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AN ECONOMIC INTERPRETATION OF THE DECLINE IN FERTILITY IN A RAPIDLY DEVELOPING COUNTRY: CONSEQUENCES OF DEVELOPMENT AND FAMILY PLANNING

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Abstract

Two aspects of reproductive behavior are investigated for 21 regions of Taiwan. A conventional economic model of fertility is fit to (1) the logarithm of cohort fertility in 1966, (2) the logarithm of marriage duration, and (3) the logarithm of the birth rate per year since first marriage. The close association noted between regional levels of child mortality and cohort fertility in Taiwan is linked with earlier marriage in regions of high child mortality. Educational attainment of men and women, which are thought to affect parent reproductive goals, account for variation in birth rates within marriage. A simple stock adjustment is then adapted to explain both the stocks of births and subsequent flows of births to women of various birth cohorts. The stocks in 1966 and 1971 and the pooled flows from 1967 to 1974 imply similar estimates of the underlying reproductive process: child mortality increases births (a replacement response), female secondary schooling decreases births (predominantly a price of mother's time effect), male secondary schooling increases births (predominantly an income effect), and local family planning field worker activity decreases births after a woman reaches age 30 (reduced informational and monetary costs of birth control).

I. INTRODUCTION

Parents make sacrifices to rear children. And though some rewards of parenthood are virtually immediate, other benefits from having children cannot be realized for years or even decades. In understanding the process by which reproductive goals change, the demand for children should be interpreted, therefore, 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, the spacing of them 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 with 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 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 birth rates, 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 child mortality experience, and the availability of birth control information and services. First, the accumulated stocks of births are analyzed by age of women and regional variation in this measure of cohort fertility is decomposed into effects operating through the age-at-marriage and through the birth rate 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, that cannot be corrected here for want of appropriate individual panel data or analytical tools that can 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 publically 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 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, e.g., 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 (Mandami, 1972; 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, for 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 equation may also help us understand how the demographic transition works its way through a population.

The paper is ordered as follows. The next section 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 third section, 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 four into marriage duration and marital fertility to acquire insight into the responsiveness of fertility and social institutions such as marriage to environmental change. The stock adjustment model is estimated in section five and the results are discussed further in a concluding section.

II. DESCRIPTION OF TAIWAN AND AVAILABLE DATA

Demographic Transition

Mortality declined in Taiwan, notably among adults, during the period of Japanese colonial administration of the island i.e. 1895-1945 (Barclay, 1954). Though the rise in per capita income among the Taiwanese in this inter-war 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 the 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 have all contributed to this achievement. Undoubtedly, the growth of income and personal consumption facilitated this change; 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 birth rates emerged in the late 1950's 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 birth rates, decreased by half (See appendix Table 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 birth rates gradually spread to younger women. This was accompanied by a slow rise in the age at marriage (see Appendix Table 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 and birth rates, the annual rate of population growth in Taiwan increased from about one percent in the first two decades of this century, to 2.3 percent during the interwar period, and peaked at more than 3.5 percent during the 1950's. Population growth has begun to ease in recent years and was somewhat less than two percent per year in 1974 (Appendix table A-3).

Family Planning Program

Taiwan organized and executed one of the first, most extensively studied, and apparently 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, an island-wide program was expanded in several years to every township and city precinct in the country(Freedman and Takeshita, 1969). Analyses of regional birth rates and regional family planning activity find a strong negative partial association between the seemingly random allocation of family planning field workers and the level and decline in birth rates of women over the age of 30 (Freedman and Takeshita, 1969; Hermalin, 1968, 1971; Schultz, 1969b, 1971, 1974). The implied effect of program personnel on birth rates, however, diminishes from 1965 to 1968, and after about 1969 it becomes difficult to assess whether or not the accumulated activity of the program has continued to affect birth rates by a statistically significant amount (Schultz, 1969b,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, i.e. the IUD and pill, the period of disequilibrium behavior that follows is likely to be shortened by the subsidized dissemination of information, services and supplies relevant to adoption. But in contrast with 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 (extention effort per women of childbearing age) unless communication between generations is absent. This tendency is already evident from cross sectional analyses of program inputs and birth rates 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, 1969b, 1971).

