where data permitted, consensual as well as legal marriage has been studied (DaVanzo, 1971; Nerlove and Schultz, 1970).

The work women perform in addition to household chores and child rearing is likely to influence the opportunity cost they incur if they have an additional child. Labor force participation, to the extent that it cannot be readily combined with child care commitments, appears to depress initially the probability of marriage and subsequently the level of fertility within marriage (DaVanzo, 1971, Harman, 1970; Maurer et al., 1972; Nerlove and Schultz, 1970; Schultz, 1970). Although women's wages are frequently viewed as predetermined or exogenous from the point of view of reproductive choice, DaVanzo (1971) has attempted to also treat them as endogenous to the behavioral system estimated at a regional level for Chile. Family (money) income depends in part upon a woman's decision to participate or not in the market labor force, but this variable has been treated as endogenous in only a few studies, based on both individual and regional data (Harman, 1970; Nerlove and Schultz, 1970).

Migration is another mode of demographic behavior that usually does not occur independently of marriage, fertility, or labor force attachments. Only in a few instances has migration been treated within the context of a more complete model of family decisionmaking (Harman, 1970; Nerlove and Schultz, 1970).

DaVanzo (1971) explored the potential determinants of child labor force participation and child school attendance rates in an effort to make these proxies for the price of a child endogenous to the behavioral system determining fertility. More work is needed along these lines to account for the determinants of the returns on schooling in addition to the demand for qualitative investments in child schooling.

Finally, to evaluate the mechanisms by which the family planning program in Taiwan influence birth rates, analysis has accounted for the regional rate of IUD acceptance as well as the direct and indirect (via IUD's) effects of the family planning program's field workers on birth rates (Schultz, 1971b).

The cautious extension of the fertility model to encompass such additional areas of jointly and simultaneously determined household choice has illuminated the strong interactions among reproduction, marriage, and the labor market participation of women. Going outside of this matrix, models of household behavior run the danger of over-extending themselves without firm theoretical guidance; consistent estimates of structural equations may be purchased by increasingly large losses of predictive efficiency.[1] The basic problem with statistical

[1]This concern has been expressed cogently by Finis Welch in numerous discussions. In other words, to assure that estimates converge to true parameter values with a very large sample, greater variance of the estimate is accepted. At some point in the analysis of relatively small samples, the increased variance of simultaneous equation estimators, e.g., instrumental variables, may conceal more than will the inconsistent ordinary least squares estimators with their smaller variance about a biased mean.

inference on the nature and magnitude of the causal relationships determining childbearing behavior is fertility's interdependency with virtually all other life cycle choices. A necessary first step in any study of such a system of behavioral relati‿ns is to define its limitations. Constructing a chain of dependencies and closing the model by selecting which variables are to be treated as predetermined must at some point appear relatively arbitrary; nonetheless, this is the explicit starting point to model and st the determinants of fertility empirically in the context of a househc decisionmaking model. Much work remains to be done.

V. METHODS OF EVALUATING FAMILY PLANNING PROGRAMS: APPLICATION OF A FERTILITY THEORY

This section reviews several methods for evaluating family planning programs and comments on the strengths and shortcomings of each.[1] Evidence from Taiwan is summarized in Section VI to show how different evaluation methods can yield different implications for improving policy. An important conclusion to emerge from these two sections on policy evaluation is that the supply of family planning services may be an unreliable indicator of a program's impact on fertility without "holding constant" the underlying socioeconomic forces affecting desired fertility. In order to isolate and evaluate the contribution of family planning programs to the reduction in birth rates, "controls" are needed for other changes occurring in a society that influence the demand for, and supply of, children.

Programs that distribute welfare services freely to the public are difficult to evaluate, *first* because program outputs are not typically subject to comprehensive monetary appraisal or market valuation, and *second* because there is some uncertainty regarding how costed program inputs combine to produce desired program outputs. This section deals only with the second point, without addressing the intricate and important problem of assigning a social value to the program's objective. More knowledge is needed on the interactions over time among economic, social, and demographic developments to translate a statement on program effectiveness (in terms of reducing birth rates) into a statement on program benefits (in terms of values that can be compared legitimately with program costs). A rigorous cost-benefit analysis of population programs will thus require a better understanding than we now have

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[1]It is not feasible to review the vast and rapidly growing literature addressed to family planning evaluation in this section; however, alternative approaches are surveyed and a few examples of each class of work are cited. Other surveys of the literature are noted: Bogue, 1970; Forrest and Ross, 1971; Kirk, 1971; Reynolds, 1972; and Ross, 1971.

of the economic and social causes and consequences of changes in fertility, and potential feedback effects of these changes on the evolving character of social systems.

KNOWLEDGE OF BIRTH CONTROL

Family planning advocates often assume that program success is synonymous with the availability of information about modern means of birth control. Increased knowledge of birth control is certainly one measure of the success of a family planning program. But one may also ask, how useful is this knowledge? How much do people benefit from it and who are they? What welfare implications follow from the changed patterns of behavior that result from the subsidized dissemination of this new information?[1]

DISTRIBUTION OF SERVICES

Family planning programs are evaluated typically according to measures of services rendered by these programs and their complementary activities--numbers of pills dispensed, IUDs inserted, traditional contraceptives given away or sold at concessionary prices within the program. Somewhat more refined measures seek to account for the length of use and effectiveness of contraceptives (Mauldin, 1967; Potter, 1969, 1971).

These measures of effectiveness derived from follow-up survey data are deficient when used to translate a program's supply of contraceptive services into an effect on the *birth rate*. One problem is that one does not know what women who accepted a form of contraception in

[1]To demonstrate the expressed need for family planning programs, sample surveys were designed to inquire into contraceptive Knowledge, Attitudes and Practices (KAP). By one count, 400 KAP surveys have been conducted in 67 countries (Mauldin et al., 1970). Aside from the controversial problems of eliciting meaningful and accurate responses to questions on these personally sensitive and complex matters, the subsequent use of KAP surveys to evaluate family planning programs has raised another issue. Is one primarily interested in announced intentions and admissions of knowledge or in actual reproductive behavior? A shift in the content of KAP surveys from contraceptive knowledge and use toward actual fertility behavior may facilitate the application of new evaluation methods such as those proposed here.

the program would have done *without* the program. To what extent do family planning programs transfer the demands for birth control from the private marketplace to the lower-cost sources of government-subsidized supply? Similarly, if women adopting modern birth control techniques had been employing traditional schemes of limited, but positive, effectiveness, the impact of the program on the birth rate would be only a fraction of that implied by the contraceptive *potential* of the birth control devices distributed by the program. The magnitude of this *"substitution effect"* remains unknown unless appropriate fertility analysis is also undertaken (Schultz, 1971a).

The second problem with this method of program evaluation is its inability to cope with the general diffusion of information fostered by the program that may alter reproductive behavior but not necessarily influence the flow of birth control services and supplies provided through the program. For example, the spread of the *idea* of family planning may stimulate interest in traditional and modern forms of birth control which may be partially satisfied in the *private marketplace* and not through the program itself; or anticipating this possibility, parents may shift the timing of births and other life-cycle activities (Keyfitz, 1971; Kirk, 1971; Schultz, 1971d).

