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4 An Economic Interpretation of the Decline in Fertiliiy in a Rapidly Developing Country: Consequences of Development and Family Planning

T. Paul Schultz

4.1 Introduction

Parents make sacrifices to rear children. And though some rewards of parenthood are virtually immediate, other benefits cannot be realized for years or even decades. In understanding the process by which reproductive goals change, therefore, the demand for children should be interpreted as in part a demand for a *durable* input that enters into many lifetime production and consumption possibilities.[1] Given the number of children parents want, their spacing undoubtedly confers on parents relative advantages that might be explained in terms of either their life-cycle production and investment environment or their anticipated psychological and economic "returns to scale" in rearing of children at different time intervals.[2] But as yet few theoretical insights have emerged to prescribe how circumstances, even under static conditions, affect a couple's desired regime of child-spacing. Clearly, it is still more difficult to deduce how parents adjust their flow of births over the course of time as environmental changes modify their reproductive goals.

As a first approximation, therefore, reproductive goals will be summarized in terms of a desired lifetime stock of children. Accepting this working hypothesis, economists have begun to explore parent-revealed

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demands for lifetime stocks of children as though conditioned by traditional determinants of consumer and producer demand: input and output prices, income, technology, and tastes. Ignoring radically different strategies in the timing of births, demand for annual increments to the existing stock of children, or period-specific birthrates, should also be systematically related to revealed demand for a lifetime stock.[3] This paper explores empirically several aspects of the time dimension of the relationship between cohort fertility in Taiwan and the presumed determinants of lifetime reproductive goals, namely, the value of time of women and men proxied by their schooling, accumulated and recent experience of child mortality, and the availability of birth-control information and services. First, the accumulated stocks of births are analyzed by age of woman, and regional variation in this measure of cohort fertility is decomposed into effects operating through age at marriage and through birthrate per year of marriage. Second, the simplest possible stock-adjustment framework is fit to the data on reproductive stocks and flows in Taiwan to describe the dynamics of behavioral change in a population that has experienced disequilibrating demographic, social, and economic change for several decades.[4] Coefficients from stock and flow demand equations estimated for various years are then used to appraise whether in Taiwan these relationships are relatively constant across birth cohorts and over time.

Several qualifications and limitations to this investigation should be stressed at the outset, ones that cannot be corrected here for want of appropriate individual panel data or analytical tools to cope with the probable complexity of reproductive capabilities and preferences. The most serious limitation is the unit of analysis: large regional populations of women born in various time periods. These aggregates are the only units for which data are publicly available on both the stocks and flows of births in Taiwan. Investigation at the level of individuals is also imperative, permitting disaggregation by women's educational attainment, a factor that appears crucial for understanding the changing age pattern of reproductive behavior in contemporary Taiwan. Nonetheless, despite the well-known deficiencies of aggregate data, it may still be fruitful to estimate behavioral relationships at different levels of aggregation in order to document the value and limitations of each unit of analysis; to neglect widely available information on grounds of "principle" is hard to justify.

Aside from subjective preferences of parents for bearing their own children, social restrictions on their exchange in most cultures encourage parents to produce their own supply.[5] Variability in supply, or in the biological capacity to bear children, prevents some individuals in all populations from achieving their reproductive goals. Yet biological differences in the supply of births do not appear to exert a dominant effect on *aggregate* fertility except under extreme conditions of malnutrition and specific endemic disease, such as gonorrhea. It is assumed that in Taiwan recent regional differences in fertility are not substantially affected by such health and nutritional impairments to the aggregate supply of births.[6]

Most studies of the determinants of reproductive demands have dealt with high-income countries, and consequently *consumer* demand theory is emphasized. In low-income countries, children are more obviously a productive asset, at least at maturity if not always at birth (Mamdami 1973; Nag 1976). The theory of producer-derived demand for inputs might provide a framework better suited to explaining differences in fertility in developing countries. A standard model of investment behavior in a durable input assumes that demand is homogeneous of degree zero in all prices, holding constant the interest rate (Griliches 1960). But imposing this restriction appears inadvisable in this case, since a couple's demand for children is limited both because consumer benefits from children are probably satiable and because the cost of funds to invest in one's children is undoubtedly upward-sloping.[7] Producer-demand theory also relies on assumptions of constant returns to scale, competitive input and output markets, and (observable) financial markets for borrowing, none of which is appealing in the study of household demand for children.

It is still useful to explore the stylized dynamic framework of the stock-adjustment model that has been extensively used to study demand for durable producer inputs and durable consumer goods. The stock-adjustment model applied to reproductive behavior is not invoked here to prescribe the path of life-cycle accumulation against which reproductive performance of a cohort can be evaluated before it reaches the end of its potential childbearing period. This shortcoming is, of course, just another reflection of our inability to specify determinants of the spacing of births. Substantial differences remain to be explained across countries at one point in time, and among countries over time, in the relative distribution of births by age of mother.[8] However, subject to identification and estimation problems discussed in subsequent sections, information for women of a particular age can be used to infer the current speed with which the apparent gap between current stock and lifetime desired stock of children is being closed. If this response parameter is assumed constant across a society but possibly variable over time, such a parameter is estimable from interregional variation in age-specific reproductive behavior. Comparisons between stock and flow predictive equations may also help us understand how the demographic transition works its way through a population.

The paper is ordered as follows. Section 4.2 describes a few salient features of the situation in Taiwan for which a model is sought and relates the limitations of available data for testing an aggregate model. The stock-adjustment framework is adapted to reproductive behavior in the section 4.3, with discussion focused on the simplifying assumptions implied by this model and on the estimation problems. Regional variation in cohort stock fertility is decomposed in section 4.4 into marriage duration and marital fertility, to provide insight into the responsiveness to environmental change of fertility and social institutions such as marriage. The stock-adjustment model is estimated in section 4.5 and the results are discussed further in a concluding section.

4.2 Description of Taiwan and Available Data

4.2.1 Demographic Transition

Mortality declined in Taiwan, notably among adults, during the period of Japanese colonial administration of the island in 1895–1945 (Barclay 1954). Though the rise in per capita income among the Taiwanese in this interwar period was probably less than the substantial growth in agricultural productivity, food consumption by the Taiwanese increased (Ho 1966). The more dramatic second phase of mortality reduction occurred after the Second World War, with land reform and economic recovery. The greatest proportionate declines were achieved among infants and children, and, though the evidence is not firm, the rural public health program, universal education, and decreased income inequality may all have contributed to this achievement. Undoubtedly, the growth of income and personal consumption helped; since 1952 the rate of per capita economic growth has been high by world standards, particularly after 1962. Today the expectation of life at birth is 67 for men and 72 for women, not far short of that recorded in high-income countries.[9]

Though the demographic transition began building from the start of the century, the first indication of a decline in birthrates emerged in the late 1950s among older women, and then only after a moderate postwar baby boom had run its course. But in the subsequent span of twenty years, the total fertility rate—that is, the sum of annual age-specific birthrates—decreased by half (see appendix table 4.A.1). This was first caused by a reduction in the frequency of childbearing among women over the age of 30, and in the last decade the pattern of declining birthrates gradually spread to younger women. This was accompanied by a slow rise in the age at marriage (see appendix table 4.A.2), which can be traced irregularly back to the turn of the century (Goode 1970; Barclay 1954). As a consequence of the separation over time of the declines in death rates and birthrates, the annual rate of population growth in Taiwan increased from about 1% in the first two decades of this century, to 2.3% during the interwar period, and peaked at more than 3.5% during the 1950s. Population growth has begun to ease in recent years and was somewhat less than 2% per year in 1974 (appendix table 4.A.3).

4.2.2 Family Planning Program

Taiwan organized and executed one of the first, most extensively studied, and apparently most effective national family planning programs in the world. Starting in 1963 with a controlled social experiment in the city of Taichung to determine the acceptability and effectiveness of family-planning activity, in several years an islandwide program was expanded to every township and city precinct in the country (Freedman and Takeshita 1969). Analyses of regional birthrates and regional family planning activity find a strong negative partial association between the seemingly random allocation of family planning fieldworkers and the level and decline in birthrates of women over the age of 30 (Freedman and Takeshita 1969; Hermalin 1968, 1971; Schultz 1969*b*, 1971, 1974). The implied effect of program personnel on birthrates, however, diminishes from 1965 to 1968, and after about 1969 it becomes difficult to assess whether the accumulated activity of the program has continued to affect birthrates by a statistically significant amount (Schultz 1969*b*, 1971).

This finding can be explained in part as a natural cycle in the diffusion of an innovation; with the introduction of distinctly superior technology for birth control—the IUD and the pill—the period of disequilibrium behavior that follows is likely to be shortened by the subsidized dissemination of information, services, and supplies relevant to its adoption. But in contrast to the classical case of agricultural extension activities in a dynamic productive environment, there has been only one quantum advance in birth control technology, not a stream of improved inputs and combinations of inputs to enhance yields and lower costs. Hence, the family planning innovation cycle is likely to eventually meet with diminishing returns to scale (extension effort per woman of childbearing age) unless communication between generations is absent. This tendency is already evident from cross-sectional analyses of program inputs and birthrates after two years, even though the output of services and supplies distributed to the population exhibited a more nearly linear relationship for several years (Schultz 1969*b*, 1971).

Another partial explanation for the difficulty of assessing the regional effect of the family planning program after 1968 is the limitation of the small (361 subdivisions) units of analysis and the uncontrolled interregional flows of knowledge, services, and users (migration). The spillover of influence of local program activity beyond regional boundaries may have blurred the cross-sectional associations between treatments and outcomes after several years. A similar spillover effect was thought to have been a shortcoming of the Taichung City experimental design in 1963 (Freedman and Takeshita 1969).

Regardless, program activity in the initial years is unambiguously linked to lower birthrates among older women, and, as one might expect, the two classes of fieldworkers working for different government agencies appear to be substitutes for each other in bringing about this outcome (T. P. Schultz 1974). Some indications are found that those regions that were lagging in reducing their birthrates toward the levels predicted by an economic-demographic model estimated from initial period cross-sectional data were regions in which the family planning program had its greatest effect (T. P. Schultz 1974).

Possibly more important than narrowing unexplained interregional differences in reproductive performance, public support for the diffusion of modern means of birth control narrows socioeconomic class differences in contraceptive knowledge and use and thereby moderates class differentials in fertility that appear to especially penalize the upward mobility of the lower class during the transitionary period of rapid population growth (Nelson, Schultz, and Slighton 1971; Freedman and Berelson 1976). These changes in class differentials of contraceptive knowledge, use, and fertility are carefully documented in Taiwan during the 1960s and 1970s (Freedman et al. 1974), but it remains difficult to infer how much of this change is due to Taiwan's family planning program.

4.2.3 Education and Fertility

I should like to interpret educational attainment as a proxy for the "value of time" of men and women. It is appropriate, therefore, for me to marshal evidence of the relation between education and wage rates for men and women in Taiwan. But I have as yet found no primary data on this score and no published analysis of education's effect on earnings in Taiwan.[10] Though this probably reflects my inability to read the relevant Chinese literature, it does not diminish the obvious emphasis recently given to education by the government and the people of Taiwan. For example, from 1966 to 1974, the proportion of men age 20–24 with some junior high school increased 32%, from 0.44 to 0.58, while exposure to junior high school increased 125% among women of the same age, from 0.24 to 0.54. This increase in the proportion reaching junior high school in an eight-year period is all the more remarkable when one realizes that the size of the birth cohort to educate in that period also increased by about 80%.

Direct evidence is available, however, that educational attainment is associated with reproductive behavior in Taiwan, for whatever reason. Tables 4.1 and 4.2 report 1974 birthrates, calculated by date of occur-

Table 4.1 **1974 Birthrates by Age and Educational Attainment of Mother (Per 1,000, by Date of Occurrence)**

Educational level	15–19	20–24	25–29	30–34	35–39	40–44	45–49	Total Fertility Rate[a]
Illiterate and those without schooling	110.5	315.8	223.3	82.8	33.6	9.3	1.1	3,882
Literate without graduating from primary school	97.2	247.7	192.2	77.3	28.2	10.7	1.7	3,275
Primary school graduate without graduating from junior high or junior vocational school	48.7	244.3	235.7	95.3	34.6	9.7	1.7	3,350
Junior high graduate without graduating from senior high or senior vocational school	8.0	136.4	221.7	96.6	29.2	5.2	1.9	2,495
Senior high graduate without graduating from junior college or university	6.6	70.7	201.3	112.5	48.6	6.5	0.7	2,235
Junior college and university graduate, graduate school attended, graduate school graduate	11.7	37.7	163.3	101.7	41.1	8.4	1.3	1,826
All educational groups	32.2	183.3	219.0	91.2	32.7	9.3	1.4	2,846

[a]Total fertility rate is five times the sum of age-specific birthrates.

Source: *1974 Taiwan Demographic Factbook*, tables 4 and 48 for Taiwan area.

Table 4.2 **1974 Birthrates by Age and Educational Attainment of Father (per 1,000, by Date of Occurrence)**

Educational Level	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60+	Total Fertility Rate[a]
Illiterate and those without schooling	5.3	72.4	188.7	180.6	79.9	31.5	14.2	4.2	1.5	0.3	2,893
Literate without graduating from primary school	13.2	67.7	220.0	155.2	67.1	31.8	20.5	8.9	3.9	0.8	2,946
Primary school graduate without graduating from junior high or junior vocational school	8.4	83.8	261.0	177.5	67.3	28.6	18.2	8.6	3.4	0.7	3,288
Junior high graduate without graduating from senior high or senior vocational school	2.2	55.4	231.5	169.0	59.6	43.0	33.4	12.8	4.7	0.9	3,063
Senior high graduate without graduating from junior college or university	2.1	24.3	174.2	151.7	49.9	46.4	34.1	11.8	4.8	0.5	2,499
Junior college and university graduate, graduate school attended, graduate school graduate	8.9	19.0	109.7	137.0	55.3	46.2	33.3	10.1	2.6	0.7	2,114
All educational groups	4.6	57.0	218.4	167.0	64.4	33.8	23.5	9.0	3.2	0.5	2,907

Source: *1974 Taiwan Demographic Factbook*, tables 4 and 47 for Taiwan area.
[a]Total fertility rate is defined as for women as five times the sum of the age-specific birthrates.

rence, for mothers and for fathers, by age and educational attainment. Three things may be noted. A sharp reduction in total fertility rates (i.e., sum of age-specific birthrates times five) occurs among women going beyond primary school. If the distribution of education must be summarized by a single measure, the distinctly nonlinear relationship with fertility is perhaps better represented by the proportion continuing to junior high school than by an average number of years of schooling (implying a linear relationship), or by another higher cutoff point such as college education, which is further from the mode of the educational attainment distribution.

The second observation drawn from table 4.1 is more tenuous, for here the cross section of age groups is used to infer the longitudinal pace of reproduction. In 1974, better educated women start having births at a later age than do less educated women, but they also appear to continue bearing children somewhat longer, into their thirties. This is a relatively new pattern in later age- and education-specific birthrates in Taiwan that was less evident in 1971 or 1966 (Anderson 1973; *Taiwan Demographic Factbook* 1974, p. 15; Freedman et al. 1976). To investigate these changing patterns of childbearing would require information on stocks and flows of births by educational group, which are not published. These changes in the timing of childbearing may explain why earlier analyses of cross-sectional changes in birthrates found that the negative effects of women's education on birthrates were attenuated after age 34 (T. P. Schultz 1974). The partial association between current births and sex-specific educational attainment may be seen more clearly when conditioned on the number of children already born to various educational groups.

The third regularity to note is the lesser, more ambiguous variation in birthrates with father's education (table 4.2) than with mother's education (table 4.1). From illiterates to those with higher education, mother's total fertility rates decline almost monotonically by 53%, whereas father's total fertility rates rise 13%, peaking among primary school graduates, and then fall 28% below the level of those men with no education. Since the correlation between husband's and wife's education is substantial in most societies, we should expect the partial effect of women's education, holding husband's education (and earnings) constant, to be even more negative, and conversely, the partial effect of men's education to be less negative and perhaps even positive. This result would be consistent with our expectation that the income effect of men's earnings will outweigh their price-of-time effect, but the price-of-time effect embodied in women's value of time (education) will outweigh the income effect, reducing reproductive demands as women's education rises (Willis 1974; Schultz 1976; Ben-Porath 1975).

Though the advance of women in secondary schooling relative to men has already been cited, table 4.3 presents the parallel data for literacy and higher education and extends the data series to earlier birth cohorts. Though women have gradually increased their literacy, as have men, the notable advance of women into secondary and higher education has occurred largely since 1950. It may be asked, How much of the decline in fertility has been due simply to the increased educational attainment of women? Partitioning the change in crude birthrates into changes in women's age composition, educational composition, and a residual change *within* age/education cells, it was found that 24% of the decline in age-specific rates from 1966 to 1974 was accounted for by change in the distribution of women by five educational classes (Freedman et al. 1976).

4.2.4 Child Mortality and the Demographic Transition

For reasons that may be intuitively plausible, if not derived from a simple formal model of reproductive behavior, fertility is generally higher in populations that experience higher child mortality rates. At the regional or individual level, differences in child mortality are observed to be directly associated with differences in fertility, moderating

Table 4.3 **Educational Attainment at Ages 20 to 24, by Year of Birth and by Sex (Percentages)**

Minimum Educational Level	1950–54	1942–46	1932–36	1922–26	1912–26
Literate					
Men	99	97	90	85	69
Women	96	82	66	46	26
With some junior high school					
Men	58	44	27	34	20
Women	54	24	11	11	6
With some higher education					
Men	16	10	5	7	6
Women	10	5	1	1	1

Source: 1950–54 birth cohort—*1974 Taiwan Demographic Factbook*, table 4. Earlier cohorts—1966 Taiwan census, vol. 2, no. 3, table 2.
Note: The 1950–54 birth cohort is observed in 1974, before all members may have attended a higher educational institution. The earlier cohorts are all observed as of 1966 (census), and it is therefore assumed that no differential mortality by educational level affects their enumerated composition at that later date. The emigration of close to a million Chinese from the mainland in the post–Second World War period notably augmented the male proportion with secondary and higher education in the cohort born between 1922 and 1926 and residing in Taiwan in 1966.

and sometimes reversing the cross-sectional pattern between mortality and size of surviving family. This evidence is strongly suggestive of a mechanism, probably both involuntary (biological) and voluntary (behavioral) in nature, that achieves some manner of population equilibrium given environmental health and economic constraints (Schultz 1967, 1976; Dumond 1975). But existing evidence does not explain how such modifications in fertility are accomplished, or how rapidly they occur as the regime of mortality changes. Knowledge of the mechanisms involved and of the lags in adjustment is essential to assessing the duration of the current phase of rapid population growth in low income countries and to appraising the gains and losses from policy interventions that seek to improve nutrition and health and thereby to reduce mortality more rapidly.

The data from Taiwan may be useful in exploring these questions; the Household Registry System appears to be a relatively accurate source of current information on fertility and mortality; the 1966 census retrospective information from women on their number of children ever born and the survival status of their offspring is internally consistent and plausible in all regions of the island. It is possible, then, in Taiwan to hold past child losses constant and examine how the recent regional variation in child mortality is associated with current fertility.

4.2.5 Overview of Available Data

The unit of analysis is a highly aggregated region of Taiwan: five major cities and sixteen counties. Only for these large subdivisions are the number of children ever born and the number of children living reported by region and age of woman (1966 census). The Household Registry System has published information since 1961 on births by age groups of mothers, and deaths by age of the deceased. A number of assumptions are made to estimate the stock of children ever born and the number living for earlier and later years, using as a benchmark the birth cohorts as enumerated in the 1966 census.[11]

The marital status of women is reported by age groups and distributed according to the year of first marriage (1966 census). The relationship between mean age of a cohort and mean age of first marriage is approximated within each region and used to interpolate regional estimates for the standardized five-year age groups for which fertility data are available. Births are not published, to my knowledge, by current age of woman and age of marriage.