Another partial explanation for the difficulty of assessing the regional impact 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 unambigouously linked to lower birth rates among older women, and as one might expect, the two classes of field workers working for different government agencies appear to be substitutes for each other in bringing about this outcome (1974a). Some indications are found that those regions that were lagging in reducing their birth rates 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 (Schultz 1974a).

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, et.al. 1971; Freedman and Berelson, 1976). These changes in class differentials of contraceptive knowledge, use, and fertility are carefully documented in Taiwan during the 1960's and 1970's (Freedman, et.al. 1974), but it remains difficult to infer how much of these changes is due to Taiwan's Family Planning Program.

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 marshall 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 percent, from .44 to .58, while exposure to junior high school increased 125 percent among women of the same age, from .24 to .54. This increase in the proportion reaching junior high school in an eight year period is all the more remarkable when it is realized that the size of the birth cohort to educate in that period also increased by about 80 percent.

Direct evidence, however, is available that educational attainment is associated with reproductive behavior in Taiwan, for whatever reason. Tables 1 and 2 report 1974 birth rates, calculated by date of occurrence, for mothers and fathers, respectively, by age and educational attainment. Three things may be noted. A sharp reduction in total fertility rates (i.e., sum of age specific birth rates 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 on to junior high school than by an average number of years of schooling (implying a linear relationship), or another higher cut off point such as college education, which is further from the mode of the educational attainment distribution.

The second observation drawn from Table 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 ag than do less educated women, but they also appear to continue bearing children somewhat later, into their 30's. This is a relatively new pattern in later age-education specific birth rates 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 birth rates found that the negative

TABLE 1

1974 Birth Rates by Age & Educational Attainment of Mother

(per thousand by date of occurrence)

Educational Level	15-19	20-24	25-29	30-34	35-39	40-44	45-49	Total Fertility rate*
Illiterate and those without schooling	110.5	315.8	223.3	82.8	33.6	9.3	1.1	3882
Literate without graduating from Primary school	97.2	247.7	192.2	77.3	28.2	10.7	1.7	3275
Primary school graduate without graduating from Junior High or Jr. Vocational School	48.7	244.3	235.7	95.3	34.6	9.7	1.7	3350
Junior High graduate without graduating from Senior High or Sr. Voc. School	8.0	136.4	221.7	96.6	29.2	5.2	1.9	2495
Senior High graduate without graduating from Jr. College or University	6.6	70.7	201.3	112.5	48.6	6.5	0.7	2235
Jr. College & College graduate, graduate school attended, graduate school graduate	11.7	37.7	163.3	101.7	41.1	8.4	1.3	1826
All Educational Groups	32.2	183.3	219.0	91.2	32.7	9.3	1.4	2846

*Total fertility rate is five times the sum of age specific birth rates.

Source: 1974 Taiwan-Fukien Demographic Factbook, tables 4 and 48 for Taiwan Area.

TABLE 2

1974 Birth Rates by Age & Educational Attainment of Father
(per thousand 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*
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	2893
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	2946
Primary school graduate without graduating from Junior High or Jr. Vocational School	8.4	83.8	261.0	177.5	67.3	28.6	18.2	8.6	3.4	0.7	3288
Junior High graduate without graduating from Junior College or University	2.2	55.4	231.5	169.0	59.6	43.0	33.4	12.8	4.7	0.9	3063
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	2499
Junior College and University graduate and graduate school attended and graduate	8.9	19.0	109.7	137.0	55.3	46.2	33.3	10.1	2.6	0.7	2114
All Educational Groups	4.6	57.0	218.4	167.0	64.4	33.8	23.5	9.0	3.2	0.5	2907

*Total Fertility rate is defined as for women as five times the sum of the age specific birth rates.

Source: 1974 Taiwan Fukien Demographic Factbook, tables 4 and 47 for Taiwan area.

effects of women's education on birth rates were attenuated after age 34 (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 educational groups.