BEFORE AND AFTER COMPARISONS

The fertility of program participants has been found to be higher before than after their involvement in family planning programs (Freedman and Takeshita, 1969; Reynolds, 1972; Robinson, 1959; Ross, 1971). Attributing this change to the program itself, though, is bound to overstate the program's effect. To what extent is the subsequent decline in fertility the *result* of the program rather than of the *characteristics* of people who tend to accept contraceptive services in the program? Acceptors are self-selected for being highly motivated family planners, and they may be prone to practice effectively whatever method of birth control they adopt. Also, they tend to be persons who have experienced above average fertility recently--perhaps owing to their greater fecundity or less effective prior knowledge of birth control (Chow et al., 1968; Freedman and Takeshita, 1969; Population Council report, 1971). Indeed, this atypical past performance is one explanation for their current motivation to restrict future fertility, and a substantial fraction of the difference between fertility rates before and after participation in a family planning program is likely to have occurred without a program (Kirk, 1971; Reynolds, 1972; Ross, 1971).[1]

MATCHING STUDIES

Matching studies are designed to control for the "substitution effect." They are structured to compare one group of women who accept some form of contraception in the program with a control who has not entered the program. Observations are matched retrospectively by such characteristics as age, education, number of births, and time since last birth. Evidence of higher fertility in the control group than in the program acceptor group can be translated into an estimate of the program's effectiveness in reducing the birth rate (Chang et al., 1969; Okada, 1969; Takeshita et al., 1964).

Although an improvement over program evaluation methods that rely only on the supply of contraceptives dispensed, the matching approach is costly, time consuming, and still vulnerable to biases. If a program contributes to available information about family planning (as it certainly must) and thereby influences some people in the control group to obtain improved methods of birth control from private sources, the matching study understates the impact of the family planning program on the birth rate. However, the matching procedure itself may overstate the role of contraceptives dispensed by the program because women who adopt contraception in the program are self-selected (hence nonrandom) and are likely to be more highly motivated to limit their subsequent fertility than those in the control group, regardless of the

[1]Follow-up surveys have found evidence consistent with this hypothesis, for where women have discontinued program-prescribed contraception their subsequent birth rates do not increase substantially. Highly motivated family planners may drop one particular method of birth control but accomplish their goal of averting further births by other means, especially abortions (Freedman and Takeshita, 1969; Population Council report, 1971; Ross, 1970).

effort made to match on objective characteristics. How these two biases balance out is unknown.

EXPERIMENTAL DESIGN

The ideal design for evaluating family planning is one in which the distribution of family planning activities is costed for different feasible policy mixes (one being perhaps the classic control in which no activities are supported). These treatments are then allocated randomly across regions; in other words, treatments are distributed independently of individual motivations and tastes, and independently of environmental factors that might affect desired reproductive behavior. Assuming such an experimental design, the subsequent statistical relationship between program inputs and fertility may be interpreted as an unbiased estimate (over the time horizon considered) of the program's effectiveness in influencing the number of births.

The prime example of experimental design in family planning was conducted in Taichung City, Taiwan (1963-1964). In this experiment social scientists and government officials undertook the laborious and time consuming task of obtaining experimental data from a large-scale social action program (Freedman and Takeshita, 1969, Chapters 6-12). Freedman and Takeshita analyze mainly the acceptance of contraception, and thus do not link different levels of program activity with the ultimate impact they might have had on reproductive behavior. Nonetheless, because of their carefully conceived experimental design, one may be more confident in this instance than in most studies of changes in contraceptive practice that the program's effect on the adoption of modern contraception had a parallel impact on birth rates, at least in the short run.

One problem with the Taichung experiment was the uncontrolled interregional diffusion of knowledge. Intensive program activity in one neighborhood (one of 2400 small yin that comprise the city) spilled over and appeared to influence contraceptive acceptor rates in adjacent neighborhoods (Hermalin, 1971, pp. 134-139). In this original study no method was proposed to take account of this indirect diffusion effect, and thus the observed relationship between program activity and (contraceptive) behavior was biased toward zero, understating the total (direct and indirect) effect of the program on behavior. A similar tendency occurred on a larger scale in Taiwan, where aboriginal regions were not allocated program activities initially, but surveys revealed that individuals from these regions migrated substantial distances to obtain program services.

The experimental approach to policy evaluation has great appeal to the social scientist, but government support for experimentally designed action-evaluation programs has generally been more restrained. Often, what is called "experimental design" is actually only aggregate comparisons of fertility for two or a few regions that have been subjected to different program treatments (Bang, 1968; Bean and Seltzer, 1968; Rochat et al., 1971; Ross, 1971). Although experimental design is a useful mode of comparative analysis, it requires the study of a larger number of units to which, ideally, treatments are randomly allocated where environmental factors considered important cannot be identified or measured. Program administrators are understandably inclined toward policy options that promise immediate results rather than long-term research findings. Consequently, experimental design approaches to the evaluation of family planning have not been sufficiently exploited.

An experiment's initial structure determines how efficiently information will be obtained for making the best allocation of a program's resources. As knowledge of the determinants of fertility and family planning behavior increases, experimental design and information systems in general can be focused more efficiently on the crucial policy choices (Butz and Schultz, 1972). For example, what are the critical environmental variables that should be experimentally or statistically controlled? What criteria should be used to stratify the sample, and how is one to determine relative sampling rates among these strata? What key dimensions of program activity should be varied across regions and in what combinations? How large should such regions be to minimize problems of information diffusion, given the mobility of the society?

Cognizant of the cost of social experiments and the time they require to plan, implement and evaluate, managers of population programs can also utilize analyses of nonexperimental data (i.e., surveys, censuses, and program records) that can help to clarify the contribution of family planning programs to declines in fertility, holding constant for observable socioeconomic factors that are *both* outside of a family's control and influential in determining reproductive goals (Schultz, 1971d).

HOLDING CONSTANT THE EFFECTS OF ENVIRONMENTAL CHANGE

To avoid the uncertainties of translating family planning services or contraceptive adoption into births averted, analysis may deal directly with reproductive behavior and attempt to infer the relationship between population program activities and the subsequent fertility level. As stressed earlier, this task is plagued by all the traditional difficulties of statistical inference in the social sciences. Without experimental data, confidence that statistical associations reflect cause-and-effect relationships rests on the realism of the abstractions embodied in the statistical model and the appropriateness of the techniques and data used to estimate the parameters of that model (Hermalin, 1971; Schultz, 1971b). In other words, the evaluation of population policy based on nonexperimental data requires a theory of fertility determination to suggest a statistical framework and specify the appropriate control variables.

To infer how program activity influences birth rates, analysis of nonexperimental data must simultaneously evaluate two sets of factors. First, environmental determinants of parents' family size goals must be identified and approximated by observed variables. Second, family planning activities that reduce the number of ill-timed and unwanted births must be specified in as much detail and as comparably as possible across different target populations. Complete specification and accurate measurement of both sets of factors should allow the analyst to infer the independent contribution of each to the birth rate level.[1]

[1]Since the appropriate specification and measurement of the environmental and program elements of the model will be subject to controversy for some time, statistical inferences with regard to policy evaluation will also be controversial. Consideration of alternative

Because the many social and economic constraints and opportunities that might reasonably influence desired reproductive behavior may be correlated, all relevant factors outside the control of the family should be considered together to appraise, without bias, their joint and individual influence on the birth rate (see Section III). The complexity of this problem precludes as impractical the convention of partitioning the population until groups are obtained that are presumably homogeneous with regard to all influential factors except program inputs. As a practical matter of statistical analysis, a functional form must be adopted to relate the various factors to each other and to the birth rate. The parameters of this functional relationship are then typically estimated by multiple regression procedures.

The dependent variable in the relationship accounting for reproductive behavior is not adequately described by a crude birth rate because of differences in the age and sex composition of the population over time and across regions that influence this measure. Also, birth rates for women of one age group at one stage in their life cycle may respond to identical conditions very differently from birth rates for women of another age group. For example, the decline in birth rates that emerged in Taiwan after the mid-1950s did not occur evenly across age groups; it was accentuated among women 30 years of age and older.