Educational attainment of the population is available in various censuses by age and sex and has recently been published by the Household Registry System. Data on regional economic conditions are regrettably scarce for Taiwan. A Household Income and Expenditure Survey is tabulated by regions for the first time in 1970, but sampling variability may be a serious limitation of these data as well as the lack of disaggregation by age and educational attainment of household head. The unweighted means and standard deviations of variables used in later analyses are summarized in appendix table 4.A.4.

Since the regional observations for Taiwan coincide with five cities and sixteen less urbanized and rural areas, it could be anticipated that relationships noted between fertility and such conditioning variables as child mortality and schooling could simply reflect urban/rural differences. If, in fact, other environmental conditions called "modernization" or culturally induced "norms and tastes" were responsible for urban/ differences in fertility, then a causal role might be erroneously attributed to health and education. Unless a case is made for the exogeneity of observable variables that produce the conditions of "modernization, norms, or tastes," it is difficult to conclude that these alternative factors are better or worse at explaining fertility than child mortality and sex-specific schooling. It is of some interest, nonetheless, to determine how much of the partial association between fertility and specific characteristics such as child mortality and schooling is captured by the direct admission of different levels of fertility (stocks and flows) in urban and rural regions. To perform this test, an urban dummy variable is introduced into the explanatory model, even though we are unable at this time to pinpoint precisely what objective features of the urban and rural environment might be responsible for such shifts in behavior.

4.2.6 Conclusions

Taiwan was launched into the demographic transition by changes in social and economic organization first imposed by the Japanese, followed by heavy investments in the agricultural infrastructure (Barclay 1954; Ho 1966). Deeper structural change in the ownership of productive assets after the Second World War facilitated rapid industrialization and urbanization, while policies also promoted the rapid modernization of small-scale agriculture. Costly investments in education and public health accelerated the declining trend in death rates and possibly fostered labor mobility, both developments that are closely associated with modern economic growth and enhanced labor productivity. The remarkable pace of recent economic growth and fertility decline holds out the possibility that more could be learned from this unusual period that would have somewhat wider applicability and relevance for policy: What was the role of growth in economic product, investment in human capital, intervention to hasten the adoption of modern birth control technology, and the peculiar social and economic institutions of Taiwan? The available data, though exceptional with respect to aggregate demographic detail, limit the goals of this study to the examination of crude proxies for the level and composition of personal household income and relative prices. To refine further the questions that currently occupy economic demography, it may be necessary to analyze household economic information, which will almost certainly entail the use of sample surveys to collect time-budget data as well as income, wealth, and expenditure detail (see Kelley's chapter in this volume).

4.3 A Stock-Adjustment Model of Reproduction

My objective is to estimate an adaptive model of demand for a durable good—children—that might clarify the process by which reproductive behavior responds over time to disequilibriums caused by economic and demographic change. A framework to account for both stocks and flows of births may also provide a means for modeling the important component decisions that determine reproductive performance—the timing of marriage and the spacing of births. The standard variety of rigid stock-adjustment model is proposed as only a useful starting point for such exercises.

To simplify the task, I neglect certain aspects of the problem that might elicit different strategies of decision-making in forming a family. A couple's reproductive preferences are represented by a *single-valued indicator* of their desired lifetime stock of births. Several strong assumptions are implied. First, it is assumed that preferences among alternative family size outcomes greater or less than the single-valued goal do not influence reproductive outcomes. In fact, given the uncertainty that attaches to both the biological capacity to bear children and their subsequent survival and development, parents probably weigh the consequences of a wide range of family-size outcomes that are likely to occur with different probabilities conditional on their behavior (Schultz 1967). Some segments of society exceed their reproductive goals and others fall short of them, possibly because their preferences are asymmetric in the vicinity of their single most preferred family-size goal. Pioneering research on the measurement and interpretation of family-size preferences indicates that asymmetries in these preferences may be important for understanding differences in fertility in Taiwan, at least at the level of the individual survey respondent or across education classes (Coombs 1974, 1976; Coombs and Sun 1978). When regions are the unit of analysis within a single cultural area, this assumption may be somewhat less restrictive.

The second simplification is required to deal with child mortality. The frequency of child mortality is undoubtedly affected by the availability of household resources, by production and consumption technology, and by relative prices, and in some circumstances it may even reflect allocative decisions and preferences of household members, all of which are to some degree endogenous. Nonetheless, it is widely believed that regional and time-series variation in aggregate mortality rates is attributable primarily to climate, public investments, available drugs and medical knowledge, and modifications in social organization, not to household decision-making. Therefore, given the scarcity of predetermined factors that are thought to influence reproductive behavior, I shall treat child mortality here as exogenous to the fertility decision.[12]

The consequences of child mortality for reproductive goals and behavior are too complex for me to simply restate demands in terms of "surviving children."[13] In the long run, as the level of child mortality decreases the number of births needed to achieve a given number of survivors decreases, and the average cost of rearing a child to maturity decreases, while at the same time all investments in the human agent, including children, appreciate in value (Schultz 1976). Though an economist may aspire to sort out these offsetting supply, price, and also wealth and cross-substitution effects of mortality on the demand for births, the essential question for population growth is simply the overall magnitude and time path by which fertility adapts to change in mortality (see Ben-Porath's paper in this volume).

4.3.1 A Simple Framework for the Joint Analysis of Stocks and Flows

With these simplifications, I assume that parents, at a particular time t, desire a specific number of births, $C_t{}^*$, over their lifetime. Demand for this durable stock will depend upon what people expect of the future and, of course, on their own preferences. The formation of expectations must be expressed in terms of current or past conditioning variables. Psychological and economic aspects of habit persistence, perception, information-processing, and uncertainty are all cited as justifications for assuming the existence of distributed lags mediating the effect of stimuli on behavior (Nerlove 1958).

(1)
$$C_t{}^* = \alpha + \sum_{i=1}^{M} \sum_{j=1}^{n} \beta_{ij} Z_{i,\, t-j-1} + u_t,$$

where the Z_i's are M conditioning variables whose effect on C^* extend for n periods, α and β_{ij} ($i = 1, \ldots, M$; $j = 1, \ldots, n$) are parameters, and u_t is a residual disturbance that represents the net effect of many omitted factors and any errors of approximation in the functional form of the relationship. Given the central role of multiplicative interactions between births, child survival rates, surviving offspring, and price effects reflected in the *relative* educational attainment of women to men, the dependent and independent variables in equation 1 are all expressed in (natural) logarithms, unless otherwise noted.[14]

Primarily for biological reasons, a lapse of time is required for the realization of desired increments to the existing stock of births, just as technological (and economic) factors introduce lags between capital investment decisions in plant and equipment and realized increases in productive capacity. Though the human gestation period is only three-fourths of one year, the median interbirth interval for couples who report they want an additional birth immediately varies from one to three years, depending on age of spouses and perhaps on their health and nutritional status.[15]

A conventional representation of the stock-adjustment process assumes that a proportion, $\delta(a)$, of the relative difference between desired stock and the actual stock is delivered in each time period. For the study of reproduction, a minimum lag of a year for conception and gestation seems appropriate.

(2) $$C_t - C_{t-1} = \delta(a)(C^*_t - C_{t-1}) + f(a),$$

where $0 < \delta(a) < 1$, the index a being possibly related to a woman's age, for reasons of biological reproductive capacity and the desired relative distribution of births over the reproductive period, and $f(a)$ is an excess fertility function discussed below. Actually, the speed of reproductive adjustment is affected by many considerations, only the most obvious and perhaps not the most important of which is the biological constraint imposed by reproductive potential. Given a lifetime reproductive goal of three children, and a tendency to have one birth every third year after marriage before terminating childbearing, one might expect $\delta(a)$ to be about 0.1 at the start of marriage. The relationship may deviate from log-linearity when large increases are sought, and of course decreases in the stock are inadmissable. These shortcomings of the stock-adjustment framework for the study of reproductive behavior are analogous to widely recognized but frequently ignored defects of the framework for analysis of investment behavior. But more serious, in my judgment, is the inability to deal explicitly with the imperfect control a couple exercises over the accumulation of stocks.

Because of birth control failures, some women wanting no more children have births. Consequently, even when a cohort's average number of births equals or exceeds the average preferred number of births, some women may prefer more children and will therefore continue to try to have additional births. Table 4.4 shows this "excess" fertility by mother's education and age, as reported in a recent survey of Taiwan (Freedman et al. 1976). The precise behavior of $f(a)$ with respect to age is not clear, since the proportion of women wanting no more children (column 5 or 7) rises with age, whereas their current-period reproductive capacity decreases with age. To sort out the offsetting factors that underlie $f(a)$ requires individual survey data on preferences and reproductive performance, or substantially stronger assumptions (see Lee 1976). At

Table 4.4 **Actual and Preferred Number of Births of Wives in 1973, Proportion Currently Married in 1971, and Birthrate in 1974, by Age and Education**

Age and Education	(1) Sample Size Wives KAP-IV 1973	(2) Mean Live Births 1973	(3) Mean Preferred Number of Children 1973	(4) Differences Between Preferred and Actual (3) − (2)	(5) Proportion of Wives Wanting No More Children 1973	(6) Proportion Currently Married 1971	(7) Estimate Wanting No More Children[a] (5)·(6)	(8) Birth Probability or Rate 1974
Ages 20–24								
Illiterate	135	2.11	3.31	1.21	.341	.738	.252	.304
Some primary school	98	1.95	3.05	1.10	.398	.704[b]	.280	.250
Primary school graduate	729	1.61	3.03	1.42	.276	.545	.150	.249
Junior high graduate	88	1.30	2.63	1.33	.205	.338	.069	.133
Senior high graduate	79	.87	2.44	1.57	.165	.171	.028	.074
Total	1,129	1.62	2.99	1.37	.281	.480	.135	.193
Ages 25–29								
Illiterate	248	3.09	3.35	.26	.641	.939	.602	.217
Some primary school	127	3.06	3.24	.18	.654	.931[b]	.609	.192
Primary school graduate	792	2.73	3.12	.40	.562	.889	.500	.248
Junior high graduate	157	2.25	2.68	.43	.541	.811	.439	.219
Senior high graduate	149	1.52	2.42	.90	.389	.691	.269	.209
Total	1,473	2.65	3.05	.40	.563	.870	.490	.228
Ages 30–34								
Illiterate	509	4.06	3.61	− .45	.841	.948	.772	.078
Some primary school	164	3.86	3.38	− .48	.817	.958[b]	.783	.075
Primary school graduate	623	3.65	3.27	− .28	.830	.933	.774	.098
Junior high graduate	104	3.29	2.97	− .32	.856	.910	.779	.095

Table 4.4 (continued)

Age and Education	(1) Sample Size Wives KAP-IV 1973	(2) Mean Live Births 1973	(3) Mean Preferred Number of Children 1973	(4) Differences Between Preferred and Actual (3)−(2)	(5) Proportion of Wives Wanting No More Children 1973	(6) Proportion Currently Married 1971	(7) Estimate Wanting No More Children[a] (5)·(6)	(8) Birth Probability or Rate 1974
Senior high graduate	102	2.55	2.60	.05	.794	.848	.673	.112
Total	1,502	3.71	3.33	.38	.832	.935	.770	.091
Ages 35–39								
Illiterate	497	4.63	3.79	− .84	.918	.949	.871	.034
Some primary school	295	4.78	3.71	−1.07	.946	.953[b]	.902	.029
Primary school graduate	502	4.19	3.52	− .67	.902	.925	.834	.035
Junior high graduate	88	3.74	3.07	− .67	.932	.918	.856	.027
Senior high graduate	52	2.96	2.63	− .33	.827	.908	.751	.030
Total	1,434	4.39	3.60	− .79	.916	.938	.859	.032

Sources: Col. 1–5, R. Freedman et al (1976, table 10); KAP Survey IV (1973), Wives; col. 6, ibid., table 8; col. 8, ibid., table 7 and *Taiwan Demographic Factbook, 1974*, table 18, based on date of registration.

[a]This estimate is based on the extreme assumption that those women not currently married would want (more) children if they could become married.

[b]Categories called literate appear to refer to persons who are literate but not graduates of primary school.

the aggregate level of analysis undertaken here, $f(a)$ is simply interpreted as a margin of excess fertility that cannot now be statistically distinguished from $\delta(a)\alpha$.

The annual flow of births or the birth probability is defined,

$$(3) \qquad B_t = e^{C_t} - e^{C_{t-1}},$$

since the stock of births are expressed in logarithms. Substituting equation 1 into equation 2, a function for the growth of the stock of births is obtained.

$$(4) \qquad C_t - C_{t-1} = \delta(a)\alpha + f(a) + \delta(a) \sum_{i=1}^{M} \sum_{j=1}^{n} \beta_{ij} Z_{i,\, t-j-1} - \delta(a)C_{t-1} + \delta(a)\mu_t.$$

If we collapse the expectation formation distributed lag into a discrete lag of τ years, say the mean length of the underlying distributed lag, then either the flow of births relative to prior stock as in equation 4 or the current period as in equation 5 below becomes a simple expression of prior stock and discretely lagged conditioning variables.

$$(5) \qquad C_t = \delta(a)\alpha + f(a)\ \delta(a) \sum_{i=1}^{M} \beta_i Z_{i,\, t-\tau} + (1 - \delta(a))C_{t-1} + \delta(a)\ \mu_t.$$

Either equation 5 or a comparable discretely lagged version of equation 4 yields identical parameter estimates and standard errors. The high collinearity between C_t and C_{t-1} yields, however, a higher R^2 in equation 5 and an "inflated" value of the t ratio for the coefficient on C_{t-1}. Hence, results are subsequently reported in terms of the flow equation 4.

Commonly $\delta(a)\beta_i$ is interpreted as a short-run (one year plus τ) demand elasticity with respect to Z_i, and β_i is the analogous long-run demand elasticity. This interpretation, however, is not appropriate here for the long run, since the value $\delta(a)$ is fixed only for a birth cohort five years in breadth. For example, if $\delta(a)$ was 0.1, and the coefficient estimated on $Z_{i,\, t-\tau}$ was 0.5, the short-run elasticity would be 0.5, and the five-year elasticity for a woman to pass through this segment of her life cycle cannot be readily inferred from information about an age cross section.

4.3.2 Estimation

Even when $\delta(a)$ is assumed constant, as may be tenable within a narrow age group, the estimation of equation 5 presents problems. Many of the omitted factors that account for the residual μ_t, in the desired stock equation 1, persist for an individual population over time or for a cohort as it ages. The disturbances are therefore likely to be positively serially correlated over time, at least toward the end of the childbearing period, and ordinary least-squares (OLS) estimates will be biased because C_{t-1} will tend to be positively correlated with $\delta(a)\mu_t$. Notably, the OLS estimates of $(1 - \delta(a))$ will tend to be biased upward (positively), and, conversely, estimates of $\delta(a)$ are biased downward (negatively) (Nerlove 1958; Griliches 1960, 1961).

This simultaneous equation bias can be eliminated if the prior stock is separately identified with additional information or, in this case, if one or more instruments are obtained that are independent of μ_t but are related to C_{t-1}. These instruments act as important identifying restrictions on this model of reproductive behavior; they determine the meaningfulness of the entire exercise.[16]

The lagged fertility stock variable can also be replaced by its determinants, and by repeating this substitution process until the start of the cohort's reproductive period we can eliminate all lagged values of C from the equation. This reduced form of the equation would require simplification to be empirically practical. In the case of conditioning factors, Z's, that did not change from the start, a single long-run response coefficient could be estimated. The response to accumulated cohort child mortality is less adequately incorporated into such a model, for in this case the dynamic path of adjustment to the timing of the child mortality may be important. But it seems a useful exercise, nonetheless, to compare the short-run response coefficients obtained from flow equation 5 with the long-run response coefficients obtained from even a simplified reduced-form stock equation. In the next section, I will discuss empirical specification of Z and the choice of identifying restrictions that permit one to estimate the stock and relative-flow equations.

4.4 Duration of Marriage and Marital Fertility Rate: Estimation of Reduced Forms

Reproductive behavior in Taiwan is first summarized by fitting reduced-form relationships for the stock of children ever born per woman by age as reported in the 1966 census. Within five-year birth cohorts a logarithmic specification is estimated from data for twenty-one administrative regions of the island.[17] The following cohort-specific explanatory variables are considered: (*a*) the reciprocal of the accumulated child survival rate; (*b*) the proportion of women with some junior high school education as a proxy for the value of a mother's time; (*c*) the proportion of men with the same level of schooling (of the same age)[18] as a proxy for male labor earnings; and (*d*) the man-months of family planning fieldworker activity in the region per woman of childbearing age—15 to 49. All but the family planning input variable are expressed in logarithms and derived directly from the 1966 census.

Since cohort fertility may vary because of variation in either the timing of marriage or the level of marital fertility, these multiplicative components are treated as dependent variables in subsequent parallel logarithmic regressions. The sum of the regression coefficients (or elasticities for those in logs) from the component equations equals the regression coefficient from the overall cohort fertility regression; the two-way decomposition of the logarithmic variance of fertility thus is straightforward.

If those married in a given cohort were married for the same number of years, on average, across regions, the readily observed proportion married at a specific age would be a reasonable proxy for the mean duration of marriage, except for a scale factor (constant) that would change with current age. The nearly universal exposure of Taiwanese women to marriage, however, makes this assumption unsatisfactory among older women when variation in the proportion ever married is relatively minor. For example, by age 35, 98% or more of Taiwanese women have been married.[19]

More satisfactory figures for age at marriage are obtained from 1966 census tabulations of married women by current age and age at marriage. How mean age at marriage is estimated from published data within regions is explained in the second part of Appendix B, and estimates of marital duration are reported in table 4.A.8.[20] The logarithm of cohort fertility is then linearly decomposed into two dependent variables: (1) the logarithm of the average years of exposure to marriage per woman, and (2) the logarithm of the residually defined annual marital fertility rate—namely, the number of children born divided by the years of marital exposure. Since fertility may vary over the life cycle, the level of marital fertility rates may be expected to reflect this, and the constant terms are likely to decrease among older age groups.[21]

4.4.1 Cohort Fertility

Among women over age 30, when childbearing is nearly completed, the proportion of women with some junior high school education is negatively associated with cohort fertility (table 4.5). The absolute value of the elasticity of fertility with respect to this measure of women's schooling increases in the cross section to age 44, then diminishes (later ages not shown). The partial association between men's schooling and reproductive performance is less uniform, though a positive partial association is evident between the ages 20–24 and 30–39. The hypothesis that in the postwar era the growth in men's schooling, and presumably income, is associated with increased demand for children is not rejected by these data.[22] After age 24 the women's education coefficient (elasticity) exceeds the men's in absolute value, and though the level of women's education is lower than the level of men's, it has recently been

Table 4.5 **Regressions on Cohort Fertility or Stocks: Logarithm of Children Ever Born per Woman by Age in 1966**

Age of Women	Constant Term	Cohort Child Mortality[a]	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning up to 1965[b]	R^2 (SEE)[c]
15–19	−2.98	20.1	1.07	−1.61	−144.0	.3628
	(6.83)	(1.75)	(1.50)	(1.17)	(1.09)	(.366)
20–24	−.613	22.1	−.269	.664	12.6	.6789
	(4.21)	(5.56)	(1.57)	(2.33)	(.31)	(.111)
25–29	.562	5.94	−.0886	.0542	9.21	.8062
	(10.2)	(5.07)	(1.54)	(.58)	(.64)	(.0403)
30–34	1.07	3.28	−.0992	.0686	−9.81	.8913
	(32.7)	(5.90)	(4.09)	(1.79)	(1.11)	(.02410)
35–39	1.26	1.77	−.148	.103	−17.7	.8865
	(32.4)	(3.87)	(6.29)	(2.76)	(1.69)	(.0289)
40–44	1.31	.680	−.168	.0761	−17.3	.8777
	(26.7)	(1.59)	(5.01)	(1.18)	(1.31)	(.0366)
45–49	1.38	−.335	−.118	−.0452	−3.33	.8422
	(20.8)	(.78)	(3.10)	(.65)	(.19)	(.0466)

Note: Numbers in parentheses beneath regression coefficients are *t* values. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, nos. 2 and 3.