The third regularity to note is the lesser, more ambiguous, variation in birth rates with father's education (Table 2) than with mother's education (Table 1). From illiterates to those with higher education, mother's total fertility rates decline almost monotonically by 53 percent, whereas father's total fertility rates rise 13 percent, peaking among primary graduates, and then fall 28 percent 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 outweigh their price-of-time effect, but the price-of-time effect embodied in women's value of time (education) 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 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 in the period since 1950. It may be asked, how much of the decline in fertility has been simply due to the increased educational attainment of

TABLE 3

Educational Attainment at Age 20 to 24, by Year of Birth and Sex[a]

(in Percentages)

Educational Level or Above	1950-1954	1942-1946	1932-1936	1922-1926	1912-1926
Literate :					
Men	99	97	90	85	69
Women	96	82	66	46	26
Attending some Junior High School:					
Men	58	44	27	34	20
Women	54	24	11	11	6
Attending some Higher Education					
Men	16	10	5	7	6
Women	10	5	1	1	1

[a]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 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 augmented notably the male proportion with secondary and higher education in the cohort born between 1922 and 1926 and residing in Taiwan in 1966.

Source: 1950-1954 birth cohort--1974 Taiwan-Fukien Demographic Factbook, table 4. Earlier cohorts--1966 Taiwan Population Census, Vol. II, No. 3, table 2.

women? Partitioning the change in crude birth rates into changes in women's age composition, educational composition and a residual change <u>within</u> age/education cells, it was found that 24 percent 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, <u>et. al</u>., 1976).

<u>Child Mortality and the Demographic Transition</u>

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 and sometimes reversing the cross sectional pattern between mortality and surviving family size. 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, nor how rapidly they occur as the regime of mortality changes. Knowledge of the mechanisms involved and of the lags in adjustment are essential to assess the duration of the current phase of rapid population growth in low income countries, and to appraise the gains and losses from policy interventions that seek to improve nutrition and health, and thereby 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 constant for past child losses and examine how the recent regional variation in child mortality is associated with current fertility.

Overview of Available Data

The unit of analysis is a highly aggregated region of Taiwan: five major cities and 16 counties. Only for these large subdivisions are the number of children ever born and the number of children living reported age of woman (1966 Census). The Household Registration 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 their first marriage (1966 Census). The relationship between mean age of a cohort and the 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 and age at marriage.

Educational attainment of the population is available in various censuses by age and sex, and is recently published from 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/or educational attainment of household head. The unweighted means and standard deviations of variables used is later analyses are summarized in Appendix Table 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 are 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 simply 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.

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 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 were undertaken that accelerated the declining trend in death rates and possibly fostered labor mobility, both developments 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 Kelly's paper in this volume).

III. A STOCK ADJUSTMENT MODEL OF REPRODUCTION

My objective is to estimate an adaptive model of demand for a durable--children--that might clarify the process by which reproductive behavior responds over time to disequilibria 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, namely, 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 decisionmaking 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 theirs, 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, 1976). 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, production and consumption technology, and relative prices, and it may under some circumstances even reflect allocative decisions and preferences of household members, all of which are to some degree endogenous.[11] Nonetheless, it is widely believed that regional and time series variation in aggregate mortality rates are attributable primarily to climate, public investments, available drugs and medical knowledge, and modifications in social organization, and not due 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 on reproductive goals and behavior are too complex 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).

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, 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).

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

where the Z_i's are M conditioning variables whose effect on C* extend for n periods, α and β_{ij} (i=1, ..., M; j=1, ..., 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 <u>relative</u> 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 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 would seem appropriate.

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

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 b 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 3 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 quite 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 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 (col. 5 or 7) rises with age, while 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 preformance, or substantially stronger assumptions (see Lee, 1976). At 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,

$$B_t = e^{C_t} - e^{C_{t-1}}, \tag{3}$$

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

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

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.