It might be hypothesized that family planning programs mainly reduce fertility by facilitating a decline in birth rates among older women. But programs may also influence reproductive behavior of younger women in a variety of more complex ways. Therefore, in evaluating population programs, age-specific and age-standardized birth rates are more appropriate for analysis than are crude birth rates, but it remains very difficult to distinguish changes in the "tempo" of reproduction from changes in the completed fertility of cohorts without allowing for the passage of time until younger cohorts have completed their childbearing years (Ryder, 1969). Changes both in the timing of births and the size of completed family may occur in response to

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formulations of the statistical model should gradually narrow the range of uncertainty that now attaches to conclusions about the effect of population policies.

population program activity and, therefore, short-run estimates of the response of age-specific birth rates should be interpreted with utmost caution, particularly for younger cohorts in which timing is likely to play a substantial role.

For example, if a family planning program informs young parents that they can reliably stop having children at an earlier age than their parents did, they may be persuaded to have their children closer together than their parents did, increasing the birth rate for younger aged women. Improved understanding of modern birth control could, therefore, be responsible in the short run for higher birth rates among women in their twenties, at which age they are likely to concentrate their childbearing, and lower birth rates among women in their thirties or forties (Keyfitz, 1971; Schultz, 1971d). Under these circumstances, increased birth rates for young women need not imply increased completed *cohort fertility*.

The impact of family planning programs on the childbearing of younger women may also vary over time, if the program is responsible for changes in the spacing of births. Part of the initial impact of the program in reducing births might only reflect a displacement of births several years hence, creating a subsequent unusual bunching of births at that time. Such oscillations in birth rates among younger women would quickly damp out.

SUMMARY OF EVALUATION METHODS

Table 4 summarizes the alternative methods for evaluating the effectiveness of family planning programs. KAP (Knowledge, Attitudes, and Practice of Contraception) surveys can document the spread of knowledge about, support for, and interest in family planning. But KAPs have not yet been shown to be satisfactory for evaluating effectiveness. The environmental determinants of desired fertility have generally been unaccounted for in the study of coincident trends in contraceptive use, reproductive behavior, and program activity. The more comprehensive approach to effectiveness evaluation based on an analysis of an *expanded* economic-demographic household survey is currently being discussed (Butz, 1972; Butz and Schultz, 1972), but has not been adopted.

Table 4

SUMMARY OF METHODS FOR EVALUATING FAMILY PLANNING PROGRAMS

Class of Method	Estimated Minimum Years from Plans to Analysis	Capacity to Estimate Program Effect on: Birth Control Use	Substitution Effect from Other Methods of Birth Control	Changes in Environment That Affect Desired Fertility: Hold These Factors Constant	Changes in Environment That Affect Desired Fertility: Evaluating Role of Individual Factors	Infer Number of Births Averted by Program Activity: On the Average[a]	Infer Number of Births Averted by Program Activity: At the Margin[a]
I. KAP surveys of change in family planning:							
A. Knowledge/attitudes	1	No	No	No	No	No	No
B. Practices	1	Yes	No	No	No	No	No
II. Services provided by program, either specific categories or aggregate formula, e.g., couple years of protection	.3	No	No	No	No	No	No
III. Matching studies, retrospective controls for program participants	2	Yes[b]	Yes[b]	Yes[b]	No	Yes[b]	No
IV. Experimental design, prospective control or random allocation of treatments to study program effect on:							
A. Contraceptive behavior	1-2	Yes	Yes	Yes	No[c]	Yes	Possibly
B. Reproductive behavior	2-3	No	Yes	Yes	No[c]	Yes	Possibly
V. Multiple regression analyses of environmental determinants of reproductive behavior in conjunction with program activity and birth control use	2-3	Yes	Yes	Yes	Yes[b]	Yes	Yes

[a]Allowances may be made for changes in the returns to scale of program activity in the regression model, which permits one to estimate separately total (average) and marginal effectiveness of personnel. Not only is the marginal effectiveness estiamte the correct criterion for incremental policy choices regarding the personnel mix, it is also the slope of the regression surface for which estimates tend to be most precise. The total and average, i.e., total divided by units of effort, effectiveness estimates should therefore be interpreted with great caution.

[b]Probably subject to some bias.

[c]Except for factors that are identified and measured for the treatment units on which analysis of variance can be based.

The impact of family planning programs on fertility cannot be ascertained conclusively from follow-up surveys of program participants, but in conjunction with matching studies they may provide a valuable first approximation of program effects.

Prospective experimental design is the most certain, but most costly, method for estimating the effect of programs on fertility. The costs of social experiments in terms of resources and elapsed time are apparently sufficient to deter their widespread use. Only one "true" experiment, in Taichung City, is known to this author; and its focus on contraceptive practice, rather than fertility, reduces its value for evaluating program effectiveness.

Finally, nonexperimental data can be analyzed to infer the marginal contribution of specific program activities to the decline (or rise) in birth rates. This approach requires information on reproductive behavior, relevant program activities, and the environmental factors outside the family's control that are presumed to influence desired fertility. These environmental determinants should be prescribed by an integrated theory of fertility determination and include, but not be limited to, child mortality, educational attainment of both parents, and their earnings opportunities. Holding constant for these environmental determinants of desired fertility, the partial association between program activities and the birth rate may be cautiously interpreted as evidence of the program's impact on fertility over the specified period. Intermediate effects of the program on contraceptive practice can also be evaluated, and public policies can be weighted that might change the socioeconomic environment of parents to accelerate change in family size goals.[1] This evaluation methodology may be pursued on the basis of areal data or individual survey data matched to regions where program activities have differed. Section VI reports

[1]Even in countries such as Taiwan, where family planning has been a great success in reducing birth rates, there is evidence that the "ideal" family size has not changed substantially. Thus any policies that indirectly facilitate the change in family size norms or goals such as health, education or manpower programs may appear an attractive supplement to family planning programs in a long-term formulation of population policy for low-income countries.

and compares such an investigation of Taiwan with evaluations of the family planning program based on the more traditional measure of success, the rate of program-subsidized acceptance of contraceptives.

VI. EVIDENCE OF THE EFFECTIVENESS OF FAMILY PLANNING IN TAIWAN

If family planning programs are evaluated in terms of their capacity to provide contraceptive services, the record of program effectiveness may not accurately portray the program's impact on fertility. To show that this is a real possibility, this section summarizes the empirical results from different methods of evaluating the Taiwan family planning program. Taiwan is the focus of this section because of its excellent data base.[1] Its family planning program is probably one of the most successful and cost-effective in the world, and certainly is one of the most frequently studied.

Our problem is essentially how to assemble available information on recent occurrences in Taiwan to infer the independent effect of family planning on birth rates.[2] To evaluate the acceptance of particular contraceptives in a program requires a leap of faith when birth control supplies are converted into births averted or fertility changed by these *intermediate measures* of program output. The preceding section suggests that evaluation of family planning program effectiveness should deal directly with fertility and allow for the concomitant changes in the society that are also responsible for evolving reproductive patterns.

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[1] Many technical issues are omitted here. More detail may be found in the Rand reports and papers by Schultz (1971a, 1971b, and 1972); in the classic study of Taiwan by Freedman and Takeshita (1969); and in that by Hermalin (1971).

[2] Many individuals have helped in the progress of the author's earlier studies on Taiwan. In particular, the guidance and insights of Drs. L. P. Chow, S. C. Hsu, T. C. Hsu, and T. H. Sun were useful. At an early stage, helpful comments were also obtained from Professors R. Freedman, A. Hermalin and W. C. Robinson.