[a]Reciprocal of cohort's proportion of children ever born who are still living as reported in 1966 census.

[b]Man-months of family planning fieldworker effort expended in region through calendar year 1965, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]Standard error of regression estimate is reported in parentheses beneath R^2.

increasing at a much faster rate than has men's. Similar results are found for both sexes when other levels of educational attainment are used in place of junior high school.[23]

Child mortality is positively associated with cohort fertility among women under age 45; after age 20–24 the magnitude of the elasticity of fertility with respect to child mortality falls with age. The regression coefficient on child mortality changes to a negative sign among still older cohorts but loses statistical significance. Among women over age 39, interregional variation in cohort fertility is insufficient to "offset" variation in child mortality. In other words, since the child mortality elasticity is less than +1.0, areas of relatively high fertility report relatively high surviving fertility. Among younger women the reverse is noted; high-fertility areas are associated with relatively low surviving fertility, other things equal. Problems of measurement lead one to suspect that the coefficient on child mortality is biased in a positive direction, but the magnitude of this bias is likely to be substantial only for the younger women.[24]

4.4.2 The Timing of Marriage and Marital Fertility

In diverse premodern and preindustrial societies it is observed that the age at marriage is an important regulator of lifetime reproductive performance. To perpetuate society and maintain family lines in the face of heavy child mortality, couples are encouraged to marry and start bearing children at an early age. This institutionalized adaptation to the regionally *anticipated* level of mortality relieves individual couples of some of the burden of controlling their fertility within marriage in response to actual child mortality (Dumond 1975). A couple's fertility might then respond to whether it experienced above- or below-average child losses, but this latter within-marriage *lagged* response to child mortality might be difficult to distinguish with aggregate data.

The median age at marriage in Taiwan increased from about 18 at the turn of the century (Goode 1970) to 21 in 1940, and to about 25 today (cf. table 4.A.2). Assuming that contemporary birthrates for married women did not change, delaying marriage six years from age 18 to age 25 implies two fewer births per woman; compared with traditional cohort lifetime fertility of five or six births, this represents a reduction in cohort fertility of one-third. An understanding of the causes for this magnitude of secular change in the timing of marriage or even lesser differences across regions should be a help in explaining fertility declines.

The questions I want to explore are the extent to which age at marriage accounts for regional differences in cohort fertility, and whether these patterns of marriage are readily explained by conditioning economic and demographic variables that are thought to modify reproductive demands. In the traditional Chinese family the timing of the marriage decision is, for the most part, made by parents for their children, and relaxation of this control is a quite recent phenomenon (Wolf 1972). The age at marriage, therefore, is likely to reflect the parents' perception of the benefits and costs of earlier marriage, of which the interval to childbearing is probably important, as well as the time parents require to accumulate a girl's dowry. Conversely, the frequency within marriage and the lifetime number of births may reflect to a greater degree the perceptions and interests of the younger generation of parents. The economic incentives of a husband's and wife's value of time are more likely to make themselves evident in this later decision-making process, though admittedly the dividing line between generations and their respective interests is not always clear (Ben-Porath 1975).

The regressions on the estimated duration of marriage and marital fertility rate are shown in tables 4.6 and 4.7. The duration of marriage

Table 4.6 Regressions on Duration of Marriage: Logarithm of the Average Years of Exposure to Marriage per Woman by Age in 1966

Age of Women	Constant Term	Cohort Child Mortality[a]	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning up to 1965[b]	R^2 (SEE)[c]
15–19[d]	−2.92	20.1	.775	−1.48	−137.	.3081
	(6.00)	(1.57)	(.98)	(.97)	(.93)	(.409)
20–24[d]	−.177	25.0	−.356	.696	−7.68	.6384
	(.93)	(4.81)	(1.59)	(1.86)	(.15)	(.145)
25–29	1.37	6.11	.0676	−.199	20.2	.6146
	(16.0)	(3.36)	(.76)	(1.37)	(.90)	(.0626)
30–34	2.19	2.18	−.0060	−.0265	6.92	.5340
	(45.0)	(2.65)	(.17)	(.47)	(.53)	(.0357)
35–39	2.63	1.04	−.0065	−.0162	7.22	.5287
	(79.1)	(2.66)	(.32)	(.51)	(.80)	(.0247)
40–44	2.95	.507	.0053	−.0327	4.90	.4583
	(107.0)	(2.11)	(.28)	(.90)	(.66)	(.0205)
45–49	3.18	.315	.0124	−.0353	4.41	.4627
	(126.0)	(1.94)	(.86)	(1.35)	(.68)	(.0177)

Note: Numbers in parentheses beneath regression coefficients are t values. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, nos. 2 and 3.

[a]Reciprocal of cohort's proportion of children ever born who are still living as reported in 1966 census.

[b]Man-months of family planning fieldworker effort expended in region through calendar year 1965, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]Standard error of regression estimate is reported in parentheses beneath R^2.

[d]Marital duration calculated by indirect procedure for women less than 25 years old. See Appendix B. Regression coefficient for cohort child mortality is biased upward because of measurement error, particularly for younger women, as explained in text and note 25.

within an age group is associated with the regional incidence of child mortality among all cohorts of women over age 20. The regression coefficients from the marital-duration equation for women age 30–34 (table 4.6), imply that a decline in child mortality from 15% to 5%, as is recorded between women age 45–49 and 30–34, is associated with a compensating variation in age at marriage of nearly two years, other things unchanged. Though this estimate is probably biased upward because of problems of measurement,[25] the linkage between child mortality and the timing of marriage deserves further study to find out why it arises, how fast it responds to change, and whether economic and social policies can encourage this potentially important institutional response to diminished mortality.[26]

Table 4.7 **Regressions on Marital Fertility Rate: Logarithm of Children Ever Born per Year of Marital Exposure by Age in 1966**

Age of Women	Constant Term	Cohort Child Mortality[a]	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning up to 1965[b]	R^2 (SEE)[c]
15–19[d]	−.0599 (.58)	.0379 (.01)	.290 (1.72)	−.126 (.39)	−6.76 (.22)	.4906 (.0873)
20–24[d]	−.436 (7.62)	−2.91 (1.86)	.0863 (1.28)	.0325 (.29)	20.2 (1.28)	.5352 (.0435)
25–29	−.805 (10.8)	−.169 (.11)	−.156 (1.99)	.253 (1.99)	−11.0 (.56)	.2315 (.0548)
30–34	−1.12 (20.5)	1.09 (1.19)	−.0931 (2.32)	.0950 (1.50)	−16.7 (1.14)	.4839 (.0399)
35–39	−1.38 (24.5)	.723 (1.09)	−.142 (4.15)	.119 (2.21)	−24.9 (1.64)	.6939 (.0418)
40–44	−1.64 (26.5)	.172 (.32)	−.173 (4.11)	.109 (1.34)	−22.1 (1.33)	.7785 (.0460)
45–49	−1.80 (24.0)	−.650 (1.34)	−.130 (3.03)	−.0099 (.13)	−7.72 (.40)	.7828 (.0529)

Note: Numbers in parentheses beneath regression coefficients are *t* values. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, nos. 2 and 3.

[a]Reciprocal of cohort's proportion of children ever born who are still living as reported in 1966 census.

[b]Man-months of family planning fieldworker effort expended in region through calendar year 1965, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]Standard error of regression estimate is reported in parentheses beneath R^2.

[d]Marital fertility rate calculated by indirect procedure for women less than 25 years old. See Appendix B. Regression coefficient for cohort child mortality is biased downward because of measurement error, particularly for younger women, as explained in text and note 25.

The proportions of men and women with junior high schooling are not consistently related to women's age at marriage, except perhaps among older women, namely those over age 44 in 1966 (table 4.6). In older groups (not shown), there is a slight tendency for women to marry earlier in regions where women had more access to secondary schooling; conversely, men's schooling is associated with somewhat later marriage among women, as is common today in high-income countries.

Marital fertility rates are not consistently associated at the regional level with child mortality (table 4.7), but a negative bias at younger ages is anticipated. The schooling variables, which are interpreted as the value of husband's and wife's time, account for much of the regional variation in later marital fertility rates; in other words, birth control within marriage is strongly affected by schooling in the anticipated manner, with women's schooling depressing fertility and men's schooling augmenting it.

When both men's and women's schooling increase by similar proportions, marital fertility rates decrease among women over age 34. But, given the actual proportionate changes in the past eight years (1966–74) in men's and women's schooling for those age 20–24 (table 4.3), the regression equations imply a 7% reduction in marital fertility rates for women age 25–29, 9% for age 30–34, 14% for age 35–39, and 19% for age 40–44. Since sex-specific levels of schooling are not notably associated with the regional pattern of marriage, the effect of the expansion of the educational system, and in particular the relative gains women have made in that system in the past twenty years, accounts for large decreases in cohort fertility between the ages of 35 and 49.

Two years after the start of the national family planning program there are already indications that local program activity is beginning to modify the regional pattern of completed fertility among older women (table 4.5). But for women 35 to 39 in 1966, only about 6% to 8% of their children were born in 1965 and 1966. Thus the impact of the program on their completed fertility must inherently be marginal, and naturally this effect operates through reducing marital birthrates (table 4.7).

4.4.3 Tentative Conclusions

Among younger women reaching their thirties in the later 1960s, regional variation in age at marriage appears to have overcompensated for remaining regional differences in child mortality. In regions with relatively high fertility and high child mortality, these younger cohorts are achieving traditional reproductive goals at an earlier age than did their parents' generation. If marital fertility is not excessively difficult or costly to control, these younger women seem likely to reduce their flow of additional births in the decade following the 1966 census.

Since a single cross section of a population by age provides no way to disentangle life-cycle effects from birth-cohort or time-series effects, the tendency for the elasticity of cohort fertility with respect to child mortality (table 4.5) to diminish with age admits to more than one interpretation.

Mortality in Taiwan appears to have declined most rapidly in two periods: during the first decade of this century and again from 1945 to 1955. For women over age 44, born before 1921, childbearing was largely completed during the second period. Moreover, many of the offspring of these older women may have died in the dislocation and conflict of the war years and their aftermath of epidemics. A smaller reproductive response relative to accumulated child losses among these older cohorts might be anticipated.

Alternatively, as a cohort advances through its life, the elasticity of fertility with respect to child mortality may be expected to decline, because offspring continue to die after their mother is unable to replace them with additional births. This gradual process should be increasingly noticeable after women reach 35 and average fecundity falls. The marked decline in reproductive response to child mortality with increased age can therefore be explained in terms of either life-cycle aging or changing historical events. It is also possible that errors in measuring child survival to a comparable age and the possible relationship between early childbearing and infant loss might exaggerate the positive association noted here between fertility and cohort child mortality, especially among younger women.

In sum, fitting a simple reduced-form equation for stocks of children confirms the commonly found positive relationship with child mortality, the negative relationship with women's schooling, and a slight indication that men's schooling is positively related to fertility. The family planning program inputs after two years are slightly related to lower completed fertility among women over age 29, which replicates earlier analyses of birthrates and family-planning activity at a lower level of disaggregation (Schultz 1969*b*). The regional cohort association with child mortality is primarily explained by the earlier age of marriage in high-mortality regions. On the other hand, the anticipated effects of regional sex-specific schooling levels on fertility is not achieved by variation in the timing of marriage, but by changes in the rate of births per year of marriage duration. The effect of women's schooling on marital fertility rates is negative and consistent across age groups, substantially exceeding the summation of positive men's schooling elasticities. The advance made by Taiwanese women, both absolutely and relative to men, in gaining access to secondary schooling in the postwar period can thus account for a substantial fraction of the contemporary decline in cohort fertility. If these cross-sectional relationships are stable over time, which will be investigated in the next section, they also imply that the recent decline in fertility will continue.

4.5 A Stock-Adjustment Model for Current Fertility in 1967

The flow of births in 1967 as a proportion of the prior stock of births in 1966 is the dependent variable in the simplified stock-adjustment equation 4. Both ordinary least-squares (OLS) and instrumental-variable (IV) techniques, the latter procedure being more appropriate if C_{t-1} is not independent of μ_t, are shown in table 4.8. In addition to the

Table 4.8 **Stock-Adjustment Equation: Relative Change in Children Ever Born, 1967**

Age of Women	Estimation Method[c]	Constant Term	Period Child Mortality[a] t-2	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning[b] t-1	Children Ever Born t-1	R^2 (SEE)
16–20	OLS[d]	.299 (2.07)	−1.07 (.64)	−.326 (3.46)	.358 (2.14)	34.3 (2.66)	−.110 (2.91)	.8301 (.0438)
	IV[d]	.938 (.93)	−6.83 (.73)	−.558 (1.44)	.541 (1.38)	52.1 (1.51)	−.075 (.26)	(.0707)
21–25	OLS	.187 (12.3)	−.0896 (.33)	−.0517 (4.44)	.0156 (.81)	7.04 (3.32)	−.162 (11.5)	.9557 (.00721)
	IV	.199 (8.78)	−.316 (.76)	−.0501 (4.07)	.00828 (.37)	6.49 (2.78)	−.146 (5.59)	(.00753)
26–30	OLS	.183 (10.6)	.307 (1.51)	−.0181 (2.38)	.00963 (.82)	−.819 (.56)	−.130 (4.20)	.6613 (.00500)
	IV	.216 (4.40)	.658 (1.25)	−.0225 (2.13)	.0110 (.81)	.142 (.07)	−.198 (2.02)	(.00575)
31–35	OLS	.0568 (1.54)	.288 (1.88)	−.00955 (2.40)	.0170 (3.52)	−2.73 (3.10)	−.0203 (.58)	.7387 (.00308)
	IV	.0286 (.47)	.186 (.80)	−.00791 (1.61)	.0167 (3.38)	−2.65 (2.93)	−.00660 (.11)	(.00314)
36–40	OLS	−.00589 (2.8)	.257 (3.82)	−.00134 (.53)	.00847 (3.34)	−1.81 (3.39)	.0110 (.65)	.8823 (.00174)
	IV	−.00937 (.29)	.249 (2.78)	−.00101 (.30)	.00829 (2.93)	−1.77 (3.03)	.0137 (.53)	(.00174)

Table 4.8 (continued)

Age of Women	Estimation Method[c]	Constant Term	Period Child Mortality[a] t-2	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning[b] t-1	Children Ever Born t-1	R^2 (SEE)
41–45	OLS	.00678	.133	−.00175	.00419	−.779	−.00406	.7841
		(.74)	(4.92)	(1.24)	(2.38)	(2.72)	(.59)	(.00097)
	IV	−.00283	.121	−.00066	.00381	−.688	.00319	
		(.15)	(3.54)	(.28)	(1.96)	(2.06)	(.23)	(.00101)
46–50	OLS	.00435	.0179	−.00276	.000049	−.003	−.00315	.6573
		(3.07)	(3.71)	(1.38)	(.17)	(.062)	(3.13)	(.00019)
	IV	−.00105	.0210	.000189	.000223	.022	.000763	
		(.12)	(2.50)	(.24)	(.46)	(.25)	(.12)	(.00027)

Note: t or asymptotic t values are reported in parentheses beneath regression coefficients. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, nos. 2 and 3. The dependent variable is the difference between the logarithms of children ever born to the cohort in t and t-1; that is, $ln\ C_{t-1} - ln\ C_t$, so that the regression coefficient on the lagged stock of children is an estimate of δ.

[a]Reciprocal of child survival rate derived from period age-specific death rates from birth to age 15, lagged two years, that is, for 1965. The choice of the two-year lag is discussed in T. P. Schultz (1974).

[b]Man-months of effort by family planning fieldworkers expended in region through 1967, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]R^2 is inappropriate basis for comparison with IV estimates.

[d]OLS: Ordinary least-squares estimates.

IV: Instrumental variable estimates where children ever born (1966) is treated as endogenous and cohort child mortality and pre-1966 family-planning inputs are the excluded instruments used to identify equation.

contemporaneous schooling variables for men and women, period-specific child mortality and accumulated family planning inputs are lagged two years and one year respectively. (See earlier work by T. P. Schultz [1969, 1974] for justification of lag structures.) The lagged stock of children ever born is identified by two instrumental variables: the cohort's prior child mortality experience, and family planning inputs prior to 1966. The reduced-form equation that implicitly accounts for the 1966 fertility stock is reported in table 4.5.

The stock-adjustment model revolves around the parameter $\delta(a)$, or minus the regression coefficient on the 1966 children ever born variable (C_{t-1}). The instrumental-variable estimates of this parameter in table 4.8 for the seven childbearing age groups are as follows: 0.07, 0.15, 0.20, 0.01, −0.01, −0.00, and −0.00. Given the low level and possibly unplanned nature of fertility in older ages, the implied lack of discernible compensatory adjustment in these age groups is not unanticipated. The moderate and statistically significant level of the estimates of $\delta(a)$ from age 21 to age 30 does not contradict the working hypothesis of the adjustment model over the prime childbearing years, but these single-year estimates for 1967 provide little support for the framework at younger and older ages.

In contrast to the earlier analysis of cohort marital fertility rates, the dynamic stock-adjustment model implied compensating higher current flow of births to women over 35 in regions where child mortality has recently been higher. When women are completing the formation of their families, their reproductive behavior is likely to be more sensitive to the survival or death of earlier children. This has been found empirically in numerous studies (T. P. Schultz 1974), and in this case the short-run response elasticity is about 0.2 from age 30 to age 39. The magnitude of this short-run response exceeds that which could be attributed to involuntary biological feedback mechanisms in a healthy population (Schultz 1976).

Women's schooling is associated with lower current flows of births among women up to age 35. For men's schooling, the positive relationship is also apparent from 31 to 45. The men's and women's schooling elasticities are of approximately the same magnitude among teen-age women, the women's elasticities exceed the men's during the twenties, and the reverse is true between the age 30 and age 44.

The intensity of family-planning activity by region is associated with a decreased flow of births among women 31 to 45, those ages where the family planning program is widely regarded to have made its major impact (Freedman and Takeshita 1969; Freedman and Berelson 1976; T. P. Schultz 1969*b*, 1974). A very different pattern of program effectiveness emerges among women 16 to 26, where the flow of births is higher in regions that are more intensively canvassed by the family planning program fieldworkers. This pattern of response among younger women in Taiwan, which I have noted before (Schultz 1969*b*, 1974), might be explained if the preferred path to obtain the desired lifetime stock of children were itself a function of birth control technology. It was hypothesized earlier that the delay of childbearing and the spacing of births may be a means of reducing the likelihood of excess fertility given the unreliability of traditional birth control measures. As modern methods of fertility control become more widely accessible and understood, birth intervals in Taiwan may increasingly conform to the pattern of most industrialized countries where married women frequently participate in the nonagricultural labor force. In some of these developed countries, the intervals between births have indeed declined in the twentieth century despite the reduction in completed cohort fertility. A corollary of this hypothesis is that birthrates in Taiwan during the 1970s may start to decline even before women reach age 30.