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

TABLE 4

Actual and Preferred Number of Births of Wives in 1973, Proportion Currently Married in 1971, and Birth Rate in 1974, by Age and Education

Age and Education	(1) Sample Size Wives KAP-IV 1973	(2) Mean Live Births 1973	(3) Mean Preferred No. of Children 1973	(4) Differences Between Preferred and Actual (3) - (2)	(5) Proportion Wives Wanting No More Children 1973	(6) Proportion Currently Married 1971	(7) Estimate Wanting No More Children[a] (5) * (6)	(8) Birth Probabilit or Rate 1974
Age 20-24								
1. Illiterate	135	2.11	3.31	1.21	.341	.738	.252	.304
2. Some Primary	98	1.95	3.05	1.10	.398	.704[b]	.280	.250
3. Primary Graduate	729	1.61	3.03	1.42	.276	.545	.150	.249
4. Junior High Graduate	88	1.30	2.63	1.33	.205	.338	.069	.133
5. Sènior High Graduate	79	.87	2.44	1.57	.165	.171	.028	.074
Total	1129	1.62	2.99	1.37	.281	.480	.135	.193
Age 25-29								
1. Illiterate	248	3.09	3.35	.26	.641	.939	.602	.217
2. Some Primary	127	3.06	3.24	.18	.654	.931[b]	.609	.192
3. Primary Graduate	792	2.73	3.12	.40	.562	.889	.500	.248
4. Junior High Graduate	157	2.25	2.68	.43	.541	.811	.439	.219
5. Senior High Graduate	149	1.52	2.42	.90	.389	.691	.269	.209
Total	1473	2.65	3.05	.40	.563	.870	.490	.228
Age 30-34								
1. Illiterate	509	4.06	3.61	-.45	.841	.948	.772	.078
2. Some Primary	164	3.86	3.38	-.48	.817	.958[b]	.783	.075
3. Primary Graduate	623	3.65	3.27	-.28	.830	.933	.774	.098
4. Junior High Graduate	104	3.29	2.97	-.32	.856	.910	.779	.095
5. Senior High Graduate	102	2.55	2.60	.05	.794	.848	.673	.112
Total	1502	3.71	3.33	.38	.832	.935	.770	.091
Age 35-39								
1. Illiterate	497	4.63	3.79	-.84	.918	.949	.871	.034
2. Some Primary	295	4.78	3.71	-1.07	.946	.953[b]	.902	.029
3. Primary Graduate	502	4.19	3.52	-.67	.902	.925	.834	.035
4. Junior High Graduate	88	3.74	3.07	-.67	.932	.918	.856	.027
5. Senior High Graduate	52	2.96	2.63	-.33	.827	.908	.751	.030
Total	1434	4.39	3.60	-.79	.916	.938	.859	.032

[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 appears to refer to persons who are literate but not graduates of primary school.

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 1974 Demographic Factbook, table 18, based on date of registration

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 subsequented 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 of demand 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 only fixed for a birth cohort five years in breadth. For example, if $\delta(a)$ was .1, and the coefficient estimated on $Z_{i,t-\tau}$ was .5, the short run elasticity would be .5 and the five year elasticity for a woman to pass through this segment of her life cycle cannot be inferred readily from information about an age cross section.

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, u_t, in the desired stock equation (1), persist for an individual population over time or for a cohort as it ages. The distrubances are likely to be, therefore, positively serially correlated over time, at least toward the end of the child bearing period, and ordinary least squares (OLS) estimates will be biased because C_{t-1} will tend to be positively correlated with $\delta(a)u_t$. Notably, the OLS estimates of $(1-\delta(a))$ will tend to be biased upward (positively), and converseley, 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, one or more instruments are obtained that are independent of u_t but are related to C_{t-1}. These insturments 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 all lagged values of C will be eliminated from the equation. This reduced form 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 would seem 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, empirical specification of Z and the choice of identifying restrictions are discussed that permit one to estimate the stock and relative flow equations.