The behavioral relationship first analyzed is that between the birth rate and (1) environmental determinants of the number of surviving children parents want--specifically, adult and child education and the agricultural composition of the labor force; (2) the child death rate; and (3) family planning activities. The theoretical and empirical rationale for the model is discussed elsewhere (Schultz, 1969a, 1971d, 1972a). The data are from the 361 small administrative units in Taiwan for the years 1961 to 1969. Both indirectly age-standardized birth rates and directly observed age-specific birth rates are considered as dependent variables in multiple regression analyses.

MULTIPLE REGRESSION ANALYSIS OF BIRTH RATES

Regional age-standardized birth rates are inversely associated with the regional allocation of family planning program field personnel from 1965 to 1967 when child mortality, schooling, agricultural composition of the male labor force, and female educational attainment are held constant using multiple linear regression techniques (Schultz, 1971d, 1972a). Sharply diminishing returns to scale of program activity are nonetheless evidenced, particularly after 1965, as seen in Table 5. The *marginal* effectiveness[1] of program personnel at average employment levels diminished from 1965 to 1969 as the cumulative level of program activity grew (read down columns in Table 5). It is also found (not shown in Table 5) that in each single year the marginal effectiveness of personnel was relatively less in regions where past program activity was more intense (Schultz, 1971d, 1972a). Both independent pieces of evidence confirm that more intensive efforts of field workers are subject to diminishing returns whether spread out over time or not: doubling personnel for a given population did not double the number of births averted by the program.

Part of the explanation for the weakening relationship between program inputs and the level of age-standardized birth rates can be found in the differential effects of the program on women of different ages (Table 5). Program inputs are most noticeably linked to lower

[1] See discussion in footnote a, Table 4.

Table 5

MARGINAL AND TOTAL EFFECT OF FIELD WORKERS ON BIRTH RATES IN TAIWAN, 1965-1969[a]

(Percent change)

Year/Type of Worker[b]	Age-Specified Birth Rates							Overall Age-Specific Effect	Age-Standardized Crude Birth Rate Effect
	15-19	20-24	25-29	30-34	35-39	40-44	45-49		
1965									
PPHW-Marginal	-3.53	-0.55	-0.28	-0.82	-2.48	-2.85	-0.68	-0.93	-1.00
Total	-21.21	-2.56	-1.72	-5.75	-13.87	-16.29	-1.67	-5.43	-5.75
VHEN-Marginal	-6.82	-0.79	0.22	-2.29	-4.99	-6.67	-8.79	-1.69	-1.62
Total	-10.57	-1.18	0.47	-4.25	-8.68	-12.37	-14.97	-2.86	-2.72
1966									
PPHW-Marginal	-0.48	0.01	-0.13	-0.36	-0.80	-0.84	-0.58	-0.24	-0.26
Total	-20.80	-2.90	-2.10	-5.57	-19.17	-26.68	-11.57	-6.49	-6.79
VHEN-Marginal	-3.88	-0.50	-0.28	-1.86	-4.54	-5.90	-6.74	-1.44	-1.54
Total	-12.59	-1.24	-0.61	-6.11	-16.61	-19.91	-20.65	-4.64	-5.03
1967									
PPHW-Marginal	-0.32	-0.04	0.05	-0.26	-0.50	-0.91	-1.10	-0.13	-0.13
Total	-24.34	-4.20	1.06	-12.04	-27.12	-43.60	-71.49	-8.46	-8.88
VHEN-Marginal	-3.15	-0.28	0.28	-1.00	-2.88	-5.16	-8.75	-0.81	-0.79
Total	-16.70	-1.73	1.17	-5.48	-18.30	-28.89	-40.09	-4.75	-4.40
1968									
PPHW-Marginal	-0.03	0.04	0.02	-0.15	-0.40	-0.43	-0.62	-0.05	-0.06
Total	-16.20	-1.15	5.58	-4.65	-25.74	-38.27	-57.73	-3.55	-4.84
VHEN-Marginal	-0.16	0.22	0.06	0.05	-0.95	-0.90	-1.85	-0.02	-0.14
Total	1.28	2.77	0.26	1.57	-3.18	-3.82	-5.32	-0.90	-0.35
1969									
PPHW-Marginal	-0.09	0.20	0.19	-0.01	-0.13	-0.08	0.00	0.01	0.01
Total	-12.93	2.23	14.14	-1.06	-12.50	-7.09	0.06	-2.92	-3.62
VHEN-Marginal	0.59	2.65	1.42	1.06	0.26	0.14	0.00	0.98	0.91
Total	3.31	14.48	7.66	5.82	1.47	0.79	-0.02	5.34	4.98

[a]Marginal effectiveness is the percentage reduction in the age-specific birth rate associated with employing an additional tenth of a man month of field personnel per thousand women of child-bearing age. This estimate is derived from the regression coefficients reported in (Schultz, 1971d) evaluated at the regression means, i.e., assuming the initial starting point is the average of program inputs. Total personnel effectiveness is the percentage change in age-specific birth rates associated with a change in program inputs from zero (no program) to their mean value (average program activity). See also footnote a to Table 4.

[b]The abbreviations refer to the two classes of family planning program field personnel. PPHW denotes the Pre-Pregnancy Health Workers, the more widely used full-time program employee. VHEN denotes the Village Health Education Nurses who were recruited half-time to work in the family planning program and were gradually phased out of the program after 1966. At full-time equivalents, the two classes of personnel were paid about the same monthly salary, and apparently their training costs in the program were also similar. Comparisons of total effect should be qualified by noting that the program employed about seven times as much of the PPHW's time as it did of the VHEN's time by 1967 or 1968.

birth rates among women 30 years and over. Among these prime candidates for family planning assistance (who are most likely to already have the number of surviving children they want), the distribution of field personnel is strongly associated with substantial declines in age specific birth rates.

A very different pattern of program effectiveness emerges from the study of birth rates among women under age 30. In 1965, the first year that the national program affected birth rates, field personnel appear to have elicited reductions in all age specific birth rates, although their impact among the younger women was mostly among women 15 to 19. After 1967 the tendency becomes increasingly statistically significant for birth rates among women 20 to 29 to be *higher* in regions intensively canvassed by family planning program field workers. This tentative evidence is consistent with the hypothesis advanced earlier that where reliable birth control methods are understood and accessible, marriage need not be delayed, and child spacing, if more widely practiced, may produce oscillations in birth rates among younger women.

Another implication of the results in Table 5 is that one class of field workers in the program--the Village Health Ed ation Nurse (VHEN)--is more effective in reducing birth rates than the other class of field worker--the Pre-Pregnancy Health Worker (PPHW). The PPHW is trained to contact and recruit mothers systematically, generally in their thirties, with a recently recorded birth; the VHEN is instructed to spread the principles and practices of home economics, family sanitation and hygiene, and family planning to the entire village population. The observed pattern of differing age-specific effectiveness of these two classes of field worker is, therefore, not implausible (Schultz, 1971a).

The VHEN were relatively more cost-effective at the margin of their employment than the PPHW in reducing the crude birth rate in 1965 through 1967. If these estimates are approximately correct, the program would have had a substantially greater impact on birth rates each year if more VHENs and fewer PPHWs had been employed, holding constant total program expenditures. The program has, on the contrary, increased its reliance over time on the PPHW and removed VHENs from the program. This may represent a costly departure from optimal staff structure. Why has this occurred?

ANALYSIS OF ACCEPTOR RATES AS A BASIS FOR PROGRAM EVALUATION

The principal measure of "success" and evaluation in the Taiwan family planning program has been the percentage of women between the ages of 20 and 44 accepting an IUD insertion. This "acceptor rate," along with more sophisticated variants computed at the local level, has been used to determine work quotas for PPHWs, and bonus incentive payments have been awarded on the basis of quota achievements and the number of referrals a local PPHW receives from women accepting an IUD. These sources of information on program accomplishments and personnel effectiveness suggest that the program operated at approximately constant returns to scale as it grew in size from 1964 to 1968, and that the PPHW was a much more effective field worker than the VHEN.[1] More recent evidence, however, has indicated that *referral* information became increasingly biased in favor of the PPHW, probably because of differential monetary incentives for recruiting IUD acceptors.[2] One

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[1]See, for example, Robinson's estimates that suggest the average cost of an IUD insertion did not rise markedly in the Taiwan program in the first several years of program expansion (Robinson, 1959; also Ross et al., 1970).