There are several methods for investigating the stability over time and the internal consistency of these estimated reproductive flow relationships and the reduced-form stock equations reported in the previous section. One approach is to use the 1966 stock equation estimates in table 4.5 to predict (average regional) cohort fertility in 1971, given the observed values of the conditioning variables observed in 1971. This exercise is reported in the upper panel of table 4.9. Apparently the 1966 relationship overpredicts declines in fertility in the youngest ages and in the later ones. But between the ages of 25 and 39 predicted declines parallel actual reductions in cohort fertility. The predicted declines among women reaching age 40–49 in 1971 exceed that which might have been achieved if they had given birth to no children in the period 1966–71. A margin of excess fertility implied by this exercise is not inconsistent with the evidence presented earlier in column 4 of table 4.4.

The predicted reductions in cohort fertility are decomposed into the changes attributable to changes in the four explanatory variables in the lower panel of table 4.9. The contribution of declining child mortality appears to be of increasing importance among younger women. The reversal in the effect of education between ages 35–39 and ages 30–34 is a reflection of the lower educational achievement in the younger age groups, who because of the war may have been denied educational opportunities compared with the older age groups; the older cohort also includes many better-educated immigrant mainland Chinese. The postwar advance of women in the schooling system appears linked to declines in fertility, but this effect cannot be realistically partialed out from the educational achievements of men, which appear to be offsetting. Taking the groups together, education's effect varies from cohort to cohort but promises to increase in magnitude in the next decade among women reaching age 35. Family planning inputs account for 28% to 66% of

Table 4.9 **Actual and Predicted Change in Sample Mean of Children Ever Born, 1966 to 1971, Based on 1966 Stock Estimates**

	Age of Women in 1966 and 1971					
	20–24	25–29	30–34	35–39	40–44	45–49
Relative changes in sample mean						
Actual	−.045	−.052	−.101	−.101	−.054	−.027
Predicted	−.120	−.036	−.109	−.144	−.135	−.062
Shares of predicted change						
Child mortality	−1.67	−1.31	−.40	−.25	−.17	+.21
Women's schooling	−.86	−158	−.22	+.07	−.18	−.173
Men's schooling	+.98	+57	+.08	−.18	+.01	−.20
Family planning	+.55	+132	−.146	−.62	−66	−.28
Men's schooling	+.98	+57	+.08	−.18	+.01	−.20
Total	−100	−100	−100	−100	−100	−100

Source: "Actual" cohort fertility based on projections as described in Appendix B; "predicted" based on regressions coefficients in table 4.5, sample means of conditioning variables in table 4.A.4, and projections of child mortality described in Appendix B.

the predicted declines in cohort fertility after age 30. Although these point estimates of the effect of family planning activity are not precise (i.e., large standard errors are associated with these coefficients), they are nonetheless large in magnitude. As a first approximation, this exercise suggests that about half of the decline in fertility among women over age 30 occurring in the period 1966 to 1971 could be attributed to reductions in child mortality and changes in educational attainment, whereas the remainder is associated with family planning.

Another way to test the stability of the 1966 stock-equation estimates is to reestimate these equations in 1971 as shown in table 4.10. Several changes may be noted between the 1966 and the 1971 coefficients. The elasticity of fertility with respect to child mortality has increased and become more statistically significant after age 25; educational elasticities of both men and women increased in later ages; the coefficients on family planning inputs are more statistically significant and of roughly similar magnitude, as in 1966, though the level of accumulated inputs increased fourfold over this five-year period. Overall, the vector of coefficients for the equation based on 1966 and 1971 data are not dissimilar. Applying the F-ratio test to the linear restriction of coefficient equality across years, one cannot reject the hypothesis of equality in any of the six age groups at the 10% level.[27]

Accounting for changes in stocks is predictably more difficult than explaining variation in levels. Reproductive behavior for a cohort ap-

Table 4.10 Reduced-Form Stock Equation for Children Ever Born, 1971

Age of Women	Constant Term	Cohort Child Mortality[a]	Proportion with Some Junior High School: Women	Men	Family Planning up to 1970[b]	R^2 (SEE)[c]
20–24	−.664	21.8	.197	−.374	4.92	.5805
	(3.31)	(3.63)	(.85)	(.96)	(.17)	(.123)
25–29	.539	6.99	−.0979	.0722	4.61	.6900
	(5.97)	(3.33)	(1.02)	(.43)	(.34)	(.0539)
30–34	1.03	4.45	−.127	.107	−7.82	.7906
	(15.1)	(3.48)	(2.12)	(1.01)	(.78)	(.0378)
35–39	1.28	4.40	−.127	.127	−18.5	.7854
	(18.6)	(3.89)	(3.58)	(2.16)	(1.66)	(.0397)
40–44	1.35	2.62	−.141	.108	−14.7	.8021
	(18.8)	(3.03)	(4.79)	(2.24)	(1.25)	(.0427)
45–49	1.35	.847	−.165	.0839	−8.39	.8534
	(19.8)	(1.39)	(5.69)	(1.51)	(.72)	(.0405)
50–54	1.35	−.620	−.122	−.0200	11.4	.7923
	(15.3)	(.96)	(3.44)	(.29)	(.75)	(.0534)

Note: Numbers in parentheses beneath regression coefficients are *t* values. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, nos. 2 and 3.

[a]Reciprocal of cohort's proportion of children ever born who are still living as reported in 1966 census.

[b]Man-months of family planning fieldworker effort expended in region through calendar year 1965, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]Standard error of regression estimate is reported in parentheses beneath R^2.

proaching the end of its childbearing period may be predicted with a reasonably stable equation, but year-to-year flows of births are more volatile and possibly sensitive to the excessively rigid specification of the stock-adjustment hypothesis and the functional forms adopted here. To test the stability of the stock-adjustment equation, birth cohorts are followed for eight years, 1967 to 1974 (see Appendix B), and since each year's cross section of birthrates is in some sense a new observation conditioned by changing stocks and environmental variables,[28] the time series of cross sections are therefore pooled. A sample of 168 observations for each birth cohort is thereby obtained, though the value $\delta(a)$ is now undoubtedly changing as the cohort progresses eight years through its life cycle, and its estimate should thus be interpreted with caution. Another problem with pooling time series is the tendency for birthrates to decline for a cohort after age 25 and, for most regions, within age groups over time, contributing to a pronounced secular decline in the time series on relative changes in a cohort's stock of children. This tendency may produce a misleading association with other strongly trended variables, notably the past accumulated inputs of family planning in a region. In table 4.11 I have chosen to introduce a linear trend in time as one method for emphasizing the cross-sectional variation about the time trend, and not the smooth time trends in variable levels.[29] These estimates are consistent, based on instrumental variables as in table 4.8 to identify the influence of the lagged-stock variable.[30]

Coefficients in table 4.11 should be compared with an analogous average of the age-specific equations in table 4.8. The signs and magnitudes of the coefficients in the two tables are not notably dissimilar, though some changes are according to expectation. The average effect of family-planning inputs has diminished, as expected given the nature of innovational diffusion cycles, though the allowance of a linear trend in time may understate the program's role in the secular downtrend of birthrates. The effect of child mortality, which is also strongly trended downward, appears somewhat larger in the entire period 1967–74 than it was in 1967, but a stable elasticity of about 0.2 to 0.3 is still evident after a woman reaches age 30. The elasticity of relative increments to the stock of births with respect to the proportion of women with junior high school is negative at all ages, but the magnitude of the elasticity is less than men's schooling for women between about the ages of 30 and 40. This is again consistent with other indications that men's schooling proxies an income effect that extends the years of childbearing until the woman is in her mid- to late thirties, whereas women's schooling *conditional on the current stock* of children exerts a dampening effect on the flow of births throughout the life cycle. The magnitudes of the adjustment coefficient are better behaved, except for a slight rise in level for the oldest birth cohort. A strict interpretation of the stock-adjustment hypothesis implies reproductive goals in the range of 5–6 births, which exceeds survey responses, perhaps because of our inability to explicitly identify the role of contraceptive failures. Overall, however, these pooled results for the stock-adjustment equation are more stable than we might have anticipated given the rudimentary nature of the working hypothesis and the limitations of the aggregate data. There is clearly an important systematic element of feedback from past stocks to current flows of births that should in the future be modeled with greater realism and examined in individual survey data.

A possible shortcoming of analyses of regional data such as are used in this study is that explanatory variables may not account for fertility differences *within* urban and rural environments but may only reflect urban/rural differences in amenities that approximately parallel reproduction without causing differences. As expected, a city/noncity dummy variable, defined as equal to one for the five major cities and zero for

Table 4.11 Stock-Adjustment Equation: Relative Change in Stock of Children Ever Born, 1967–74

Instrumental Variable Estimates[d]	Constant Term	Period Child Mortality[a] t-2	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning to t-1[b]	Calendar Year −1900[d]	Children Ever Born t-1[e]	SEE[c]
Age of Women								
Age 15–19 in 1966 and age 22–27 in 1974	−.853 (.94)	.710 (1.18)	−.0629 (3.27)	.0317 (.95)	.146 (.08)	.0136 (1.10)	−.221 (10.0)	.0255
Age 20–24 in 1966 and age 28–32 in 1974	.960 (3.19)	−.142 (.61)	−.0337 (6.81)	.00752 (.85)	.086 (.16)	−.0108 (2.49)	−.148 (6.85)	.00831
Age 25–29 in 1966 and age 33–37 in 1974	.782 (5.35)	.122 (.64)	−.00657 (1.57)	.00307 (.52)	−.191 (.40)	−.00970 (3.97)	−.0510 (1.54)	.00700
Age 30–34 in 1966 and age 38–42 in 1974	.211 (5.31)	.335 (2.78)	−.00794 (3.31)	.0123 (5.00)	−.505 (1.88)	−.00224 (2.63)	−.0329 (1.39)	.00402
Age 35–39 in 1966 and age 43–47 in 1974	.0375 (2.10)	.261 (3.91)	−.00486 (2.38)	.00701 (4.09)	−.616 (4.14)	−.00007 (.18)	−.00224 (1.51)	.00223
Age 40–44 in 1966 and age 48–52 in 1974	.0369 (1.88)	.192 (2.47)	−.0102 (2.13)	.00572 (2.29)	−.361 (2.04)	.00064 (1.30)	−.0617 (2.06)	.00215

Note: Asymptotic t values reported in parentheses beneath regression coefficients. See note e for definition of dependent variable and note f for identifying instruments.

[a]Reciprocal of child-survival rate derived from age specific death rates from birth to age 15 two years before in 1965. The choice of the two-year lag is discussed in T. P. Schultz 1974.
[b]Family-planning inputs per woman summed to the prior year as an accumulative stock of nondepreciating knowledge.
[c]R^2 is inappropriate basis for comparison with IV estimates.
[d]Linear time trend introduced by the variable of the last two digits to the calendar year; i.e., 66, 67, etc.
[e]The dependent variable in this equation is the first difference of the logarithms of children ever born—i.e., $ln\ C_{t-1} - ln\ C_t$—so that the regression coefficient on lagged children is an estimate of δ.
[f]The identifying excluded exogenous variables are the cohort's child mortality to t-2, and family planning inputs summed to t-2.

the other sixteen regions of Taiwan, is found to be strongly negatively correlated across our sample with reproductive stocks among older women, the simple correlation being on the order of —0.6 to —0.8 in both 1966 and 1971; the city dummy variable is less highly correlated with birth flows in 1967 among older women, namely —0.2 to —0.3. Including this city dummy variable in the birth-stock equation often significantly increases the explanatory power of the equation, particularly for older women (see appendix tables 4.A.9 and 4.A.11), whereas it is not important in partially explaining regional differences in the flow of births (table 4.A.10). The only variable whose coefficient is notably altered by this modification in model specification is that of family planning inputs in the stock equation, where the previously noted partial association is largely subsumed by the city/noncity distinction. The apparent diminution of the effect of family planning on accumulated reproductive performance is not confined, however, in the temporally better-specified birth-flow equation for 1967. Quite the contrary. Overall, it does not appear that child mortality and schooling patterns are only a proxy for "urbanization" and capture this alleged modernizing influence on reproductive goals and performance. Urban/rural differences in completed fertility remain, however, a spur to further research into reproductively relevant characteristics of urban life or those who choose it. In 1971, women by age 40 still had 10% fewer children if they lived in the five major cities of Taiwan rather than elsewhere on the island (table 4.A.11), after controlling for important associations with child mortality and sex-specific schooling. It is not difficult to think of many omitted variables, particularly lagged conditions and ethnic diversity in these large populations, that might account for this residual urban/rural variation in past reproductive performance. On the other hand, somewhat unexpectedly, one finds that flows of births in 1967 conditioned on prior reproductive performance do not differ substantially across city and noncity regional populations in Taiwan, holding constant the same four seemingly crude proxies for child mortality, educational status of women and men, and prior family planning.

4.6 Concluding Notes and Qualifications

How should disequilibrium be characterized, and how should behavior be modeled as it adapts to unexpected changes in conditioning variables? Theories of fertility, particularly in developing areas, are moving beyond the widely replicated exercises of accounting for differences in lifetime stocks of births, toward simplified explanations of how current reproductive behavior is conditioned by past accumulated reproductive performance and other variables. The past matters for present behavior and future goals, as in most areas of household behavior where the life-cycle durability of decisions is inescapable.

But past outcomes and current behavior cannot be realistically assumed to be statistically independent. The identification quandary arises for lack of time-independent variables that conveniently perturb a behavioral relation in one period but leave it untouched in the succeeding period. These exogenous variables are hard to come by, and to measure, in the household sector, and those used in the last section of this paper, though tenable, can easily be criticized for belonging in the current-period distributed lag function. Moreover, the stock-adjustment framework is only the simplest way to deal with a most complex process. With more and better data for cohorts over time, more elaborate frameworks may add much to our understanding of reproductive behavior.[31]

Another problem arises in part because I have worked with aggregate data. The lack of information on individual preferences, or at least the distinction whether or not parents want more births, limits how one can treat the unreliability of birth control and resulting margins of "excess fertility." Though these subjective variables add richness to a model (Lee 1976), they also extract their claims, for to close the system they too require explanation in terms of environmentally given conditioning variables.

A third area that requires more explicit study is the age of marriage. The timing of marriage has many implications for the allocation and accumulation of resources in the household sector and the transfer of resources between generations. Its effects on fertility are unmistakable. As a starting point, decomposition of cohort fertility into an age at marriage and a marital fertility rate may help to sort out sources of fertility change over time and to clarify how social institutions respond to environmental constraints. Though the required data are available in virtually every census and survey, analysis of age at marriage remains uncommon using cross-sectional data. I have encountered few econometric studies of the causes of time-series change in age at marriage within communities or over generations within families, though much thinking has gone into the problem (Goode 1970).

The hypothesis has been advanced that education's effect on a considerable range of household behavior can best be understood in terms of its influence on the marginal productivity of labor, and hence on the opportunity value of time (T. W. Schultz 1974). But education surely has other consequences for behavior, and abstracting a single "price of time" may mislead if it is not recognized that time is not homogeneous and perfectly substitutable over an individual's diurnal, seasonal, and life cycles. The "value of time" hypothesis predicts that better-educated women allocate more time and interest to market-oriented activities and less time to child-rearing. How can one get directly at the mechanisms by which education influences fertility? Can a variety of subtler predictions be advanced as to how education affects the value of time and thereby the mix of inputs used in a variety of household activities, as well as demands for final family outputs, such as children? Are there other aspects of the husband's and wife's economic contribution to the family that can be quantified and related to schooling? What are the consequences of physical wealth on the household's choices? Does wealth augment the strength of its owner's "time-value" based viewpoint in the allocation of family resources, or does it increase the demand for all normal goods, particularly leisure, without introducing an offsetting price-of-time effect? In particular, does material wealth increase fertility, even if it enters the family from the mother's side? What are the limits to the family in terms of its ability to pool economic resources, and how do they change with development? Modern economic growth places a premium on regional and occupational mobility that seems designed to erode the economic foundation of the extended family.

Finally, the intertemporal transfer of resources is at the very heart of the nuclear family and its relations with previous and succeeding generations. It might be postulated that the increase by half in life expectancy in many low-income countries in the last three decades would have reduced the rate of social time preference, with predictable consequences for savings and investment behavior. The mortality reduction should also enhance the returns on human capital relative to physical capital, shifting the balance in family portfolios. Conversely, if income streams can be purchased more cheaply in terms of physical assets due to rapid economic development such as in Taiwan, will household resources allocated to enlarging the subsequent generation diminish? The testing of many of these propositions and obtaining a consistent set of assumptions that account for related facets of household behavior could make the "value of time" hypothesis pivotal for the study of the household sector in low-income economies.

Appendix A. Additional Statistical Tables

Table 4.A.1 **Age-specific Annual Birthrates for Taiwan: 1949–74 (Births per 1,000 Women of Childbearing Age)**

Births Registered in Year[a]	Total Fertility Rate[b]	Number of Births per 1,000 Women of Specific Ages[c]						
		15–19	20–24	25–29	30–34	35–39	40–44	45–49
1949	5,900	61	241	290	263	186	111	27
1950	6,030	61	246	297	269	191	112	30
1951	7,040	68	287	349	311	226	132	35
1952	6,615	53	272	342	294	220	113	29
1953	6,470	48	265	336	292	218	108	27
1954	6,425	48	263	334	292	218	104	26
1955	6,530	50	273	341	295	219	103	25
1956	6,505	51	264	340	296	222	105	23
1957	6,000	45	249	325	275	197	92	17
1958	6,055	43	248	336	281	199	90	14
1959	5,990	46	258	334	270	190	86	14
1960	5,750	48	253	333	255	169	79	13
1961	5,585	45	248	342	246	156	71	10
1962	5,465	45	255	338	235	145	65	10
1963	5,350	41	252	337	231	139	60	10
1964	5,100	37	254	335	214	120	52	8
1965	4,825	36	261	326	195	100	41	6
1966	4,815	40	274	326	188	91	38	6
1967	4,220	39	250	295	158	70	28	4
1968	4,325	41	256	309	161	68	26	4
1969	4,120	40	245	298	151	63	23	4
1970	4,000	40	238	293	147	59	20	3
1971	3,705	36	224	277	134	51	16	3
1972	3,365	35	208	257	117	41	13	2
1973	3,210	33	203	250	105	37	12	2
1974	3,045	34	197	235	96	35	10	2

Source: 1949–64, *Demographic Fact Book 1964*.
1964–74, *Demographic Fact Book 1974*.

[a]Births are attributed to the year in which they are registered.

[b]The total fertility rate is five times the sum of the age-specific birthrates. Perhaps because of rounding, the totals do not always add up.

[c]Births by age of mother divided by the midyear estimate of the number of women of that age.

Table 4.A.2 Percentage of Women Ever Married in Taiwan by Age, 1940–74

Period and Source	Percentage of Age Group						
	15–19	20–24	25–29	30–34	35–39	40–44	45–49
1940 census	29.5	84.4	95.9	98.3	98.8	99.2	99.4
1956 census	11.5	70.6	95.2	97.9	98.5	98.7	99.0
1966 census	8.6	59.5	92.9	98.1	98.9	99.1	99.1
1970 census	7.2	49.7	91.3	97.8	98.8	98.8	98.8
1974 Household Registry	5.8	44.1	84.9	95.4	97.0	97.6	97.4

Sources: 1940 census, table 13, p. 54.
1956 census, table 17, p. 265.
1966 census, vol. 2, no. 3, table 2, p. 125.
1970 census, extract, table 9, p. 135.
1974 *Taiwan Demographic Factbook*, table 9, p. 366.