IV. 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 21 administrative regions of the island.[17] The following cohort specific explanatory variables are considered: (i) the reciprocal of the accumulated child survival rate; (ii) the proportion of women with some junior high school education as a proxy for the value of a mother's time; (iii) the proportion of men with the same level of schooling (of the same age)[18] as a proxy for male labor earnings; and (iv) the man months of family planning field worker activity in the region per woman of childbearing age i.e., 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 is thus 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, after age 35, 98 percent 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 data Appendix B, and estimates of marital duration are reported in Table B-4.[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]

Cohort Fertility

Among women over age 30, when childbearing is nearly completed, the proportion of women with some junior high school experience is negatively associated with cohort fertility (Table 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, and 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

Table 5

Regressions on Cohort Fertility or Stocks: Logarithm of Children Ever Born per Women by Age in 1966[a]

Age of Women	Constant Term	Cohort Child Mortality[b]	Proportion with Some Jr. High Schooling: Women	Proportion with Some Jr. High Schooling: Men	Family Planning Up to 1965[c]	R^2 (SEE)[d]
15-19	-2.98 (6.83)	20.1 (1.75)	1.07 (1.50)	-1.61 (1.17)	-144. (1.09)	.3628 (.366)
20-24	-.613 (4.21)	22.1 (5.56)	-.269 (1.57)	.664 (2.33)	12.6 (.31)	.6789 (.111)
25-29	.562 (10.2)	5.94 (5.07)	-.0886 (1.54)	.0542 (.58)	9.21 (.64)	.8062 (.0403)
30-34	1.07 (32.7)	3.28 (5.90)	-.0992 (4.09)	.0686 (1.79)	-9.81 (1.11)	.8913 (.02410)
35-39	1.26 (32.4)	1.77 (3.87)	-.148 (6.29)	.103 (2.76)	-17.7 (1.69)	.8865 (.0289)
40-44	1.31 (26.7)	.680 (1.59)	-.168 (5.01)	.0761 (1.18)	-17.3 (1.31)	.8777 (.0366)
45-49	1.38 (20.8)	-.335 (.78)	-.118 (3.10)	-.0452 (.65)	-3.33 (.19)	.8422 (.0466)

Notes:

[a] In parentheses beneath regression coefficients are t values. Observations are 21 major subdivisions of Taiwan for which data are published in the Taiwan 1966 Census, Vol. II, 2 and 3.

[b] Reciprocal of cohort's proportion of children everborn who are still living as reported in 1966 Census.

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

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

men's, it has recently been 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 less than 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 looses statistical significance. Among women over age 39, interregional variation in cohort fertility is insufficient to "offset" variation in child mortality, or 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 aged 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]

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, children are encouraged in the face of heavy child mortality 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 20 in 1920, and to about 23 today (Cf. Table A-2). Assuming that contemporary birth rates for married women did not change, delaying marriage five years from age 18 to 23 implies one to two fewer births per woman; compared with traditional cohort lifetime fertility of five or six births, this represents a substantial reduction in cohort fertility. 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 question I want to explore is 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 parent's 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 6 and 7. The duration of marriage 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 6), imply that a decline in child mortality from 15 to 5 percent, as is recorded between women age 45-49 and 30-34, is associated with a compensating variation in age at marriage of nearly 2 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 facilitate this potentially important institutional response to diminished mortality.[26]

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 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 7) but a negative bias at younger ages is anticipated. The schooling variables, that are interpreted as the value of husband and wife 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 fertility.

Table 6

Regressions on Duration of Marriage: Logarithm of the Average Years of Exposure to Marriage per Woman by Age in 1966[a]

Age of Women	Constant Term	Cohort Child Mortality[b]	Proportion with Some Jr. High Schooling: Women	Proportion with Some Jr. High Schooling: Men	Family Planning Up to 1965[c]	R^2 (SEE)[d]
15-19[e]	-2.92 (6.00)	20.1 (1.57)	.775 (.98)	-1.48 (.97)	-137. (.93)	.3081 (.409)
20-24[e]	-.177 (.93)	25.0 (4.81)	-.356 (1.59)	.696 (1.86)	-7.68 (.15)	.6384 (.145)
25-29	1.37 (16.0)	6.11 (3.36)	.0676 (.76)	-.199 (1.37)	20.2 (.90)	.6146 (.0626)
30-34	2.19 (45.0)	2.18 (2.65)	-.0060 (.17)	-.0265 (.47)	6.92 (.53)	.5340 (.0357)
35-39	2.63 (79.1)	1.04 (2.66)	-.0065 (.32)	-.0162 (.51)	7.22 (.80)	.5287 (.0247)
40-44	2.95 (107.)	.507 (2.11)	.0053 (.28)	-.0327 (.90)	4.90 (.66)	.4583 (.0205)
45-49	3.18 (126.)	.315 (1.94)	.0124 (.86)	-.0353 (1.35)	4.41 (.68)	.4627 (.0177)

Notes:

[a-d] See Table 5.