[2]As the program developed, doctors and health station workers increasingly gave "credit" for referrals to the local PPHW, for they recognized that this would help her reach her quota (and receive her financial bonuses) while having no effect on their status (Freedman and Takeshita, 1969, pp. 316-317). Because the bonus incentive payments were awarded to only one class of responsible personnel, these payments apparently introduced a growing bias in the referral information that was intended for program evaluation purposes. For example, the PPHW referrals increased from 36 percent of the total in 1964 to 62 percent in 1968, whereas VHEN referrals fell from 7 to 3 percent in this period (Freedman and Takeshita, 1969, Table XIII-2, p. 317). A follow-up of IUD acceptors conducted in 1966 confirmed that acceptors report the PPHW as their primary source of information on the IUD eight times as often as they report the VHEN (Freedman and Takeshita, 1969, p. 318). Since only six times as many man-months of PPHW as VHEN were employed in the program through 1966, the PPHW exhibited somewhat greater average effectiveness in fostering the acceptance of IUDs than did the VHEN in these early years. Regression analysis of local acceptor rates provides some confirmation for this conclusion (Schultz, 1969c, p. 41).

may speculate that the decision to increase program employment of PPHWs and decrease program employment of VHENs was made with access only to the *referral* information from the first two years of program operation and the 1965 survey study of who accepted IUDs. The apparent superiority of the PPHW implied by these data would have reasonably justified the employment decisions actually made.

A sharply contrasting image of the relative cost-effectiveness of field personnel emerges unambiguously from the summarized analysis of the more appropriate indicator of program "success," namely the program's contribution to reducing the birth rate. Both the marginal and average effectiveness of the VHEN in *reducing birth rates* exceeds that of the PPHW from the first years of the program until the VHEN were phased out.

GUIDELINES FOR EVALUATION

In this important area of social policy, it is disconcerting that different evaluative approaches yield different conclusions with regard to the program's overall impact, changes in returns to the scale of program activity, and the relative effectiveness of various classes of field workers. More research will be needed to determine the reasons for these differences in policy conclusions, but plausible explanations for these inconsistencies imply a number of guidelines for future policy formulation and program evaluation.

First, analysis of *intermediate outcomes* in a family planning program, such as the number of IUD acceptors served or a formula combination of services rendered (Lee and Isbister, 1966; Mauldin, 1969), may not accurately reflect the final impact of the program on birth rates (Bean and Seltzer, 1968), especially when various workers receive different incentives for disseminating intermediate products (Schultz, 1969c) and no information is obtained on the role of the private market for birth control (Kirk, 1971). There is an obvious need to focus more analytical study on what social and economic forces outside of the family's control account for existing fertility patterns. Only when agreement is reached on this broader behavioral framework for the study of fertility can one hope to isolate the contribution of population programs to the reduction in fertility. It must be recognized, nonetheless, that the *study of fertility as a final output* rather than acceptance of family planning services *requires more lead time than may be available for some policy decisions.*

Second, day-to-day information on the functioning of a program should be drawn from unbiased and broadly based sources of data to improve short-run policy making and to assure that these operational guidelines approximately coincide with those derived from longer-term studies of the program's final impact on fertility. If demands for all forms of birth control, including abortion, had been monitored in Taiwan, whether they were satisfied within or outside of the program, a different image of program success might have emerged at an earlier date.[1]

Third, a potential problem with inference from nonexperimental data is that statistical associations between treatments (levels and mixes of program activity) and outcomes (levels of birth rates) may not denote cause-and-effect relationships. The geographical distribution of program activity may parallel some social forces that were neglected in an evaluation design, such as that used in Taiwan.[2] If these forces were themselves responsible for variation in birth rates, their effect might be spuriously attributed to program activity.

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[1]Greater reliance on the marketplace for dissemination of birth control services and supplies might increase the effectiveness of programs and provide the means for monitoring demand satisfied through the market. For example, field staff might offer potential clients discount vouchers that had cash value to a doctor or contraceptive supplier equal to the public sector program costs of providing that particular service or good. Great caution must be exercised, however, when any such incentive scheme is used, in order to determine precisely how these payments bias the flow of information about the program's success. Many such schemes have been used in experimental form in Taiwan, but they are far too rare in other programs.

[2]In the case of Taiwan the simple correlations between the allocation of VHEN and PPHW and birth rates were quite modest; for example, 1967 personnel and 1968 age-standardized birth rates were correlated -0.04 and -0.05, respectively. Nor were the personnel inputs strongly associated with the explanatory variables of fertility, such as child death rates. -0.14 and -0.12, or women's education, -0.09 and -0.10, respectively (see Schultz, 1971d, Table D-4).

It would be advisable, therefore, where it did not compromise the program objectives, to plan the geographic distribution and mix of program activities with the aid of some random selection process. For example, the same total expenditure per capita could be allocated to each region, but where and when to build and staff schools or health or family planning facilities would be decided independently of community characteristics. Eventually, all communities would have all facilities, but in the interim this mode of advanced planning would permit the unbiased evaluation of the effects of each class of activity on fertility.

TENTATIVE CONCLUSIONS

The problems of evaluating population programs are not easily resolved; indirect inferences or seemingly arbitrary assumptions cannot be avoided at one stage or another, for there are unobserved links in the complex chain of events that relate policy instruments to ultimate policy objectives. It has been argued here that the tenuous link between the distribution of family planning services and the resultant decline in births must be statistically estimated if the evaluation of population programs is to be improved.

The approach adopted here has been to observe births directly and develop a conceptual and statistical framework within which it should be possible to obtain unbiased estimates of the average and, more important, marginal effects of program activities on birth rates.[1] The inferences for policy drawn from this methodology in the case of the family planning program in Taiwan differ systematically from those derived from other approaches aimed at measuring services. The program's initial impact on the birth rate in 1966 and 1967 appears to have been greater than previously estimated, but the program has also been subject to diminishing returns as personnel inputs have accumulated over time. Although this analysis does not indicate why the program's impact has been so substantial or transitory, it may be due to the initial

[1] Note distinction between average and marginal effectiveness of personnel drawn in footnote a, Table 3.

innovative effect of birth control information disseminated by the program's field staff; clearly, it is not entirely a consequence of the acceptance of the particular contraceptive (IUD) initially emphasized by the program (Schultz, 1971b).

VII. SUMMARY AND POLICY CONCLUSIONS

There are several ways a society may influence its fertility level and population growth rate if it decides changes are socially desirable. It may legalize and subsidize the dissemination of birth control knowledge and related goods and services, making it easier for people to avert *unwanted* births. It may go even further and try to influence the number of children parents *want*, sensing that at this time a divergence exists between private and social interests in having additional children. Two options are then open. Payments and/or penalties may be introduced to elicit *directly* from individual parents the desired change in reproductive behavior. Alternatively, social policy may be promoted that changes the structure of household opportunities in order to affect *indirectly* the number of children parents want. Although it would be premature to suggest that the demand approach to understanding fertility determinants has yet shed much light on the design and evaluation of population policy, this general theoretical approach might help in the future to choose among these classes of policy measures and aid in their individual effectiveness evaluation.