Table 4.A.3 Selected Demographic Time Series for Taiwan, 1906–74

Period	Natural Rate of Population Increase (% per Year)	Crude Vital Rates (per 1,000 Population)		Infant Death (per 1,000 Live Births)	Life Expectancy (Years at Birth)	
		Birth	Death		Male	Female
1906–20	1.02[a]	42	31	172	25–30	
1921–40	2.32[a]	45	22	155	35–45	
1947–49	2.5	40	15	—[b]	—[b]	—[b]
1950–54	3.58	45.9	10.1	37	56.1	60.2
1955–59	3.49	42.9	8.0	37	60.5	65.9
1960–64	3.08	37.2	6.4	30	62.7	68.0
1965–69	2.44	29.7	5.3	22	64.4	70.0
1970–74	2.01	24.8	4.8	16	66.5	71.8

Sources: 1906–40, Barclay 1954, pp. 13, 161, 241.
1947–49, *1959–1961 Household Registry Statistics of Taiwan*, table 1.
1950–64, *1972 Demographic Factbook, Taiwan*, table 1, *1970 Demographic Factbook*, table 15.
1965–74, *1974 Taiwan Demographic Factbook*, tables 61, 74, 76.

[a]Taiwanese geometric rate of growth between censuses (Barclay 1954, p. 13).
[b]Not available.

Table 4.A.4 Means and Standard Deviations of Variables Used in Regressions on Fertility

	Age Group of Women						
Variable	15–19	20–24	25–29	30–34	35–39	40–44	45–49
Children ever born 1966: C_{66}	.0622 (.0285)	.853 (.157)	2.50 (.204)	3.95 (.253)	4.93 (.366)	5.44 (.483)	5.65 (.558)
Log (C_{66})	−2.86 (.410)	−.174 (.175)	.912 (.0818)	1.37 (.0653)	1.59 (.0766)	1.69 (.0934)	1.73 (.105)
Log (C_{67}/C_{66})	.781 (.0920)	.296 (.0297)	.105 (.00743)	.0362 (.00522)	.0137 (.00440)	.00431 (.00181)	.00056 (.00028)
Log (reciprocal of cohort child survival 1966)	.0238 (.00817)	.0262 (.00718)	.0352 (.00931)	.0514 (.0120)	.0744 (.0164)	.110 (.0221)	.152 (.0277)
Log of child death rate 1965[a]	.0521 (.0112)	Not age-specific variable; i.e., identical for all age groups					
Log (proportion of women with junior high school)	−1.16 (.339)	−1.55 (.355)	−2.19 (.442)	−2.42 (.477)	−2.36 (.511)	−2.50 (.586)	−2.89 (.713)
Log (proportion of men with senior high school)	−.692 (.184)	−.870 (.217)	−1.25 (.259)	−1.39 (.300)	−1.14 (.314)	−1.15 (.301)	−1.43 (.386)
Family planning per woman to 1965	.00161 (.00063)	Not age-specific variable, i.e., identical for all ages					
Family planning per woman in 1966	.00268 (.00081)	Not age-specific variable, i.e., identical for all ages					

Note: The standard deviations of the variables are reported in parentheses beneath the means. Values are unweighted over sample of twenty-one regions.

[a]The natural logarithm of the reciprocal of the product of the age-specific rates within the region from birth to age 15.

Table 4.A.5 Initial Estimate of Marital Fertility Rate by Age of Woman Used to Calculate Beta

Age of Woman	Initial Relative Value of Fertility	Age of Woman	Initial Relative Value of Fertility
14 or less	0		
15	.100	35	.125
16	.200	36	.100
17	.250	37	.090
18	.300	38	.080
19	.350	39	.070
20	.400	40	.060
21	.425	41	.050
22	.450	42	.040
23	.425	43	.025
24	.400	44	.010
25	.375	45	.007
26	.350	46	.005
27	.325	47	.003
28	.300	48	.002
29	.275	49	.001
30	.250	50 and over	0
31	.225		
32	.200		
33	.175		
34	.150		

Table 4.A.6 Initial Proportions of Children Living by Current Age and by Age of Mother in 1966

Age Group of Mothers	Age of Children						
	0	1–4	5–9	10–14	15–19	20–24	25 and over
15–19	.545	.455	0	0	0	0	0
20–24	.313	.624	.063	0	0	0	0
25–29	.149	.525	.305	.021	0	0	0
30–34	.066	.321	.414	.186	.013	0	0
35–39	.033	.148	.319	.341	.150	.009	0
40–44	.014	.064	.166	.295	.316	.137	.008
45–49	.004	.023	.074	.161	.289	.307	.142
50–54	0	0	.025	.073	.162	.291	.449

Table 4.A.7 Form of Age at Marriage Tabulations in Taiwan 1966 Census

Age at First Marriage	Current Age of Married Women				
	12–24	25–34	35–44	45–54	55 and over
12–14	X	X	X	X	X
15–19	X	X	X	X	X
20–24	X	X	X	X	X
25–29		X	X	X	X
30–34		X	X	X	X
35–44			X		
35–54				X	
55 and over					X

Source: 1966 Taiwan census, vol. 3, table 6.

Table 4.A.8 Logarithms of Estimated Marital Duration in Years and Marital Fertility Rate per Year

	Current Age of Women					
	15–19		20–24		25–29	
Region	Duration	Rate	Duration	Rate	Duration	Rate
Taipei Hsien	−2.10382	−0.37907	0.55780	−0.60008	1.72252	−0.81382
Ilan Hsien	−2.32702	−0.31383	0.45386	−0.56378	1.82714	0.88363
Taoynan Hsien	−2.19788	−0.30315	0.52947	−0.59850	1.75780	−0.81288
Hsinchu Hsien	−2.53190	−0.44011	0.27596	−0.53876	1.52539	−0.62567
Miaoli Hsien	−2.95563	−0.37978	0.15718	−0.51614	1.69647	−0.81278
Taichung Hsien	−2.79355	−0.32774	0.22025	−0.55726	1.72383	−0.83792
Changhwa Hsien	−3.20471	−0.38523	0.09867	−0.55769	1.76350	−0.89020
Nantou Hsien	−2.57412	−0.39012	0.42442	−0.61280	1.75533	−0.82081
Yunlin Hsien	−3.05406	−0.34214	0.42273	−0.06939	1.76606	−0.81746
Chiayi Hsien	−2.79355	−0.41044	0.36615	−0.59859	1.71474	−0.78803
Tainan Hsien	−2.85851	−0.39600	0.33541	0.56633	1.71127	−0.77974
Kaohsiung Hsien	−2.40954	−0.33907	0.48844	−0.60049	1.69939	−0.77058
Pingtung Hsien	−2.36250	−0.33907	0.54631	−0.64095	1.73837	−0.78945
Taitung Hsien	−1.46114	−0.43598	0.93131	−0.69679	1.87130	−0.77446
Hualien Hsien	−1.80229	−0.40681	0.76965	−0.62858	1.89169	−0.84556
Penghu Hsien	−2.22124	−0.40681	0.51707	−0.67512	1.68380	−0.72545
Taipei City	−2.87916	−0.14497	0.10938	−0.50213	1.58571	−0.86141
Keelung City	−2.31328	−0.29855	0.58543	−0.54755	1.74900	−0.80420
Taichung City	−2.97814	−0.07310	0.21069	−0.47258	1.63904	−0.80583
Tainan City	−2.58319	−0.06786	0.15804	−0.53521	1.59571	−0.82723
Kaohsiung City	−2.58319	−0.19582	0.46793	−0.63304	1.61767	−0.78990

Current Age of Women							
30–34		35–39		40–44		45–49	
Duration	Rate	Duration	Rate	Duration	Rate	Duration	Rate
2.36912	−1.01742	2.75858	−1.20307	3.03816	−1.43261	3.25641	−1.64611
2.42640	−1.01091	2.79850	−1.16805	3.06907	−1.32586	3.28181	−1.51797
2.38573	−0.99612	2.76848	−1.15355	3.04460	−1.34002	3.26075	−1.52457
2.25035	−0.86078	2.66619	−1.06082	2.95903	−1.25094	3.18525	−1.44524
2.35351	−0.96674	2.74529	−1.10062	3.02657	−1.25766	3.24586	−1.43801
2.37108	−0.98711	2.76076	−1.14050	3.04046	−1.30656	3.25878	−1.47185
2.39278	−1.01548	2.77602	−1.16066	3.05240	−1.31516	3.26870	−1.48560
2.38276	−1.00161	2.76533	−1.15637	3.04136	−1.31001	3.25744	−1.48560
2.39439	−1.00955	2.77728	−1.16172	3.05348	−1.30157	3.26967	−1.43490
2.36939	−0.98332	2.76169	−1.14882	3.04272	−1.31312	3.26185	−1.45404
2.36981	−0.99729	2.76347	−1.15425	3.04519	−1.31108	3.26475	−1.44204
2.35495	−0.97507	2.74756	−1.13297	3.02875	−1.30340	3.24798	−1.49287
2.36853	−0.98359	2.75209	−1.13727	3.02864	−1.30868	3.24504	−1.46783
2.43966	−0.94375	2.79982	−1.09924	3.06405	−1.28396	3.27285	−1.49504
2.45088	−0.98566	2.80739	−1.14138	3.06966	−1.30299	3.27724	−1.50264
2.34374	−0.89526	2.73788	−1.02009	3.01985	−1.21238	3.23956	−1.40605
2.30452	−1.09198	2.71839	−1.32313	3.01025	−1.56729	3.23589	−1.77588
2.38227	−1.01284	2.76695	−1.23370	3.04407	−1.42552	3.26083	−1.73593
2.33181	−1.02575	2.73715	−1.22409	3.02477	−1.42552	3.24787	−1.59262
2.31230	−1.04113	2.72546	−1.23271	3.01696	−1.42930	3.24239	−1.58972
2.31519	−1.05075	2.72211	−1.25518	3.01052	−1.45753	3.23410	−1.64437

Table 4.A.9 Regressions on Cohort Fertility or Stocks: Logarithm of Children Ever Born per Woman by Age in 1966 (Including Urban-Rural Component)

Age of Women	Constant Term	Cohort Child Mortality[a]	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning up to 1965[b]	Urban-Rural Variable[d]	R^2 (SEE)[c]
15–19	−2.53	21.5	1.41	−1.57	−125.0	−.343	.4022
	(3.99)	(1.86)	(1.79)	(1.14)	(.94)	(.99)	(.3665)
20–24	−.551	22.1	−.232	.662	14.2	−.035	.6812
	(2.30)	(5.40)	(1.11)	(2.25)	(.34)	(.33)	(.1138)
25–29	.722	5.83	−.079	.155	16.0	−.0826	.8534
	(8.23)	(5.53)	(1.52)	(1.62)	(1.21)	(2.20)	(.0362)
30–34	1.19	3.32	−.0681	.0952	−1.65	−.0592	.9297
	(25.0)	(7.18)	(2.97)	(2.87)	(.21)	(2.86)	(.0200)
35–39	1.37	1.76	−.0973	.0959	−7.33	−.0691	.9339
	(29.8)	(4.89)	(4.01)	(3.25)	(.83)	(3.28)	(.0027)
40–44	1.42	.704	−.124	.0805	−6.59	−.0759	.9180
	(24.3)	(1.94)	(3.82)	(1.48)	(.56)	(2.72)	(.0309)
45–49	1.45	−.237	−.0998	−.0193	4.45	−.0599	.8612
	(17.5)	(.56)	(2.57)	(.28)	(.25)	(1.43)	(.0452)

Note: Numbers in parentheses beneath regression coefficients are *t* values. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, Nos. 2 and 3.

[a]Reciprocal of cohort's proportion of children ever born who are still living as reported in 1966 census.

[b]Man-months of family planning fieldworker effort expended in region through calendar year 1965, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]Standard error of regression estimate is reported in parentheses beneath R^2.

[d]Urban-rural variable equals 1 for five cities (Tainan, Taipei, Keelung, Taichung, and Kaohsiung), 0 for seventeen rural areas.

Table 4.A.10 Stock-Adjustment Equation: Relative Change in Children Ever Born, 1967 (Including Urban-Rural Component)

Age of Women	Estimation Method[d]	Constant Term	Period Child Mortality[a] (*t*-2)	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning[b] (*t*-1)	Children Ever Born (*t*-1)	Urban-Rural Variable	R^2 (SEE)[c]
16–20	OLS[d]	.308 (1.99)	−1.07 (.62)	−.315 (2.83)	.354 (2.05)	34.7 (2.57)	−.111 (2.82)	−.00902 (.21)	.8306 (.0453)
	IV[d]	.818 (1.33)	−5.87 (.99)	−.536 (1.81)	.515 (1.66)	4.85 (1.94)	.0456 (.25)	.0137 (.20)	(.0661)
21–25	OLS	.180 (9.23)	−.0818 (.30)	−.0558 (4.06)	.0157 (.80)	6.81 (3.09)	−.162 (11.3)	.00421 (.60)	.9568 (.00737)
	IV	.190 (7.57)	−.282 (.70)	−.0545 (3.81)	.00923 (.41)	6.31 (2.64)	−.148 (5.83)	.00434 (.60)	(.00763)
26–30	OLS	.185 (7.53)	.312 (1.46)	−.0182 (2.30)	.0107 (.76)	−.731 (.45)	−.132 (3.87)	−.000884 (.15)	.6618 (.00517)
	IV	.240 (4.21)	.749 (1.61)	−.0238 (2.19)	.0191 (1.01)	.921 (.37)	−.222 (2.46)	−.00620 (.72)	(.00633)
31–35	OLS	.0416 (.92)	.253 (1.52)	−.00993 (2.42)	.0159 (3.01)	−2.96 (3.02)	−.00962 (.24)	.00223 (.60)	.7452 (.00315)
	IV	.0594 (.84)	.311 (1.28)	−.0106 (2.31)	.0164 (2.98)	−2.93 (2.95)	−.0254 (.41)	.00157 (.37)	(.00317)
36–40	OLS	−.0344 (1.38)	.215 (3.25)	−.00139 (.59)	.00746 (3.10)	−2.02 (3.99)	.0293 (1.59)	.00343 (1.87)	.9059 (.00161)
	IV	−.0244 (.60)	.236 (2.50)	−.00202 (.65)	.00792 (2.79)	−2.07 (3.92)	.0219 (.73)	.00303 (1.36)	(.00162)

Table 4.A.10 (continued)

Age of Women	Estimation Method[d]	Constant Term	Period Child Mortality[a] (t-2)	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning[b] (t-1)	Children Ever Born (t-1)	Urban-Rural Variable	R^2 (SEE)[c]
41–45	OLS	.00589	.133	−.00174	.00415	−.789	−.00354	.000138	.7843
		(.50)	(4.71)	(1.19)	(2.24)	(2.57)	(.43)	(.13)	(.00101)
	IV	−.00125	.126	−.00115	.00385	−.769	.00148	.000474	
		(.05)	(3.39)	(.46)	(1.79)	(2.40)	(.08)	(.30)	(.00102)
46–50	OLS	.00420	.0181	−.000274	.000036	−.00700	−.00308	.000035	.6581
		(2.47)	(3.54)	(1.32)	(.12)	(.12)	(2.73)	(.18)	(.00195)
	IV	−.00516	.0247	.000274	.000126	−.0170	.00329	.000463	
		(.27)	(1.54)	(.28)	(.22)	(.15)	(.25)	(.50)	(.000352)

Note: Numbers in parentheses beneath regression coefficients are t values. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, nos. 2 and 3.

[a]Reciprocal of cohort's proportion of children ever born who are still living as reported in 1966 census.

[b]Man-months of family planning fieldworker effort expended in region through calendar year 1965, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]Standard error of regression estimate is reported in parentheses beneath R^2 for OLS estimates, whereas R^2 is inappropriate for comparisons with IV estimates.

[d]OLS: Ordinary least-squares estimates.
IV: Instrumental variable estimates where children ever born (1966) is treated as endogenous and cohort child mortality and pre-1966 family-planning inputs are the excluded instruments used to identify equation.

Table 4.A.11 Reduced-Form Stock Equation for Children Ever Born, 1971 (Including Urban-Rural Component)

Age of Women	Constant Term	Cohort Child Mortality[a]	Proportion with Some Junior High School: Women	Proportion with Some Junior High School: Men	Family Planning up to 1970[b]	Urban-Rural Variable[d]	R^2 (SEE)[c]
20–24	−.582	20.9	.271	−.347	11.1	−.0707	.5942
	(2.49)	(3.34)	(1.05)	(.87)	(.36)	(.71)	(.1244)
25–29	.556	6.83	−.0850	.0753	6.28	0.0139	.6917
	(5.11)	(3.06)	(.79)	(.43)	(.41)	(.29)	(.0555)
30–34	1.10	3.82	−.106	.153	−.617	−.0584	.8274
	(14.3)	(3.06)	(1.85)	(1.50)	(.06)	(1.79)	(.0355)
35–39	1.36	3.74	−.0865	.145	−8.09	−.0680	.8280
	(17.7)	(3.40)	(2.22)	(2.63)	(.70)	(1.93)	(.0367)
40–44	1.47	2.06	−.0725	.117	−.686	−.104	.8955
	(23.1)	(3.10)	(2.50)	(3.24)	(.07)	(3.66)	(.03203)
45–49	1.47	.534	−.104	.0860	3.92	−.0978	.9158
	(23.0)	(1.10)	(3.53)	(1.98)	(.40)	(3.33)	(.0317)
50–54	1.46	−.640	−.0871	.00916	17.8	−.0875	.8331
	(14.5)	(1.07)	(2.33)	(.14)	(1.23)	(1.92)	(.04942)

Note: Numbers in parentheses beneath regression coefficients are *t* values. Observations are twenty-one major subdivisions of Taiwan for which data are published in the Taiwan 1966 census, vol. 2, nos. 2 and 3.

[a]Reciprocal of cohort's proportion of children ever born who are still living as reported in 1966 census.

[b]Man-months of family planning fieldworker effort expended in region through calendar year 1965, divided by the number of women in the region of childbearing age (i.e., 15–49).

[c]Standard error of regression estimate is reported in parentheses beneath R^2.

[d]Urban-rural variable equals 1 for five cities (Tainan, Taipei, Keelung, Taichung, and Kaohsiung), 0 for seventeen rural areas.

Appendix B. Procedures for Regional Cohort Projections

Consistent Estimates of Birth Stocks and Flows

First, the proportion married by single year of age *j*, in the *i*th region is defined

$$_{j+1}m_{ji}(66) = (p_{ji}(66) - s_{ji}(66))/p_{ji}(66),$$
$$i = 1, \ldots, 21$$
$$j = 15, \ldots, 49$$

where p refers to all women and s to those single or never married according to the 1966 census (vol. 3, table 2).