[e] Marital duration calculated by indirect procedure for women less than 25 years old. See Data Appendix.

[f] Regression coefficient for cohort child mortality is biased upward, particularly for younger women as explained in text and footnote 25 because of measurement error.

Table 7

Regressions on Marital Fertility Rate: Logarithm of Children Ever Born per year of Marital Exposure by Age in 1966[a]

Age of Women	Constant Term	Cohort Child Mortality	Proportion with Some Jr. High Schooling: Women	Proportion with Some Jr. High Schooling: Men	Family Planning Up to 1965[c]	R^2 (SEE)[d]
15-19[e]	-.0599 (.58)	.0379 (.01)	.290 (1.72)	-.126 (.39)	-6.76 (.22)	.4906 (.0873)
20-24[e]	-.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)

Notes:

[a-d] See Table 5.

[e] Marital fertility rate calculated by indirect procedure for women less than 25 years old. See Data Appendix.

[f] Regression coefficient for cohort child mortality is biased downward, particularly for younger women as explained in text and footnote 25 because of measurement error.

Increasing both men's and women's schooling by similar proportions, marital fertility rates decrease among women over age 34. But given the actual proportionate changes in the last eight years (1966-1974) in men's and women's schooling for those age 20-24 (Table 3), the regression equations imply a 7 percent reduction in marital fertility rates for women age 25-29, 9 percent age 30-34, 14 percent age 35-39, and 19 percent 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 last 20 years, account for large decreases in cohort fertility between the age 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 5). But for women 35 to 39 in 1966, only about 6 to 8 percent 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 birth rates (Table 7).

Tentative Conclusions

Among younger women reaching their 30s in the later 1960's, regional variation in age at marriage appears to have over compensated 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 would 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 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 before the second period. Moreover, many of the offspring to these older women may have died in the dislocation and conflict of the war years, and the 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 either in terms of 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 birth rates and family planning activity at a lower level of disaggregation (Schultz, 1969b). 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, as will be investigated in the next section, they also imply that the recent decline in fertility will continue.

V. 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). Using both ordinary least squares (OLS) and instrumental variable (IV) techniques, the latter procedure being more appropriate if C_{t-1} is not independent of u_t, are shown in Table 8. In addition to the contemporaneous schooling variables for men and women, period specific child mortality and accumulated family planning inputs are lagged two and one year respectively. (See earlier work by 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 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 8 for the seven childbearing age groups are as follows: .07, .15, .20, .01, -.01, -.00, and -.00. Given the low level and possibly unplanned nature of fertility in older ages, the implied lack of discernable 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 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 implies compensating higher current flow of births to women over 35 in regions where child mortality has recently

Table 8

Stock Adjustment Equation: Relative Change in Children Ever Born in 1967[a]