FAMILY PLANNING EVALUATION

The most common approach to evaluating family planning programs is to measure the program's output of services per unit of input. Information on the age of individuals accepting a method of birth control in the program and the clinically estimated effectiveness of the method they adopt can be converted to a sophisticated measure of the *potential* number of births averted by the program's services, given the biological fecundity of "acceptor" population. But no method has been devised to estimate the extent to which program subsidized services replace or substitute for other higher cost and perhaps less reliable sources of birth control available in the private marketplace. The more price inelastic parent demand for children is, the smaller the actual effect of a family planning program on the birth rate would be as a fraction of the potential contraceptive effect of the program's services, and the larger the "substitution" effect would be.

If the evaluation of population policies is to be substantially improved, the tenuous link between the distribution of family planning activities and the resultant decline in births must be statistically estimated. In this instance, it is not feasible to measure directly the unobserved relationships that constitute the chain of events linking policy instruments to policy objectives. Indirect procedures of statistical inference are, therefore, unavoidable. But if these procedures are applied with care, they might greatly increase the precision with which family planning programs are currently evaluated.

The demand approach to fertility determination stresses the need to identify and to allow for the influences of changing economic and demographic constraints on the household sector that are likely to modify reproductive goals. In most countries, family planning activity is likely to be correlated with the level of these socioeconomic constraints and their change over time, giving rise to differential rates of birth control practice and program acceptance by region and class. To infer what independent contribution a family planning program has made to the fertility level, it is necessary to analyze simultaneously the (exogenous) factors affecting the demand for births and the family planning program inputs in conjunction with regional, class and, if possible, individual fertility behavior (Schultz, 1971a, 1971b, 1972).

Summarizing the success of population policy in terms of its impact on the birth rate, one should not overlook the important distributional consequences of public family planning programs. An economic analysis of family planning might view this activity as an investment, augmenting and diffusing a useful stock of new knowledge about birth control techniques not unlike technical assistance through farm extension agents. By lowering the fixed informational costs and perhaps also subsidizing the marginal user costs of modern birth control methods, this investment should contribute to more efficient patterns of birth control adoption. There is growing evidence, however, that suggests the distribution of benefits among segments of the population from a national family planning program favors the poor and disadvantaged. These personal distributional effects of a family planning program may be as important as any overall measure of the program's effectiveness in reducing the birth rate. Although all classes might benefit from the reduced marginal user costs, the fixed informational costs are probably a particularly severe barrier to adoption among segments of the population that reside in remote rural areas and have less sophisticated skills for searching out and evaluating the benefits of new products and services. Perhaps in a dynamic society the benefits in terms of reduced fixed informational costs are likely to be greatest among the lowest classes. If this is true, the highest payoff to family planning over a period of generations will be in slowing or reversing the disconcerting growth of economic disparities among classes in a society.[1]

POLICIES MAY MODIFY BOTH THE DEMAND AND SUPPLY OF BIRTHS

The past search for policy options to cope with rapid population growth mirrors a natural but nonetheless one-sided technocratic view of the complex social problem. It seems far simpler to disseminate a better birth control technology, which is already operational in developed countries, than to modify parent reproductive goals by processes of social change that tend to be unique to each culture. For example, expenditures on family planning that seek to lower the *supply* price of modern birth control technology and hence reduce the cost (pecuniary and subjective) of restricting fertility are a widely approved policy response. Alternatively, expenditures on, say, public health that seek to reduce child death rates, contributing to a downward shift in parent *demand* for numbers of births, are thought to be a counterproductive or at best a controversial policy strategy. Both sets of policy options--the "supply" and "demand" sides--need further quantitative study if decisionmakers are to be able to select an equitable and efficient mix of family planning and development policies for each social setting.

A controversial dimension of the problem is forecasting technological change. It appears that further improvements in birth control

[1]See for example the illustrative simulations of income and wealth inequality performed under different class structures of fertility by Pryor (1973).

technology cannot continue to reduce the cost and increase the acceptability of newer control techniques as they have in the last two decades. Given the apparent price inelasticity of parent demand for children, one may doubt whether further improvements in birth control technology will be responsible for a continuing fall in desired or actual fertility. The distinct possibility exists, therefore, that if family planning programs throughout the world succeed during the next few decades in transmitting their more-or-less *fixed* stock of information and services to all social strata, further activity in the family planning field will have a sharply diminishing payoff. This is already evident in a small country such as Taiwan that has had a massive and an unusually effective national family planning program (Schultz, 1971a, 1972).

The relative emphasis that a society should attach to population policy interventions that operate through the demand and supply of births depends on numerous factors, but these conditions and underlying relationships are amenable to study and measurement. If, as is often asserted, familial behavior, involving marriage, reproduction, and women's role in the labor force, is particularly resistant to environmental changes associated with alternative development strategies, then aligning development policies to foster the adoption of smaller family size goals may be ineffectual. Public policy would then wisely emphasize, for the moment, improvements in birth control technology and the dissemination of these improved techniques to all strata of society. Alternatively, if demand for children is price inelastic, as appears to be frequently the case, and family size goals are insensitive in the long run to the available mode of birth control, widespread acceptance of better birth control methods may not independently accomplish substantial reductions in the fertility level.

A common reaction to the apparent declining efficacy of improved birth control technology in the aftermath of a successful family planning program is to explore direct economic incentives to change parent reproductive behavior. The common "economic welfare" arguments used in this regard to buttress the case for slowing rapid population growth are seriously flawed.[1] In applying economic logic to evaluate the consequences of population growth, the unacceptable assumption is implicitly made that children are *nothing more* than a pecuniary investment. Although these average productivity or efficiency arguments for slowing population growth by direct incentive payments to parents are conceptually inadequate and empirically misguided, the unattractive consequences of rapid population growth on the personal distribution of income and wealth are inescapable. Moreover, in the long run, these inequitable effects of rapid population growth are possibly more important than those influencing the overall efficiency of economic growth.

The attraction of the demand model of fertility is that it identifies environmental conditions that presumably motivate parents to want fewer children and invest more in each child. Moreover, these conditions are generally linked to eminently desirable social investment programs that should contribute in the future to a less unequal personal distribution of income. Support is growing for such programs as, for example, promoting the health and nutrition of mothers and young children, accelerating the growth of educational opportunities at the elementary and secondary level for women as well as for men, facilitating the entry of women into the labor force, and strengthening the economic and legal status of women and children. Such fundamental changes in any social order will meet with substantial resistance and, as levers to lower fertility, these changes may perhaps absorb more resources per averted birth than alternative options. But the returns to promoting such changes in social organization and household resource allocation are broader than their effect on birth rates. To compare the social returns from direct incentive payments to parents to avert births with indirect investments in social change that promise,

[1] The microeconomic approach calculates the present value of preventing a birth, as advanced by Stephen Enke, but ignores the nonpecuniary returns from children, and presumes that parent resources expended on their own children are somehow social costs. The second approach constructs a macroeconomic growth model and simulates the effect of population growth, as pioneered by Coale and Hoover (1961). Social benefits are essentially measured in terms of per capita income which also excludes, conveniently, the nonpecuniary returns parents obtain from their offspring (Blandy, 1974).

among other goals, to reduce desired family size will require two major advances in the social sciences. First, agreement must be reached on how to characterize a society's interpersonal and intergenerational goals and their tradeoffs. Second, a much improved understanding will be required of how economic and demographic variables are influenced by, and affect, reproductive behavior both at the family and the community levels.