In years after 1966, information is annually published from the Household Registry on proportion of the population ever married by five-year age groups. Using the individual year population totals for each subsequent year, t, a predicted proportion married is calculated; for example, for age 15 to age 19:

$$ {}_{19}M_{15,i}(t) = \left[\sum_{j=15}^{19} p_{ji}(t) * m_{ji}(66) \right] \sum_{j=15}^{19} p_{ji}(t). $$

I then define alpha (α) as a marriage deflator for each region, each year, and the seven five-year age intervals for which Household Registry data are available:

$$ {}_{19}\alpha_{15,i}(t) = {}_{19}M_{15,i}(t) / {}_{19}m_{15,i}(66), $$

where ${}_{19}m_{15,i}(t)$ is the actual proportion of women between the ages of 15 and 19 registered as ever married in year t. If the age weights had not relatively changed, and age-specific marital rates declined over time, the α's would presumably increase and exceed unity after 1966. The estimated proportion of women married by single year of age, in calendar year t, can then be expressed for, say, age 18 as follows:

$$ {}_{19}m_{18,i}(t) = {}_{19}m_{18,i}(66) / {}_{19}\alpha_{15}(t) $$

The second step is to estimate birthrates for women by individual ages, though birthrates are reported from the Household Registry only by five-year intervals. Using initial arbitrary estimates of marital fertility reported in table 4.A.5, denoted F_j, that are not untenable at the national level for the base year 1966, a similar procedure of deflation is performed to obtain estimates of individual-year birthrates that are roughly consistent with the changing age composition of regional populations, marriage patterns, and age-aggregated birthrates as recorded in the household registration system by date of registration. The base-year estimate of the birthrate would become:

$$ {}_{19}B_{15,i}(t) = \left[\sum_{j=15}^{19} p_{ji}(t) *_{j+1} m_{j,i}(t) * F_j \right] \sum_{j=15}^{19} p_{ji}(t), $$

and a birthrate deflator for the seven age intervals is defined as beta (β),

$$ {}_{19}\beta_{15,i}(t) = {}_{19}B_{15,i}(t) / {}_{19}b_{15,i}(t), $$

where ${}_{19}b_{15}(t)$ is the registered birthrate for women of ages 15 to 19 in region i in calendar year t. Similarly, a final estimate of the birthrate for women of individual ages is obtained:

$$ {}_{19}b_{18,i}(t) = [F_{18} *_{j+1} m_{j,i}(t)] / {}_{19}\beta_{15,i}(t). $$

Women are then followed by individual years in the 1966 census age distribution, attributing to them their estimated birthrates in subsequent years, in addition to the number of children already born as reported in the 1966 census. These single-year-of-birth cohorts are summed into five-year age groups each calendar year, and observations are constructed to follow through time the aging regional cohort, neglecting the effects of internal migration. Thus the 35- to 39-year-old women in region 2 (Ilan Hsien) had 5.11 children on average in 1966 and in 1971 were estimated at age 40–44 to have 5.34 children ever born. In contrast, those women age 35–39 in 1971 had on average only 4.63 children ever born.

Survival of Cohort's Living Children

The mortality rates for each region and year are read or calculated for infants and children age 1–4, 5–9, and 10–14. Based on national levels of age-specific mortality between 1965 and 1970, the mortality rates for children age 15–19, 20–24, and 25 and over are arbitrarily assumed to be proportional to the death rate for children 10–14 in the region, where the factors of proportionality are 1.73, 2.55, and 2.90, respectively. Mortality among older offspring is relatively low and intrinsically of less interest to us here because an increasing proportion of their mothers are no longer of childbearing age.

To project the cohort's living offspring forward to the next period, age-specific survival rates are applied to the age distribution of the initial living children. The total number of living children for the seven standard (five-year) age intervals of women is obtained by region from the 1966 census (vol. 3). Initially, I assume the proportion of those living children in each current age group is as arbitrarily reported in table 4.A.6, chosen to be roughly consistent with national birthrates in the early 1960s. But if absolute differences in infant mortality remain substantial by region, as in Taiwan in the 1960s, it seems appropriate to use regional Household Registry birthrates in 1966 to estimate directly the number of infants (age 0) by region and age of mother, and use the relative proportions in table 4.A.6 to distribute only living children age 1 and over. For example, women 20–24 in region 1 (Taipei Hsien) registered a birthrate of 0.287 in 1966 and reported in the census 0.938 children living. Ignoring infant mortality, the rest of children living, 0.651, are distributed between the age groups 1–4 and 5–9 in proportion to their cell values in table 4.A.6, or 90.8% and 9.2%, respectively.[32] Clearly, further refinements and more extensive checks for consistency could be introduced by using information on registered birthrates and death rates in prior years (Maurer and Schultz 1972, p. 8), but these errors need not jeopardize our objective of obtaining estimates of cohort accumulative fertility and surviving offspring.[33]

Overall, the procedures described above should not introduce relatively large errors unless the census and registry systems are incompatible. The least satisfactory assumption is probably that embodied in the uniform age-specific marital fertility schedule. There has been much change in age-specific marital birthrates in recent years in Taiwan. As the age at marriage has increased, the marital birthrate has increased among those who still married early, between the ages of 15 and 19 (Anderson 1973). This may have been partially due to changes in the age composition of married women in this interval (becoming older), but it would also be consistent with a selectivity process by which those getting married are increasingly fecund, either because they were pregnant before marriage (perhaps unusually fecund for their age) or inclined to start their childbearing immediately, and hence marrying at an atypically young age. Whatever the cause, these changes in marital fertility rates are not allowed to modify the relative shape of the schedule but only displace the schedule up and down uniformly over the five-year age intervals. This, in fact, may be a poor approximation for how marital fertility schedules have been changing in different regions of Taiwan. However, since our primary interest attaches to the behavior of older women, I hope this defect in my calculations will not be a serious shortcoming for this analysis.

Estimates of Duration of Marriage

The 1966 census is tabulated by region, for women by five current age intervals, and for those ever married by several age intervals of first marriage (see table 4.A.7). Neglecting the intervals between dissolution of marriages and remarriage, on which there is no information, these census tabulations can be used to approximate the average number of years elapsed since first marriage for each current five-year age group of women.

There are three distinct issues: (1) estimating the mean current age in the age intervals reported; (2) estimating the mean age at first marriage in the age at marriage intervals; and (3) interpolating age at marriage for the standard five-year age intervals to complement other published data. In the first case, the mean age within current age intervals can be directly calculated for ever-married women at the regional level from single-year age distributions by marital status (vol. 3, table 2). In the second case, two procedures are used. Among women age 25 or more, most of the cohort is married. An estimate of the average age at marriage (AM) for those married at each current age is calculated as follows:

$$AM_j = \left(\sum_{k=1}^{n} m_{jk} \cdot AM_{jk} \right) \sum_{k=1}^{n} m_{jk}, \qquad \begin{array}{l} j = 1, \ldots, 5 \\ k = 1, \ldots, n \end{array}$$

where the regional subscript is suppressed, j refers to current age interval, and k refers to age-at-marriage interval. A relation over age cohorts between AM and current age would be affected by the tendency of older groups to have had more years to get married, increasing with age the average reported age at marriage, other things being equal. Also, there is some evidence that the median age at marriage has decreased among more recent birth cohorts during the twentieth century (Goode 1970; Barclay 1954). Linear regressions are fit within regions to the four current age groups over age 24, with the mean age at marriage expressed in either arithmetic or logarithmic form as a function of the current mean age and an intercept. The arithmetic form accounted satisfactorily for the secular upward trend in age at marriage and was used to interpolate values for five-year intervals over age 25—that is, coefficients of determination were between 0.8 and 0.9.

For younger women a different approach was needed, given the form of the age at marriage tabulations (see table 4.A.7). The working assumption is that cross-sectional differences in the proportion married at different single ages represents the marrying fraction of a stable "synthetic" cohort that begins to marry at age 12. For women currently aged 15 to 19, for example, the average duration of marriage is then approximated as

$$_{19}D_{15} = \sum_{l=15}^{19} \sum_{i=12}^{l} (m_j - m_{j-1})*p_l*(l-i))/\sum_{l=15}^{19} p_l,$$

where the regional subscript is suppressed, and m_j and p_j refer to single-year married proportions and female populations of exactly age j. For women currently 20–24, the summations over the l index run from age 20 to age 24.

To determine if the first method of direct observation yields results similar to those of the second, comparisons are possible only over the entire current age interval from 15 to 24 and later age groups. The two resulting estimates of marriage duration for age 15–24 are correlated at 0.99 over the 21 regions. At later ages the two approaches are, as one might anticipate, less highly correlated.

The first direct interpolation method is used to obtain the estimates of the average duration of marriage or years of exposure since first marriage for the age cohorts older than 24 in 1966. The second synthetic cross-sectional method is used to obtain the duration estimates for the two younger birth cohorts in 1966. The natural logarithm of this marital duration variable is reported in table 4.A.8 by region along with the logarithm of the cohort's birthrate per year of exposure to marriage. The sum of these logarithmic variables is, of course, the logarithm of the cohort's average number of births per woman.

Notes

1. The services produced by the numerical stock of children enter into many family consumption and production activities. The output of these activities depends on associated expenditures of time and goods, some of which directly enhance the value of the child services, such as the children's schooling and health. Unfortunately, the final outputs of these family activities are not generally observed or ascribed market prices. Therefore the dimension of demands for child services that is used here is simply the number of children born or surviving to a specified mature age. See Becker (1960); Willis (1974); DeTray (1974); Becker and Lewis (1974).

2. See Zajonc (1976) for review of evidence and a stylized interpretation of intelligence differences by birth order and number of siblings. Lindert (1974) presents new evidence on this pattern and provides an explanation in terms of a mother's allocation of time among children.

3. Economic models of fertility have usually been formulated in terms of a single period-static choice problem in which parents demand the optimal lifetime stock of children for their income, relative prices, and technology (Becker 1960; Willis 1974). Empirical tests of this framework have examined reproductive stocks or flows as though one were proportional to the other. Easterlin (1968) and others have stressed a dynamic mechanism by which fertility is adjusted in response to the gap between actual and anticipated income. Linking cohort income deviations to relative cohort size, Lee (1975) has proposed to complete the demographic feedback loop. But in the context of low-income countries or in Europe during its demographic transition, there is surprisingly little exploration of adaptive behavioral models. Indeed, the period of demographic transition is interpreted by some as convincing evidence that no generalizations are applicable beyond an ethnic/cultural region (Coale 1969, 1973). Given the nature of the data available and the sophistication of its analysis to date for evidence of multicausal relations, such a broad conclusion may be premature.

4. The desirability of incorporating stocks in the interpretation of reproductive flows was appropriately stressed by Tobin (1974). Though he is not responsible for this application of the stock-adjustment framework, his comments stimulated my search for the stock data analyzed in this paper.

5. Children are generally viewed by society as irreversible commitments by parents, and markets to exchange children are not condoned except in placing orphans or unwanted illegitimate offspring. But in Taiwan exceptional arrangements historically evolved for combining adoption and marriage to provide parents with the opportunity to "adopt out" girls and even boys into uxorilocal marriages. It was common for a couple to adopt a baby girl who was later to marry their son in a "sim-pua" form of marriage. This arrangement permitted a poor couple to avoid the economic sacrifice of rearing a girl to marriageable age and assured the adopting couple a loyal and servile daughter-in-law (Wolf 1972, chap. 11). More than half of the marriages in the Taipei area before 1925 did not require the transfer of a young woman into her spouse's household (Wolf 1972, p. 171). Adoptions are today 50% more common for girls than for boys and equaled about 3% of the births in 1970–72. There are other reflections of the lesser demand for girls (p. 60) including the reported historical practice of infanticide among girls (p. 54). Contemporary analysis of birthrates reveals a greater reproductive replacement response when a male infant dies than when a female infant dies (Schultz 1969), and preferences for male offspring are well documented in contemporary Taiwan surveys (Coombs and Sun 1978).

6. See Tabbarah (1971) and Easterlin (1975). In fact, difference in health conditions may affect the rate with which cohorts achieve their lifetime reproductive goals, but this effect is thought to be secondary to demand factors. To the extent that health-related supply limitations were positively associated with child mortality rates, the estimated partial association between child mortality and fertility would be biased in a negative direction by the omission of supply limitations or their determinants. There are still instances in which far less healthy and more malnourished populations, such as exist in sub-Saharan Africa and Bangladesh, might display regional differences in fertility that are attributable to differences in reproductive capacity or supply (Mosley and Chen 1976). See also Easterlin, Pollak, and Wachter's chapter in this volume.

7. Children as a producer durable expand the household's budget constraint (see Kelley's chapter in this volume), but not indefinitely, given imperfectly elastic supplies of contemporary inputs. For example, a small farmer might be able to borrow to buy additional land for his sons to farm, but the capital market may not view sons as the least risky form of collateral and might thus require an increasing risk premium on such a loan.

8. See United Nations (1965) for evidence of dissimilar age patterns of births across countries and over time. As yet no characterization of optimal child-spacing strategies has gained wide acceptance, though models are implicit in several studies (Sanderson and Willis 1971; Heckman and Willis 1975).

9. Barclay (1954, pp. 154–65) suggests life expectancy increasing from 25–29 about the turn of the century to 40–45 by 1936–40, but surprisingly little reduction occurred in infant mortality. Infant mortality declined from levels of 160 per 1,000 about 1940 to 32 by 1960 and 14 in 1974. (*Taiwan Demographic Factbook* 1974). Though some understatement of mortality exists and some transfer of infant deaths to the second year of life probably persists in the registry, these errors are unlikely to alter the noted trends or undermine confidence in interregional variation in registered vital rates (*Taiwan Demographic Factbook* 1964).

10. I have since found a reference by Chien-shen Shih (1976, p. 296) to a mimeographed study, "Rates of Return to Education in Taiwan, Republic of China, July 1972," prepared by K. G. Gannicott for the Ministry of Education. Gannicott's estimates of the social rate of return to education, as cited by Shih, are 27, 12, 13, 13, and 18% per annum for primary, junior high, senior high, senior vocational, and university education, respectively. It is unclear whether returns are calculated separately for men and women or what secular growth in real labor incomes is assumed that adjusts upward the cross-sectional age differences to obtain a synthetic estimate of longitudinal (cohort) returns to education.

11. These assumptions are discussed in the Appendix B; except for a variety of smoothing procedures to interpolate values for individual years, the primary assumption is that internal migration is not selective with respect to women according to their fertility, and that age-specific mortality does not differ with the child's mother's age.

12. In 1950, for example, multiplying out age-specific survival rates for Taiwan, the life table probability for a live birth to reach age 15 was 0.84, and having reached age 15 the chance of reaching age 30 was 0.95. In 1960 these survival rates had increased to 0.93 and 0.97 respectively, and by 1974 they stood at 0.96 and 0.98. See *Taiwan Demographic Factbook* for 1964, table 11, and 1974, table 34.

13. An obvious approach for dealing with child mortality is to choose a threshold age at which to measure "surviving children"; an age before which most child mortality occurs and beyond which survival prospects are favorable (see note 12).

Though arbitrary, this procedure appears at first to be an improvement over assuming that parents formulate their reproductive goals in terms of live births, valuing all the same regardless of survival status (see O'Hara 1972 on problems of evaluation and summation). But if we assume a multiplicative model of demand for births, and child-survival rates are an explanatory argument, we can rearrange terms and directly test the hypothesis whether demand for "surviving children" is indeed perfectly inelastic with respect to child mortality. However, imposing the "surviving child" hypothesis on the demand equation not only loses information, it makes it more difficult to interpret parameter estimates across birth cohorts of women for whom child survival is inherently observed to different threshold ages.

The equation estimated later in table 4.5 can be written

$$ln\, CEB = \alpha + \beta ln(CEB/CA) + \gamma ln\, SF + \delta ln\, SM + \epsilon FP + \mu,$$

where CEB is the number of children ever born per woman, CA is the number of those children still living per woman, SF and SM are the proportions of women and men with some junior high schooling, FP is family-planning inputs per woman, μ is a normally distributed constant variance disturbance, and α, β, γ, δ, and ϵ are estimated response elasticities. Rewritten in terms of the number of living children per woman, one has

$$ln\, CA = \alpha \beta + (\frac{\beta - 1}{\beta}) ln\, (CEB) + \frac{\gamma}{\beta} ln\, SF + \frac{\delta}{\beta} ln\, SM + \frac{\epsilon}{\beta} FP + \mu/\beta.$$

But, if estimated in this form, the high definitional collinearity of CA and CEB makes interpretation difficult, as would the admission of errors in measuring cohort fertility. The "surviving child" hypothesis could be rigidly tested in this context by determining if the coefficient on CEB were actually zero, that is, $\beta = 1$.

14. The measures of education and the inverse of the child-survival rate (based on either cohort experience or recent period-specific rates) are essentially proportions and are not unreasonably specified in the double logarithmic or constant elasticity form. Family planning effort, on the other hand, is an absolute measure of inputs up to the previous calendar year per potential recipient, and in this case the exponential functional form has the appeal of permitting the elasticity to rise or, more likely, fall with the scale of inputs. The predictive power of the cohort-fertility equation was also increased slightly when family planning inputs were specified in a form that required the fertility response to inputs to approach an asymptotic limit, such as $1/(1 + FP)$.

15. Stochastic models of the biological components to their interbirth interval are compatible with the distributed-lag framework, modified to allow the lag structure to be unimodal and skewed to the right, such as the log normal in excess of the minimum gestation period. See Sheps and Menken (1973) and Potter (1975).

16. Another estimation approach was explored for three age groups (30–44). An iterative maximum likelihood procedure would choose a value of δ, obtain OLS estimates of β where the dependent variables is $C_t - \delta C_{t-1}$, and iterate on δ to maximize the predicted fit for C_t. Similar parameter estimates were obtained, but t ratios were generally increased, particularly for women's schooling and child mortality.

17. Barclay (1954, pp. 248–54), in his classic study of Taiwan up to 1945, disparages the idea that there is little variation in the prewar high fertility level between rural and urban areas. He notes further that "it has not been possible to find any evidence of association between fertility and other recorded types of behavior of rural Taiwanese by Districts" (townships), whereas "the strongest spatial pattern of fertility was the sectional one, viewed in prefectual units" (counties examined here). This puzzles him, since Taiwan was recently settled and did not appear to have evolved distinct regional cultural traditions. Earlier, however, Barclay did note that the prefectual spatial arrangement of mortality and fertility is "somewhat the same." Though Barclay does not indicate what recorded types of behavior he investigated, it seems unlikely that he looked at child mortality, women's schooling, or women's labor force activity outside of agriculture.

18. The husbands of a cohort of women are, on average, older. But without information from the census on exactly how much older, the educational attainment of men of the same age has been used here. The estimated relationship should not be greatly confounded by this relatively uniform error in measurement. The tendency would be for the estimated coefficient to be biased toward zero from that for actual husbands who are older and less well educated than the age group used here.

19. Cohort fertility can also be decomposed into the proportion married and the number of children born per married woman. Since it is uncommon to find census tabulations by age at marriage and current age and common to encounter tabulations by marital status and age, it is worth noting that this less satisfactory decomposition reveals roughly the same results as does the duration-of-marriage decomposition (tables 4.6, 4.7). Particularly among the younger women for whom the proportion married appears a reasonable proxy for marital duration, the associations with child mortality are notable. Similarly, the education variables are more important in the regressions on children born per married women.

20. Divorce is rare though not absent in Taiwan, but remarriage appears to occur promptly (Barclay 1954, chap. 8). Presumably an increasing share of the time since first marriage is spent without a husband as the cohort ages, owing to widowhood. This effect may be impounded in the fertility regression constant term among older women. Regional and time series variation in marriage proportions and the frequency of divorce has been attributed to sex ratio differences in Taiwan (Goode 1970, pp. 289–316), but this endogenous aspect of the problem is not treated here.

21. Standardizing these marital fertility rates according to a given reproductive schedule is not necessary. There is obviously a parallel between this form of cohort fertility decomposition and the procedures adopted in the Princeton European Fertility Study (Coale 1969, 1973). Since their methodology relies on regional period-specific births and indirectly standardizes these for age and marital status composition of the population, a Hutterite fertility schedule is used to weight the age distribution. In Taiwan there is little evidence in cohort data of the tradeoff found by Demeny (1968) in marriage and marital fertility indexes, but further research on this issue is needed.

22. Though our expectation is that income from the husband's earnings increases the demand for children, other things equal, this result does not follow from the simple demand theoretical framework without additional assumptions (T. P. Schultz 1974). Therefore a two-tailed t-test of significance seems appropriate in evaluating the male schooling regression coefficients.

23. The proportions literate, with primary school (or more), and with senior high school (or more) were used in place of the proportion with some junior high

school (or more) as measures of schooling/wage rates. They were slightly less successful in explaining fertility, but similar age patterns of regression coefficients were obtained.

24. Since it is likely that higher fertility is associated with earlier childbearing, the children of mothers' of a given age may be somewhat older, on average, in regions where fertility is higher. With older children, child survival would be lower, even if age-specific death rates are uniform across regions. This inability to measure child mortality to the same age level imparts an upward bias to the estimated elasticity of cohort fertility with respect to cohort child mortality. In addition, some evidence suggests that child mortality is greater among the offspring of very young mothers (see also note 25). There are clearly many difficulties to disentangling life-cycle relationships among age at marriage, fertility, and child mortality, and this investigation deals only with a few preliminary indications of such relations.

25. As indicated in note 24, the relationship between marriage duration and child mortality is undoubtedly overstated (positively), since women who married earlier had their children earlier, on average. Their children were therefore older at the time of the census and had experienced more mortality risks. This effect, however, diminishes markedly as the cohort of women age and their youngest children outgrow the period of heaviest mortality. But earlier-born children were also exposed to the earlier and undoubtedly higher infant and childhood death rates. This time-series effect and the duration effect would both tend to bias upward the partial association between marriage duration and child mortality. Techniques proposed by Brass, Sullivan, and Trussell to estimate life-table mortality rates from retrospective survey information on child-survival rates should help to mitigate the bias arising from the greater age of offspring of mothers that married at a younger age.

26. Coale (1973, p. 57) is convinced that the timing of marriage, at least in Europe, does not respond to reproductive goals, and he thereby directs his attention to changes in marital fertility as a precursor to the demographic transition. "Few couples marry at 25 instead of 24 because of a calculation that they will have one birth less; whereas the practice of contraception or abortion is directly aimed at fewer births." Both components of cohort fertility may bear further examination by behavioral scientists to better understand the demographic transition, even in the European setting.

27. The F-statistics with 5 and 37 degrees of freedom are 0.98, 0.45, 0.52, 1.55, 1.59 and 0.95 for the age groups 20–24, 25–29, 30–34, 35–39, 40–44, and 45–49, respectively. At the 10% confidence level, one could reject the hypothesis of coefficient equality if the $F(5,37)$ exceeded 2.01.

28. Child mortality is observed in each year in each region through the age of 15. The measure of schooling of men and women—that is, the proportion with some junior high school—is interpolated between the 1966 census and tabulations published from the Household Registry system in the Factbooks of 1973/1974. These changes would primarily reflect cohort migration among regions. Family planning inputs are accumulated per potential recipient. A slightly better fit to the data is obtained if the family planning inputs are transformed to $1/(1 + FP)$, which implies more sharply diminishing returns to scale approaching an asymptotic limit as past inputs accumulate. The easier to interpret linear exponential specification is retained in tables 4.8 and 4.11, however.

29. Another procedure is to include a vector of dummy variables for all but one calendar year to account for yearly changes in flows, without restricting the trend

to be linear. This more flexible procedure reduces degrees of freedom but implies similar results.

30. As in table 4.8, the two variables used to identify the lagged endogenous stock variable are the cohort's child mortality experience, lagged two years, and family planning inputs, lagged two years. Note that the cohort's child mortality is derived initially from different data than the period-specific child mortality level that enters directly into the stock-adjustment equation. The former is based primarily on retrospective child survival as reported in the 1966 census and adjusted over time by period-specific death rates, as discussed in the Appendix B. The latter period-specific variable is obtained from the region's age-specific death rates (for all cohorts) two years before the dependent variable birthrate.

31. One step would be to estimate continuous distributed lag structures rather than the discrete two-year lag in mortality and the one-year lag in family planning inputs. Another step would be to model the innovation (birth control technology) adoption mechanism along the lines proposed by Welch (1970), allowing for more flexible substitution possibilities between classes of family planning workers (Schultz 1969*b*) and interaction effects between women's (and men's?) schooling and the application of family planning extension activity. When I explored such interaction effects in the context of the stock-adjustment equation (tables 4.8, 4.11), the interaction coefficients were positive (as expected if women's schooling substitutes for extension effort in diffusing modern birth control technology), but not quite statistically significant from age 35 to age 44. The coefficients (and their *t* ratios) for the cross-product terms were for age 35–39, 29.3 (1.00), age 40–44, 20.0 (1.33).

32. The convention is followed of subjecting the calendar year's registered births to mortality of that year on 31 December before obtaining the population of living children for the next year. Hence, the census at the end of November 1966 is taken as a year-end population total, in which the births are assumed to occur on the last day of the accounting period. The 1967 year-end total of one-year-olds will then be the 1966 registered births diminished by the 1967 infant mortality rates. The small error in measurement introduced by this convention in the initial year, therefore, will not be cumulative, though it will overrepresent infants in these demographic accounts.

33. Methods could be applied at the regional level based only on current-period fertility and mortality schedules by age. (See p. 8 of Maurer and Schultz 1972.) Using more information about recent levels of birthrates and death rates seems superior, though perhaps more complicated.

Comment   Ronald Freedman

As usual, T. Paul Schultz has prepared a stimulating paper. He has anticipated in one way or another most of the questions that might be raised about his models and their empirical test, but discussion of some of these problems may nevertheless be worthwhile, since a number of points are debatable.

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The stock-adjustment concept, as I understand it, is the economist's version of the demographer's cohort analysis, in which current and prospective reproductive experience is examined in the light of past performance of the cohort. This becomes especially useful when (*a*) the experience to date is broken down into different attained parities and progression ratios, preferably by parity, computed from year to year; and (*b*) for explanatory purposes significant social or economic subgroups are examined for differential cumulative experience to date and differential progression ratios. This requires a great deal of data. However, a similar problem confronts attempts to make the stock and flow concept applicable to meaningful subgroups.

As the stock and flow model is set forth, it involves making certain assumptions that Schultz acknowledges might be problematic. I want to discuss a few of these.

One assumption is that a constant proportion of the relative difference between desired stock and the actual stock is delivered in each time period across population categories. But a number of component elements enter into the timing of the adjustment flow of births. Among these are spacing of births, age at marriage, and the preferred number of children. We know that there is a strong relation between education and first use of contraception for spacing. (See my table C4.1.) This will tend to slow the absolute pace at which the better educated have children once they marry.

Second, we also know that the proportion married at each age (especially at the younger ages) is strongly related to education (see table C4.5). If one measures the pace at which different educational strata move toward their reproductive goals from similar ages, as this model does, then late age at marriage also contributes to a slower rate of movement toward the reproductive goal of the better educated. Working in an opposite direction is the fact that preferred number of children is less for the better educated (see Schultz's table 4.3), so any given absolute pace of movement toward the observed goal means a faster rate of attainment of the additional stock wanted for the better educated. In the same direction, there will be small effects making for faster movement at higher educational levels because the better educated have higher fecundity (Jain 1968) and make somewhat less use of breast-feeding (Jain et al. 1970).

All these phenomena are changing over time. These observations illustrate how a set of specific mechanisms that affect the timing of fertility are changing differentially between educational strata and also between rural and urban strata (and five of the twenty-one regional units in this analysis are Taiwan's five largest cities). A model that does not take this into account is likely to miss essential elements of the dynamics that Schultz is valiantly trying to represent in the aggregate. The

Table C4.1 Percentage of Wives Who Have Ever Used Contraception and Percentage of All Wives and of All Users Who First Used Contraception for Spacing Purposes, by Wife's Education and by Marriage Duration: Taiwan, 1973 (KAP-IV)

Wife's Education	% Ever Using Contra-ception	% of All Wives First Using for Spacing	% of Users First Using for Spacing	N Total	N Users
Marriage duration 0–4 years					
None	20.7	12.4	60.0	145	30
Some primary school	25.4	12.7	(50.0)	71	18
Primary graduate	30.7	21.8	71.2	815	250
Junior high graduate	54.8	39.7	72.5	146	80
Senior high graduate or more	65.0	56.4	86.7	197	128
Total	36.8	27.2	73.9	1,374	506
Marriage duration 5–9 years					
None	62.5	17.2	27.5	355	222
Some primary school	61.8	19.8	32.1	131	81
Primary graduate	71.9	27.5	38.2	841	605
Junior high graduate	83.9	45.0	53.6	149	125
Senior high graduate or more	92.4	51.9	56.1	106	98
Total	71.5	27.8	38.9	1,582	1,131
Marriage duration 10–14 years					
None	76.7	11.4	14.9	489	375
Some primary school	86.0	16.6	19.3	157	135
Primary graduate	85.8	21.5	25.1	599	514
Junior high graduate	92.3	31.9	34.5	91	84
Senior high graduate or more	92.9	51.8	55.8	56	52
Total	83.3	19.3	23.2	1,392	1,160
Marriage duration 15 years or more					
None	80.7	5.4	6.6	503	406
Some primary school	85.4	7.3	8.5	247	211
Primary graduate	83.1	10.9	13.2	402	334
Junior high graduate	79.2	18.9	23.8	53	42
Senior high graduate or more	100.0	53.8	53.8	26	26
Total	82.8	9.2	11.1	1,231	1,019
Total	68.4	21.4	31.3	5,579	3,816

problem here is perhaps similar to the one Simon Kuznets addresses in his paper (chap. 8): aggregation that summarizes components or processes that are themselves moving differentially and in opposing directions in a rapidly changing reproductive regime may miss some essentials, both for prediction and for understanding.

Schultz deals explicitly with some of these problems when he argues that, while an assumption such as we have just discussed may not be justified at the individual or social strata level, it can be sustained for the interregional analysis he is carrying out. I have two observations:

1. Five of the twenty-one regions he deals with are Taiwan's five largest cities, and we know they are different from the other sixteen units with respect to many characteristics, including the use of contraception, the use of contraception for spacing births, and age at marriage. Apart from the large number of development variables not explicitly treated, there is a marked bimodality with respect to education. For example, among women 25–29 in 1966, the proportions who were junior high school graduates or more were 28% for Taipei, 15–18% for the four other large cities, and less than 10% for fourteen of the other sixteen units. Schultz deals mainly with only two predictor variables, mortality and education. It seems plausible that their relationships with fertility and nuptiality may be a function of some of the large number of other variables in which the five big cities differ from the other sixteen areas.

2. It is not necessarily desirable that using these particular regional units washes out some specific relationships involving specific social strata because they are not differential between regions, even though it simplifies the equations. It can, and in some cases does, lead to omission of important relationships that are pertinent to population dynamics in Taiwan but that do not emerge on an interregional basis. Although the analysis is in terms of the twenty-one regions, the inferences made, and some of the public policy discussion, appear to lose this strict reference and move to the individual or social stratum level.

A second basic assumption of the model is that preferences as to number of children are distinctive single values and that "preferences among alternative outcomes greater or less than the single valued goal are assumed not to influence reproductive behavior." (All quotations are from Schultz's paper.) Schultz properly acknowledges that "parents . . . probably weigh a range of family size outcomes that are likely to occur with different probabilities" and that "asymmetries in these preferences may be important for understanding differences in fertility in Taiwan at least at the level of individual survey respondent or across educational lines." However, he adds that "when the regions are the units of analysis within a single cultural area, the assumption may be somewhat less restrictive."

In this connection he cites the work of my colleagues L. Coombs and T. H. Sun, who have demonstrated the empirical utility of what they call IN, a scale that measures the underlying preference structure for number and sex of children—a structure that lies behind the usual single-valued preference statement on surveys. I think it is worthwhile for the conference to have a few tables illustrating this work. My table C4.2, for example, indicates within educational strata the variation in the

Table C4.2 Educational Level Differences in the Relationship of IN Values to Selected First Preferences: Taiwan, 1973

First Preference for Number of Children and Wife's Education	Percentage Distribution in IN Scale				
	IN1–3	IN4	IN5	IN6–7	(N)
First choice = 2 children					
No education	31	58	8	3	(116)
Primary school	37	57	6	0	(518)
Junior high	37	57	3	0	(150)
Senior high and over	49	47	4	0	(216)
First choice = 3 children					
No education	5	23	38	24	(547)
Primary school	10	30	48	13	(1,430)
Junior high	13	42	43	2	(231)
Senior high and over	23	46	29	2	(157)
First choice = 4 children					
No education	0	10	38	52	(642)
Primary school	1	12	45	42	(1,057)
Junior high	0	21	52	12	(70)
Senior high and over	4	20	64	12	(25)
Total	12	28	36	25	(5,463)

Source: Coombs and Sun (1976).

underlying preference structure or bias for smaller or larger numbers of children for persons who have expressed the same first preference. My table C4.3 shows that these variations in the underlying structure or IN scale are associated with behavioral differences in contraceptive use after adjusting for the effects of first preference and for whether the wife said she wanted more children. Finally, my table C4.4 shows the variation in preference structure with the rural-urban categories for persons having the same first preference. This is particularly relevant to Schultz's paper because it indicates the distinctive variation in the preference structure of the five large cities among the twenty-one regions. The assumption that the asymmetry is not pertinent to the regional variation may not be applicable.

I turn now to some comments on the specifications and empirical aspects of the model:

1. First of all, that five of the twenty-one regions are Taiwan's five largest cities and that the other sixteen include all the smaller towns and the rural areas leads to questions about a model that involves just two explanatory variables—education and mortality. The five cities are different from the other sixteen units with reference to a long list of development and demographic variables. It seems likely that these other

differences that do not enter the model directly would affect the relationships Schultz measures. While he fully acknowledges this complexity and the need for further detail in specification, I think the point needs to be stressed, especially since he makes rather emphatic statements about the connection between mortality and nuptiality that I think are debatable.

2. Let us turn to that issue. Based on the analysis represented in his tables 4.6–8, Schultz finds the support for the interesting and important idea that there is a linkage between prior mortality declines and later age at marriage, "which deserves further study to find out why it arises, how it responds to change and whether social and economic policies can facilitate this important institutional response to declining mortality." It was this kind of statement that I had in mind when I said that findings based on a rather specific and limited set of regional variations were followed by inferences and policy speculations that transcend regional

Table C4.3 **Relation of IN Values to Use of Birth Control, with Adjustments for First Preference and Marriage Duration (Wives 20–39 Years)**

	Percentage Ever Using Contraception			Percentage Currently Using Contraception			Percentage Ever Using Abortion			
	Actual	Adjusted		Actual	Adjusted		Actual	Adjusted		
IN Values		A1[a]	A2[b]		A1	A2		A1	A2	N
20–29 years										
1–3	67	65	67	50	48	50	16	16	17	401
4	58	57	57	43	42	42	13	12	12	844
5	49	51	51	34	36	36	10	9	9	910
6–7	51	43	42	28	31	29	8	9	8	416
Total	54			39			11			2,571
30–39 years										
1–3	87	88	89	76	74	75	29	30	32	240
4	84	84	85	72	71	71	30	30	30	691
5	84	83	83	70	69	69	30	29	29	1,028
6–7	76	78	77	65	67	66	23	25	24	927
Total	82			69			28			2,886
20–39 years										
1–3	75	75	79	60	60	66	21	23	25	641
4	70	70	71	56	57	58	19	21	22	1,536
5	67	67	66	53	53	54	20	20	20	1,940
6–7	65	64	61	53	53	48	18	18	16	1,346
Total	68			55			20			5,463

Source: Coombs and Sun (1976).
[a]Adjusted in multiple classification analysis for first preference for number of children.
[b]Adjusted for first preference and marriage duration.

Table C4.4 **Distribution of IN (Number Preference Scale) by First Preference, for Five Large Cities and Other Regions: Taiwan, 1973**

First Preference and Type of Place	IN				N
	1–3 Small Families	4 →	5 →	6–7 Large Families	
2 Preferred					
Five large cities	50	45	4	0	454
Other places[a]	30	62	7	1	554
(Rural townships)	26	60	11	2	211
3 Preferred					
Five large cities	13	33	44	10	714
Other places	8	30	47	15	1,662
(Rural townships)	6	29	46	20	764
4 Preferred					
Five large cities	1	15	42	42	390
Other places	1	11	42	46	1,418
(Rural townships)	0	12	36	52	758

Source: Data from unpublished work by L. C. Coombs and T. H. Sun.
[a]Includes smaller cities, and urban and rural townships.

differences. But I also have some questions about the relationship itself.

In the first place, one plausible explanation of the relation is that mortality decline and later age at marriage are both responses to a broad range of other development changes that differentiate the regions, particularly the large cities from the other places. Second, I have a question on a technical point. The measure of mortality used in tables 4.6 and 4.8 are simply the survival rates for the children ever born to the women in each age group, that is, the ratio of surviving children to those ever born. You may remember that in tables 4.6 and 4.8 the relationship between mortality and nuptiality or marriage duration is very strong in the younger ages and rapidly diminishes with the age of the women. My question is, To what extent is this a simple result of the fact that the mortality measure is sensitive to the differential exposure to mortality of the children that is related to marital duration?

In the young age groups, variations of a year or so in the age at marriage will result in large variations in marriage duration and, therefore, in the period of risk of child mortality. In older cohorts a variation of a year or so in marriage age makes much less difference. To what extent is the strong relation in the young ages a result of a mortality measure that has a built-in nuptiality component, producing as an artifact a strong correlation with nuptiality? This problem does not arise in tables

4.9 and 4.10, where the mortality measure is directly based on age-specific death rates and where the results in the relation to fertility are therefore rather different. Schultz acknowledges this problem in a footnote, but, in view of the importance he attaches to the relation of nuptiality and mortality, the nature of this effect needs empirical clarification. On the other hand, in tables 4.7 and 4.8, on the basis of the regional units, Schultz finds very little relation between education and age at marriage or percentage married at even the younger ages. This is inconsistent with the cross-sectional data for strata that show very strong educational differentials in the percentage married, especially at the younger ages. This relationship, which has prevailed for quite a few years, is illustrated in my table C4.5 for 1966.

Perceptions that mortality of children is still relevant for childbearing were still fairly common in Taiwan as recently as 1973. Responses to this question: "People used to think families should have a large number of children because some would die; do you think this is still important these days?" are indicated in my table C4.6. About 10% answered "very important" and 27% more said "fairly important"; only 19% said "not important at all." The number of children preferred varied by half a child between those considering mortality very important and those considering it not important at all, even after adjusting for the effects of education, type of residence, and marital duration.

Table C4.5 **Proportions of Women Married by Age and by Education: Taiwan, 1966**

Age and Educational Status	Percentage Married	Age and Educational Status	Percentage Married
15–19		*25–29*	
Illiterate	17.0	Illiterate	92.6
Literate	13.7	Literate	93.1
Primary school graduate	8.3	Primary school graduate	88.6
Junior high graduate	3.6	Junior high graduate	81.0
Senior high graduate	4.0	Senior high graduate	69.7
Total	8.7	Total	88.6
20–24		*35–39*	
Illiterate	74.1	Illiterate	94.2
Literate	70.9	Literate	93.0
Primary school graduate	59.3	Primary school graduate	91.5
Junior high graduate	40.0	Junior high graduate	91.5
Senior high graduate	24.5	Senior high graduate	90.5
Total	57.4	Total	92.3

Source: Table II-1, *1966 Demographic Factbook, Republic of China*, Department of Civil Affairs, Taiwan Provincial Government, October 1967.