Appendix A

AN OUTLINE OF THE HOUSEHOLD PRODUCTION APPROACH TO FERTILITY[1]

This framework is typically stated in terms of a single period integrated family utility function, a series of production functions for final untraded consumption commodities, and a budget constraint expressed in terms of both the time of family members and market goods.

$$U = U(Z_1, Z_2, \ldots, Z_n) \tag{1}$$

$$Z_i = f_i(x_i, M_i, F_i), \quad \text{for } i = 1, 2, \ldots, n \tag{2}$$

$$Y = \sum_i x_i p_i = W_n N_m + W_f N_f + V \tag{3}$$

$$\sum_i M_i + N_m = \sum_i F_i + N_f = T \;, \tag{4}$$

where $U(\cdot)$ is the family utility function; Z's are final consumption commodities; f's are production functions using market goods, x's, husband's time, M's, and wife's time, F's; Y is money income; p's are money prices of market goods; N_m and N_f are husband and wife time allocated to market activities for money wages of W_m and W_f, respectively; V is the return on the family's nonhuman wealth; and T is the total available time each spouse has to allocate between market and nonmarket activities.[2]

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[1]The origins to this approach may be found in Mincer (1963) and Becker (1965), and are stated in the simplified manner presented below by Ben-Porath (1973) and elaborated in different directions by Willis (1971, 1973), DeTray (1973), Michael (1971), and Becker and Lewis (1973).

[2]Utility is maximized subject to technology, time, and income constraints when

$$\frac{\partial U}{\partial Z_i} = \lambda\left(\pi_i \cdot \frac{\partial x_i}{\partial Z_i} + \frac{\mu_m}{\lambda} \cdot \frac{\partial M_i}{\partial Z_i} + \frac{\mu_f}{\lambda} \cdot \frac{\partial F_i}{\partial Z_i}\right), \quad \text{for } i = 1, 2, \ldots, n,$$

where λ is the marginal utility of income, and μ is the marginal utility of time. The ratios of marginal products of all inputs in each activity

Assume that there are only two nonmarket commodities, the number of children, C, and all other commodities, G, and that both production functions are linear homogeneous and independent of each other. The full price of the i^{th} commodity is

$$Z_i \pi_i = M_i W_m + F_i W_f + p_i x_i \; ; \quad i = C, G. \tag{5}$$

Full income, I, of the household is then defined as

$$I = \pi_c C + \pi_g G = TW_f + TW_m + V \; ; \tag{6}$$

the full price elasticity of demand for the j^{th} commodity is

$$\eta_{j\pi_j} = \frac{dZ_j}{d\pi_j} \cdot \frac{\pi_j}{Z_j}$$

and the full income elasticity of demand for the j^{th} commodity is

$$\eta_{jI} = \frac{dZ_j}{dI} \cdot \frac{I}{Z_j} .$$

The income elasticity is positive if j is not an inferior commodity. The own-price elasticity, holding income constant, must be negative. The elasticity of demand for children with respect to nonhuman wealth, V, is

$$\eta_{CV} = \frac{V}{C} \cdot \frac{dC}{dV} = \eta_{CI} \, , \tag{7}$$

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are equal to the ratios of their shadow prices when the optimum allocation conditions are satisfied; for example for the male,

$$\frac{\partial Z_i / \partial M_i}{\partial Z_i / \partial x_i} = \frac{\mu_{m/\lambda}}{\pi_i} = \frac{W_m}{\pi_i}, \text{ for } i = 1, 2, \ldots, n.$$

See Gronau (1970) for an empirical application of this simple model to the study of single-person households, or Becker (1965) for further elaborations of the framework.

and if children are not an inferior commodity, as seems plausible, this expression should be positive in sign.

The shares of the total cost of the i^{th} commodity accounted for by time inputs of the husband and wife are

$$S_{mi} = \frac{M_i W_m}{Z_i \pi_i} ,$$

and

$$S_{fi} = \frac{F_i W_f}{Z_i \pi_i} , \text{ respectively.}$$

Following Ben-Porath (1973), the elasticity of demand for children with respect to a change in the husband's or wife's wages can be expressed in terms of these value shares, the shares of full income earned in the market by each spouse, and the compensated (holding full income constant) price and income elasticities of demand for children.[1]

$$\eta_{CW_m} = \frac{W_m}{C} \cdot \frac{\partial C}{\partial W_m} = \eta_{C\pi_c} (S_{mC} - S_{mG}) + \frac{N_m W_m}{I} \eta_{CI} \tag{8}$$

$$\eta_{CW_f} = \frac{W_f}{C} \cdot \frac{\partial C}{\partial W_f} = \eta_{C\pi_c} (S_{fC} - S_{fG}) + \frac{N_f W_f}{I} \eta_{CI} . \tag{9}$$

The elasticity of demand for children with respect to a change in the return, r, on the household's nonhuman wealth, A, where $r = V/A$, is

[1]The expression for the derived demand of a factor also includes the possibilites for substitution between husband's and wife's time in production. The above expression for the elasticity of demand for children permits only the substitution in consumption to occur along a given production isoquant. The compensated price elasticity may be alternatively defined as the product of the share of income spent on other household commodities and the elasticity of substitution between children and other household commodities (but with the opposite sign).

$$\eta_{Cr} = \frac{r}{C} \cdot \frac{\partial C}{\partial r} = \frac{V}{I} \eta_{CI} . \tag{10}$$

Generally it may be assumed that $N_m W_m > N_f W_f$, since both male wages and market hours worked tend to exceed those of females. The positive income effect associated with a change in male wages will, therefore, usually exceed that associated with a change in female wages, but the price effects are more complex.[1] If it is assumed that the difference between the female time intensity of children and that of other non-market goods equals or exceeds the difference between the male time intensity of children and that of other nonmarket goods, or, in other words, that

$$(S_{fC} - S_{fG}) > (S_{mC} - S_{mG}) ,$$

then the relative magnitude of the income effect prevails and

$$\eta_{CW_m} > \eta_{CW_f} . \tag{11}$$

This fomulation of the determinants of consumer demand in terms of price and income effects yields regrettably few refutable empirical propositions. The effect of an exogenously determined increase in the net price of a child, whether it stems from a shift in anticipated costs or benefits, should decrease demand for children. The effect of an unanticipated permanent increase in income, holding prices constant, should relax the family's resource constraint and stimulate increased demand for children and other ordinary goods. However, depending upon the ultimate source of the increase in income, an offsetting increase in the opportunity cost or time-price of a child may also take place, weakening or even reversing the net effect of the increased income.

[1] If one assumes that only one spouse, say the wife, allocates time to the production of C and G, stronger conclusions obtain (see Rybczynski, 1955; Gronau, 1970, 1973; Willis, 1971, 1973), notably when the wife ceases to work in market activities altogether.

Given plausible parameter values for relative wages, market work, and time intensity of nonmarket goods, one might anticipate that the effect on demand for children of a change in male wages should be more positive than that of a change in female wages. Indeed, even if price and income elasticities of demand for children were of approximately the same *absolute* magnitude (but of opposite sign), increases in male wages could increase demand for children, and increases in female wages could decrease demand because of the different value shares attached to each.[1] If the income elasticity were absolutely smaller than the

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[1]A numeric example may clarify how these relationships might work. Let us assume that men receive a wage 50 percent greater than women (say \$3 versus \$2 per day); and men work four times as much in market activity as do women (4/5 as compared with 1/5 of their allocatable time); and women allocate six-tenths of their time to child rearing and men only one tenth, with the remainder used to produce other nonmarket goods; one-fifth of the household's market income is spent on children; and nonhuman wealth income per day amounts to \$.20, then approximately $S_{fC} = 0.571$, $S_{fG} = 0.129$, $S_{mC} = 0.143$, $S_{mG} = 0.097$, and $I = \$5.20$. Assuming the same absolute magnitude for income and price compensated elasticities, say $\eta_{CI} = 0.3$ and $\eta_{C\pi_C} = -0.3$, we obtain the results by plugging in the illustrative values:

$$\eta_{CW_f} = (-0.3)(0.442) + (0.077)(-0.3) = -0.110$$

$$\eta_{CW_m} = (-0.3)(0.046) + (0.46)(0.3) = +\ 0.124 \text{ and}$$

$$\eta_{Cr} = (-0.3)(0.0) + (0.04)(0.3) = +\ 0.012$$

In this example the negative price effect associated with the male wage is less than 3 percent of the price effect associated with the female wage, whereas the male wage income effect is more than five times the female wage income effect. Consequently, the sex specific relative magnitudes of both the price and income effects contribute to the more positive (less negative) effect on the demand for children of a change in men's wages compared with women's wages. Because of the small share of household income that was assumed to flow from nonhuman assets, the magnitude of a change in the (interest rate) return on these assets elicits a small, but necessarily positive, effect. An unanticipated change in asset level would, of course, affect the demand for children directly via the assumed income elasticity of +0.3.

It might be more realistic to assume that the income elasticity of demand was much smaller, say +0.05. In this case, the elasticity of demand with respect to female wages would be -0.13 with respect to male wages (+0.01) and with respect to a change in interest rates (+0.002).

price elasticity, as seems likely, the relevant wage effects on the demand for children would all be reduced, or more negative.

The only observable source of exogenous variation in the relative price of children is associated with the value of time parents allocate to the care and enjoyment of their children. No progress has been made in measuring the pecuniary or subjective returns derived from children as either producer or consumer goods, respectively. At this point one is again confronted by the interrelatedness of parent choices regarding the number of children they want and the resource intensity of child rearing they deem optimal. Almost any observable measure of differential costs of child rearing implicitly reflects some degree of parent choice, and is hence endogenous to the decisionmaking process that the demand model of fertility seeks to explain.[1]

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[1]One can imagine that regional differences in climate and agricultural conditions might exogenously dictate regional differences in the productivity of child labor, with associated effects on desired fertility levels. Analysis of the structure of wages by age, sex, and education in low-income countries is an important but neglected field of economic study.

Appendix B
STATISTICAL ESTIMATION TECHNIQUES

Section II seeks to identify within a promising theoretical framework some of the factors determining fertility. This appendix sets forth guidelines for empirically estimating the nature and magnitude of these effects.[1]

When approaching a new set of data, it may be reasonable to estimate first an unrestricted reduced form equation obtained by ordinary least squares (OLS) regression of fertility on all exogenous variables that are thought to affect directly or indirectly reproduction in the observed population. These estimates of the combined direct and indirect effects are consistent; that is, they would tend to the true parameter values in the existing population if the sample were sufficiently large and the model correctly specified. These estimates of the reduced form equation, however, are less efficient (i.e., they have greater variance) than those solved from estimates of the entire system of structural equations. Without knowledge of the complete model, its limitation and restrictions, this may nonetheless be a good unbiased first approximation.[2]

To unravel the lines of causality and determine how much of the effect of, say, women's wages on fertility operate through the wage effect on propensity to marry or to participate in the labor force, additional structural equations must be estimated for those explanatory variables that are clearly endogenous to the household context in which fertility is determined. OLS estimates of these structural equations are generally inconsistent, and will be consistent only when *all*

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[1]They are discussed at greater length in Butz (1972), and examples are shown and discussed in Schultz (1971b).

[2]Restrictions usually take the form of particular parameters being set equal to zero, i.e., some variable exerts no direct effect on an endogenous variable.

explanatory variables in the particular equation are uncorrelated with the equation's disturbances.[1]

Simple, but relatively inefficient, simultaneous-equation estimation techniques utilize information on the restrictions on each single equation, but neglect all that might be known (or not known) about the rest of the system. Instrumental variable estimates, of which two-stage least squares is a special case, replace explanatory endogenous variables in the fertility equation by the best fitting linear combination of all or a specified subset of the system's exogenous variables. A second-stage regression is then performed by OLS with the estimated explanatory variables replacing their observed values. To satisfy the order condition for identifiability in this procedure, the total number of exogenous variables used as instruments in a particular equation must be at least as large as the number of exogenous variable(s) excluded in that structural equation plus the number of explanatory endogenous variables identified by the added instruments (Fisher, 1966; Simon, 1953; Heise, 1969).

This extra regression stage purges the explanatory endogenous variables of their correlation with disturbances in the structural equation for fertility and leaves only the systematic (estimated) portion of these explanatory variables for inclusion in the second stage. Since all explanatory variables in the second-stage regression are linear combinations of exogenous variables, and hence asymptotically uncorrelated with disturbances in the system, the second stage OLS estimates are consistent.

It must be emphasized that this consistency may at times be purchased at a price. If there is no theory to predict which exogenous variables influence an explanatory endogenous variable, such as age at first marriage, then the instrumental variable estimate of age at first marriage will probably not be a good predictor for the endogenous

[1]Technically speaking, the covariance matrix of disturbances must be diagonal to treat the model as a recursive time-ordered system of equations and apply OLS or path analysis methods of estimation. (See original statement by Wold, 1953; Simon, 1953; and less technical restatements Heise, 1969; Goldberger, 1969.)

explanatory variable; the inefficiency of the estimation technique must be balanced against its consistency. Where large samples are available and a reasonable theory exists to account for the endogenous explanatory variable, as may be true for female labor force participation, there is no obvious reason why simultaneous equation estimation techniques should not be used.[1]

Full-information estimators, such as full-information maximum likelihood and three-stage least squares, are more efficient techniques for estimating the parameters for an entire system of simultaneous equations. With more restrictions incorporated into the estimation procedure, these estimates are more efficient, but they also appear less robust to specification error. Except under special circumstances, it does not seem necessary to use these full-information techniques across different classes of household behavioral relations until the relations are better understood. (For comparison of differences between 2SLS and 3SLS see Schultz, 1970.) A rationale may be found, however, for using Zellner's (1962) related technique to gain efficiency across cohort equations within the same class of behavior such as migration.

The simultaneous equation estimates of a system's structural equations can be solved in turn for the reduced form equations that embody the restrictions on the complete model. They should approximate those initially obtained by OLS on all exogenous variables. If direct and indirect lines of influence on fertility are sought, the traditional "path analysis" diagram can be recreated with the more satisfactory consistent estimates of the system. (For a comparison of results see Schultz, 1971b.)

If the dependent variables in several structural equations might plausibly interact with one another, one may test to determine whether they are part of a simultaneous equation system. If they are, the

[1]Analysis of various levels of aggregate and individual data poses problems for distinguishing whether prediction is satisfactory for this purpose. The coefficient of determination on R^2 is certainly not a satisfactory indicator of the predictive power, in this sense, of an auxiliary regression.

disturbances (i.e., residuals from simultaneous equation estimates) from the different structural equations are likely to be correlated. Evidence of substantial correlation implies that the stochastic shocks that account in theory for unexplained variance in a dependent variable impinge, to a degree, on these other equations in the system. An alternative interpretation would be that these disturbances incorporate not only purely stochastic shocks, but also numerous, difficult to observe, factors that are unavoidably neglected in specifying and estimating each equation. The correlation among disturbances across equations suggests, from this viewpoint, that some of the omitted variables should have entered more than one equation. To the author's knowledge, the only case in which this test of simultaneous equation bias was performed in the analysis of fertility was across behavioral equations accounting for IUD acceptance rates, birth rates, and regional doctor participation in Taiwan's family planning program. The multiple correlations among estimated residuals were statistically significant according to the χ^2 test beyond the 0.001-percent level (Schultz, 1971b). In this instance, the inconsistent OLS estimates of the system of behavior relations are substantially different from those that are obtained by simultaneous equation techniques; their implications for policy are also strikingly different.

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