Table C4.6 **Importance Attached to High Mortality of Children as Reason for Having Large Families—Proportions Giving Various Responses and Preferred Numbers of Children Related to These Responses: Taiwan, 1973**

	% Distribution of Responses	Mean Preferred Number of Children	
		Unadjusted	Adjusted[c]
Response:[a]			
Very important	10.2	3.54	3.48
Fairly important	26.8	3.51	3.44
Not too important	43.7	3.15	3.18
Not important at all	18.8	2.95	3.02
Total percentage[b]	100.0		
N	5,588		

[a]The question asked was: "People used to think families should have a large number of children because some would die; do you think this is still important these days? Would you say, Very important, Fairly important, Not too important, or Not important at all?"
[b]Includes 0.6 no answer.
[c]Adjusted for wife's education, marriage duration, and type of place of residence.

A third basic aspect of the model specification interprets women's education as a proxy for value of time—a common procedure in economic models of reproductive behavior. I wonder if this is meaningful with respect to marital fertility in societies like Taiwan, in which few wives work in the modern sector. For example, Eva Mueller (unpublished manuscript), analyzing Taiwan survey data for 1969–70 found that only about 7% of the married women 22–42 years old were working away from home full time, and an additional 3% worked away from home part time. Among these, almost half were wives of farmers who often worked as agricultural laborers for other local farmers. In addition, about 42% had worked at some time in the preceding year on a family farm or in some other family enterprise. But that kind of work has been found to have little relationship to fertility either in Taiwan or elsewhere.

The role of education as an indicator of value of time in relation to nuptiality is much more plausible and much more consistent with the micro data than the relationship to marital fertility. A large number of Taiwanese women do work in the modern sector during the period before marriage. They often state their reason as saving toward a trousseau and household furnishings for when they do marry. A recent issue of the *Wall Street Journal* called attention to a current labor shortage in Taiwan. This is in the face of a large potential reservoir of well-educated young married women who might be expected to work under the value-of-time interpretation. Apparently, so far the normative and cultural restraints are more important than the demands of the labor market.

I suspect that one reason why Taiwan fertility has not fallen even more rapidly to date and why the strong preference for sons remains an important barrier to more rapid fertility decline is that the institutional restraints on paid work by wives means that their educational attainment has not been translated into valued time that is redeemable in the modern labor market. A change in that situation might help to erode the institutional basis for the strong preference for sons. In the meantime, however, for married women education is not plausibly interpreted primarily in terms of value of time.

An additional factor bearing on the value-of-time hypothesis is that large numbers of Taiwanese couples of childbearing age are living with parents or married siblings who could provide child care even if the wife worked away from home. As of 1973, somewhat more than half of the wives 20–39 were living in such extended households (Freedman et al. 1978). In addition, 12% of the husbands' parents were living with one of his married brothers in the same town, and visiting relationships to couples living in nuclear households are reported as very frequent and offer the possibility of child care. In a large proportion of these cases the couple is also making financial contributions to the husband's parents.

Schultz has quite properly called for additional research to get at the meaning of the relation between education and fertility. In such a situation as Taiwan's, the value-of-time interpretation seems a little strained for marital fertility but not for nuptiality, as I have indicated. In passing I suggest several other possibilities: education in Taiwan, as elsewhere, leads to nonwork activities and interests outside the home; education and its close connection to mass media access exposes the individuals to the Western role model of the small family and later marriage. Jack Caldwell (1976) has advanced the view that this Western (rather than modern) model has a powerful direct effect that is additional to development per se in Africa and elsewhere.

Schultz calls attention to the possible continuing role of parental mate selection, at least on nuptiality. I can supply some data on this point. As of 1973, 50% of the Taiwanese wives 20–39 years old said that their marriages had been arranged by their parents, 31% by parents and the couple together, and only 18% by the couple alone. Those whose marriages were arranged did marry earlier than others and were more poorly educated. There is also a carryover relation to preferred family size after marriage. Those whose marriages were arranged wanted about 12% more children than other couples, even after adjusting for the effects of wife's education and degree of urbanization of place of residence.

Schultz specifies that a necessary assumption in the empirical work is that migrants between the regions should not be different from the nonmigrants with respect to fertility. I think one might add that they also should not differ in the rate at which they reach their reproductive goals. As of 1973, in the sixteen regions that do not include the five largest cities the cumulative fertility of migrants was about 10% less than that of nonmigrants for the age groups 30–34 and 35–39, and in these age groups the migrants had a larger proportion of couples originally using contraception to space their children. (A migrant is here defined as a person who has moved between townships, which are subcategories of the regions; so these are not necessarily all interregional migrants in terms of the Schultz model.)

M. C. Chang (1976) also shows that, among migrants from rural areas to large cities, both preferred and actual fertility tend to be lower for migrants than for nonmigrants at the place of destination (as well as at place of origin) after adjustment for effect of age and duration of marriage. Chang's analysis is based on a definition of migration as involving a move from place of birth to current place of residence.

Schultz uses one of his regression equations and micro data for 1966–74 to estimate reductions in marital fertility attributable to education ranging from 7% to 18% as one moves from ages 25–29 to ages 40–44. This can be compared with total declines in marital fertility at these ages ranging from about 25% at ages 25–29 to 75% at ages 40–44. This averages out to be about 25% of the total marital fertility decline as attributable to education changes and 75% to changes within education categories—closely comparable to the finding Schultz cited from work based on analyses of the vital statistics. It is important to keep in mind that the decline in fertility within educational strata is three times as great as the decline attributable to structural changes in the educational distribution. This, together with the rapidity of the decline, is one plausible argument for rapid diffusion of birth control consistent with program effort effects during this period in Taiwan, involving women of low educational status at least as much as those of high educational status. It also indicates an important phenomenon affecting fertility that is not so well represented by macro data at the regional level.

In this connection, a fact Schultz mentions—that well-educated women were having their children later into the thirties in 1974 than the less well educated—is not a result of any known new trend toward postponement of births for those well educated. It results instead from the fact that, while age-specific birthrates declined for all educational strata between 1966 and 1974, the much greater decline in this period for the poorly educated at the older ages (over 30) means that the differentials in period rates by education were reversed from a high negative relation in 1966 to a modest positive relation by 1974.

In his comments on the final stock-adjustment model (table 4.9), Schultz finds that inputs of the family planning program are uniquely positively correlated to fertility at ages 15–19 and 20–24, and the expected negative correlation appears at older ages. He offers a possible interpretation of the peculiar relationship at younger ages that would be plausible if "the preferred path to obtain the desired stock of children were itself a function of birth control technology." I interpret Schultz to mean here that these young women either married early or had their babies early in order to attain desired family size very quickly and then stopped childbearing with the aid of birth control. He draws as a possible parallel the shorter birth interval in the twentieth century, along with lower fertility in some Western countries. I do not find this interpretation highly plausible.

The married women at ages 15–19 and 20–24 have been increasingly the select group who did not postpone marriage. They are significantly less well educated than those who did not marry young, and a substantial proportion, especially of those 15–19, were premaritally pregnant. In 1966, for example, only 9% of the women 15–19 were married and, among these, 32% were less than primary school graduates and only 8% had more than a primary education. Among those 20–24 years old in 1966, 58% were married and, among these, 37% were less than primary school graduates and only 12% had more than a primary education. A further consideration is that during this period around 1966 the family planning program was primarily directed to and accepted by couples with at least two living children. This is not the kind of group background from which one would expect the rational reproductive regime I understand Schultz to be describing. They are more plausibly the backward, rather than a vanguard, group in areas of rapid transition.

Finally, setting aside the specifics, the general objective Schultz sets forth is certainly desirable. We do need better models and more appropriate data to permit us to relate dynamic changes in the reproductive system to dynamic changes in the social and economic system. As he indicates for developing countries, this requires dealing with relationships under conditions of disequilibrium. In these circumstances, I think it is particularly important to have, as part of the enterprise, initial disaggregation of important variables that are subparts of the model when we have reason to believe that elements in such subsystems are changing at differential rates for different strata of the population. This, as I have tried to indicate, is probably the case with respect to the dependent variable in the stock-adjustment model—the rate at which major groups of families are moving from the existing number of children ever born to their eventual goals.

Fertility is part of a very complex biosocial system. Demographers have made some progress in taking elements of this system apart and measuring their dynamic components. We have done less well in putting the parts back together into models that represent the functioning whole or in relating the reproductive system to the social and economic determinants on a cohort basis. Economists are more skilled, and I think more interested, in building models, especially at the macro level or with macro units. Demographers tend to be more concerned with empirical specifics, with data at the social and demographic stratum level. The broad goal Schultz sets forth requires both kinds of materials. Otherwise an effort that is conceptually of great interest is limited because everything in the system is represented by a few variables whose interpretation then becomes problematic. Looking to the future and recognizing the value of the objective, I wonder if the model need lead to the use of the kinds of regional units employed, which are awkward for reasons I have tried to indicate.

This brings me back to my opening comments. Are we really much further ahead with a translation of cohort fertility analysis into the stock-adjustment model at the regional level? Could we not apply the concept to time series of surveys providing data to relate to ongoing cohort analyses of major strata? Then such matters as reproductive preferences and many other variables could be obtained from the surveys. As I understand it, the stock-adjustment model is often used with reference to a sample of firms; then why not deal with samples of individuals aggregated into the social units that are socially and economically meaningful, rather than into geographical-administrative units that blur some important aspects of the dynamics of reproduction?

Comment   Riad B. Tabbarah

In the field of the economics of fertility as it stands today, it is important to differentiate between theoretical validity and technical sophistication. While theory can stand on its own, the value of the techniques in the application of theory depends not only on the inherent quality and consistency of the techniques, but also on the validity of the theory itself. The criticisms I shall present of Schultz's paper and, particularly, of some of its conclusions, relate to the theoretical basis to which the techniques were applied and not, generally speaking, to the techniques

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themselves. Let me hasten to add that this theoretical shortcoming, which Schultz readily admits in the introduction to his paper, is to some extent an unfortunate characteristic of the field he was asked to deal with.

Children are a peculiar commodity, unlike any other for which economic demand theory has been formulated (Leibenstein 1974). The tools developed in conjunction with demand theory therefore need to be adapted and supplemented for the analysis of the demand for children. This is admittedly a very difficult task—one that perhaps requires more time than has already passed since the field of the economics of fertility has become popular among economists and that certainly requires more concentrated effort. The temptation, therefore, has been very strong among many economists to adapt the problem to their tools rather than fit their tools to the new problem. Beginning with Becker in 1960, economists have assumed children to be a consumer durable, a commodity for which their tools of analysis were highly developed. Schultz assumes at the outset that "the demand for children [is] in part a demand for a *durable input* that enters into many lifetime production and consumption possibilities." Reproductive goals are then "summarized in terms of a desired lifetime stock of children." While this represents, perhaps, a greater degree of sophistication than Becker's assumption, it remains basically an attempt at adapting the problem to the tools and not the other way around.

Schultz readily admits that the theory of demand is not workable because consumer benefits from children are satiable and because the cost of funds to invest in children is upward-sloping. But there are more fundamental reasons why the theory of demand is not applicable in the case of children, and these have to do with the tools underlying the theory.

Let me take one example—the cost of children. What is important here, it seems, is the cost of a child relative to the income of the parents. One may argue that, to the extent that the items of expenditure on the child in the household budget remain basically the same with development, this relationship should remain fairly constant: as the income of the head of the family rises, his expenditure on, say, food, housing, and clothing for himself will increase in approximately the same proportion as that spent on the other members of the family. With development, however, new items of expenditure on children emerge (notably education), and this tends to make the burden of dependency relatively higher, if, of course, a significant cost is attached to education.

But more important than the relative *cost of a child* is, perhaps, the relative *cost of children*. In societies at the very early stages of development, a child becomes financially independent of his household (and may become a contributor to its income, but this will be neglected here) at a relatively early age—say nine years. If we assume that, given the relatively low fecundity and high infant mortality in these societies, a child surviving to maturity is born every three years to given parents, then by the time the fourth child is born the first one becomes financially independent, by the time the fifth child is born the second becomes financially independent, and so on, so that the burden of support of children of this household is limited to three children no matter how many it eventually produces. By extending the period of support and reducing the potential interval between surviving children (because of increased fecundity), the spread of education—and hence development—increases the *cost of children* to parents relative to their income in a very significant fashion. Thus, in a developed country, if parents were to have, say, eight children spaced two years apart and to be supported to the age of 17 years, they would at a given moment in their life, be supporting all eight children at the same time. Therefore, even when education is free, the relative cost of children increases immensely by the mere increase in the average schooling period.

This observation has obvious implications for, say, the budget line in an indifference curve analysis. In a society at the early stages of development, the budget line might slope downward from the Y-axis (representing all other goods) to the point corresponding to two or three children and then become horizontal to the X-axis (representing number of children). More popularly stated, if parents in these very underdeveloped societies can afford two or three children, they can afford "as many as God wills."

As we have already learned from various authors (Leibenstein 1957; Easterlin 1969), a socioeconomic theory of fertility must take into account, inter alia, the utility and disutility of children, the adequacy of income given conventional standards (Tabbarah 1972), the cost of a child also given conventional standards, and the cost of children as explained earlier. The effect of a given variable on the demand for children (that is, on desired family size) can then be assessed in terms of its effect on these components of household decision-making. For example, educational attainment tends to reduce the desire for children because, among other things, it increases the disutility of children by opening up competing alternatives, increases the cost of a child because it represents a new item of expenditure, increases the cost of children because of the resulting increase in the period of support, and perhaps also has straining effects on the adequacy of income. Schultz's models interpret educational attainment as a proxy for the value of time of men and women, and he finds that, as such, educational attainment is negatively associated with the desire for children. His conclusion is therefore probably correct. But is the explanation of it an adequate one? Or is this explanation so partial that it is of limited significance? Schultz himself wonders whether one can sustain the economists' broad and powerful hypothesis that the productive "value-of-time" is the driving force behind education's effect on diverse forms of household behavior and whether there are other aspects of the husband's and wife's economic contribution to the family that can be quantified and related to schooling. The answer to the first question is probably no, and to the second is probably yes. But what is more important is that this wondering reflects the limitation of the theoretical base on which the quantitative model is built.

A socioeconomic theory of fertility must also take into account the fecundity constraint (or supply constraint), which is most evident in countries and among groups at the early stages of demographic development. In these circumstances, at least a large majority of couples are unable to achieve their desired number of children in their completed family. This is due not only to a relatively low fecundity (caused by malnutrition, infections associated with childbearing, and the prevalence of certain diseases), and to high infant and child mortality, but also to a relatively high number of children desired. Since Schultz, in drawing conclusions from his models, takes fertility as a proxy for the desired number of children—that is, for the demand for children—the existence of this constraint could considerably weaken the validity of his conclusions. Although Schultz is aware of the difficulty this constraint might introduce in his models, he nevertheless assumes it away on the grounds that it is only significant "under extreme conditions of malnutrition and specific endemic disease, e.g., gonorrhea"—conditions that presumably did not exist in Taiwan, the country to which his models are applied. I find this assumption not completely tenable. Because I have been responsible for pointing out this fecundity constraint (Tabbarah 1964) and have since presented a model of demographic development based on it (Tabbarah 1971), I should perhaps explain in some detail why I believe Schultz's assumption is not necessarily justified.

The model I am referring to identifies four stages of demographic development: the first stage is where the desire for children is relatively high because of prevailing social and economic conditions and where the maximum attainable number of children is relatively low because of both low fecundity and high infant and child mortality. At this stage, a large proportion of couples are unable to attain their desired number of children and therefore aim at maximum reproduction. Because their reproductive aims are unattainable, they are often expressed in terms of "as many as God wills" or "as many as possible," and their knowledge of methods of fertility regulation is limited.

The second stage is reached when the desired number of children becomes more or less equal to the maximum attainable number owing both to a decline in the desired number caused by improved social and economic conditions and to an increase in the maximum attainable number mainly owing to the improved health of parents (i.e., higher fecundity) and of children (i.e., reduced infant and child mortality). At this stage, a large proportion of couples are able to just attain their reproductive goals, with a proportion able to exceed them and another proportion unable to attain them.

At the third stage of demographic development, the desired number of children becomes lower than the maximum attainable number for the large majority of couples, creating a potential need for fertility regulation and the use of contraceptive methods. During this stage, however, lags in the decline of fertility tend to appear because of the lack of family planning programs and inadequate societal knowledge of contraception, and because of underestimation by couples of the extent of the decline in mortality and other such factors, thus resulting in a significant proportion of unwanted births (Tabbarah 1976).

Finally, at the fourth stage of demographic development, which is characteristic of the developed countries, a situation is reached where the desired number of children is relatively low and easy to achieve, and is actually achieved by most couples. (It must be noted that the population of a given country might be, at any given point, at more than one stage of demographic development. See Tabbarah [1978]. See also the model presented in this volume by Easterlin, Pollak, and Wachter.)

Now Schultz maintains that "fertility is generally higher in populations that experience higher child mortality rates" and that "this evidence is strongly suggestive of a mechanism, probably both involuntary (biological) and voluntary (behavioral) in nature, that achieves some manner of population equilibrium given environmental health and economic constraints." But if the model of demographic development is basically correct, then it is clear that the relationship between fertility and child mortality is not as simple as stated here. At the first stage of demographic development fertility might be low and child mortality high, while only at the second and third stages would the positive relationship between fertility and child mortality begin to appear.

What is more important for the present purpose, if such a relationship (a positive association between fertility and child mortality) was actually observed in Taiwan when making regional comparisons, as Schultz indicates, then one might draw the conclusion that the various regions of Taiwan were, in 1966, at the second and third stages of demographic development. If this is true, it follows that a significant proportion of couples, at least in some regions, were not achieving their desired number of children; and their fertility therefore could not be taken as proxy for their desire for children (i.e., demand for children), as Schultz does throughout the paper. In fact, the situation is more serious than this, since women up to the age of 60 and over in 1966 enter into the analysis. Many of these women had their main reproductive years sometime in the 1940s or earlier, a time when Taiwan was undoubtedly at an early stage of demographic development, where no positive relationship existed between fertility and desired number of children. Schultz's findings actually show that the positive relationship between fertility and child mortality is strong only for the younger age groups; after age 40 the elasticity of fertility with respect to child mortality becomes almost nil, and the association eventually becomes negative but loses statistical significance. Schultz's explanation of this is that, "as a cohort advances through its life, the elasticity of fertility with respect to child mortality may be expected to decline, because offspring continue to die after their mother is unable to replace them with additional births." But considering the low mortality rates of children after age 15 or 20 when mothers reach the end of their reproductive years, the fact that even at younger ages mothers may not replace lost offspring, and the very significant decline and eventual disappearance of association between fertility and child mortality, this explanation cannot be readily accepted. The existence of a fecundity constraint among the older age groups during their reproductive years seems to offer a much more powerful explanation; and if this is so, fertility, at least for these women, would not reflect their desired family size and may not, therefore, be taken as proxy for their demand for children.

In conclusion, quantitative models like the ones used by Schultz, which are intended as applications of a given theory, are necessarily *associative*. The conclusions derived from them as to the causal relationship between variables can be made only on the basis of the causal model on which they are based, since correlation by itself does not mean causation. Thus, if the causal theory is weak or untenable, then the quantitative associative model based on it is itself necessarily weak, no matter how internally consistent or sophisticated it is. Considering the inadequacy of the traditional tools of economic theory in analyzing the demand for children, it is difficult to develop quantitative associative models based on them that could satisfactorily explain the mechanism of household decision-making with regard to desired family size. This does not mean that associative models, such as the ones Schultz presents, should not be developed; imperfect as they may be, they generate information that itself can be valuable for the eventual development of new tools and an appropriate causal theory. From this perspective, Schultz's paper serves the purpose for which it was written—to shed light on certain important associative relationships between fertility and some social and economic variables.

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