Age of Women	Estimation Method[d]	Constant Term	Period Child Mortality[b] t-2	Proportion with some Jr. High Schooling: Women	Proportion with some Jr. High Schooling: Men	Family Planning t-1	Children Ever Born t-1	R (SE
16-20	OLS	.299	-1.07	-.326	.358	34.3	-.110	.83
		(2.07)	(.64)	(3.46)	(2.14)	(2.66)	(2.91)	(.04
	IV	.938	-6.83	-.558	.541	52.1	-.075	
		(.93)	(.73)	(1.44)	(1.38)	(1.51)	(.26)	(.07
21-25	OLS	.187	-.0896	-.0517	.0156	7.04	-.162	.95
		(12.3)	(.33)	(4.44)	(.81)	(3.32)	(11.5)	(.00
	IV	.199	-.316	-.0501	.00828	6.49	-.146	
		(8.78)	(.76)	(4.07)	(.37)	(2.78)	(5.59)	(.00
26-30	OLS	.183	.307	-.0181	.00963	-.819	-.130	.66
		(10.6)	(1.51)	(2.38)	(.82)	(.56)	(4.20)	(.00
	IV	.216	.658	-.0225	.0110	.142	-.198	
		(4.40)	(1.25)	(2.13)	(.81)	(.07)	(2.02)	(.00
31-35	OLS	.0568	.288	-.00955	.0170	-2.73	-.0203	.73
		(1.54)	(1.88)	(2.40)	(3.52)	(3.10)	(.58)	(.00
	IV	.0286	.186	-.00791	.0167	-2.65	-.00660	
		(.47)	(.80)	(1.61)	(3.38)	(2.93)	(.11)	(.00
36-40	OLS	-.00589	.257	-.00134	.00847	-1.81	.0110	.88
		(2.8)	(3.82)	(.53)	(3.34)	(3.39)	(.65)	(.00
	IV	-.00937	.249	-.00101	.00829	-1.77	.0137	
		(.29)	(2.78)	(.30)	(2.93)	(3.03)	(.53)	(.00
41-45	OLS	.00678	.133	-.00175	.00419	-.779	-.00406	.78
		(.74)	(4.92)	(1.24)	(2.38)	(2.72)	(.59)	(.00
	IV	-.00283	.121	-.00066	.00381	-.688	.00319	
		(.15)	(3.54)	(.28)	(1.96)	(2.06)	(.23)	(.00
46-50	OLS	.00435	.0179	-.00276	.000049	-.003	-.00315	.65
		(3.07)	(3.71)	(1.38)	(.17)	(.062)	(3.13)	(.00
	IV	-.00105	.0210	.000189	.000223	.022	.000763	
		(.12)	(2.50)	(.24)	(.46)	(.25)	(.12)	(.00

Notes:

[a] t or asymptotic t values are reported in parentheses beneath regression coefficients. Observations are 21 major subdivisions of Taiwan for which data are published in the Taiwan 1966 Census, Vol. II-2 and 3. The dependent variable is the difference between the logarithms of children ever born to the cohort in t and t-1, i.e., $\ell n\ C_{t-1} - \ell n\ C_t$, so that the regression coefficient on the lagged stock of children is an estimate of δ.

[b] Reciprocal of child survival rate derived from period age specific death rates from birth to age 15, lagged two years, i.e., for 1965. The choice of the two year lag is discussed in Schultz 1974a.

(Notes continued)

Notes to Table 8 continued

[c] Man months of effort by family planning field workers expended in region through 1967 divided by the number of women in the region of child bearing age (i.e., 15-49).

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

[e] OLS: Ordinary least squares estimates.

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

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 (Schultz, 1974) and in this case the short run response elasticity is about .2 from age 30 to 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 teenaged women, the women's elasticities exceed the men's during the 20's, and the reverse is true between the ages 30 and 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; Schultz, 1969b, 1974a). 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 field workers. This pattern of response among younger women in Taiwan, which I have noted before (Schultz, 1969b, 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 20th century despite the reduction in completed cohort fertility. A corollary of this hypothesis is that birth rates in Taiwan during the 1970's may start to decline even among women before they reach age 30.

There are several methods for investigating the stability over time and 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 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 9. Apparently the 1966 relationship overpredicts declines i 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 1966-1971. A margin of excess fertility implied by this exercise is not inconsistent with the evidence presented earlier in column 4 of Table 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 9. The contribution of declining child mortality appears to be of increasing importance among younger women. The reversal in the effect of education between the ages 35-39 and 30-34 is a reflection of the lower educational achievement in the younger age groups, who may have been denied by the war 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 partialled out fro

Table 9

Actual and Predicted Change in Sample Mean of Children Ever Born from 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
I. Relative Changes in Sample Mean:						
Actual	-.045	-.052	-.101	-.101	-.054	-.027
Predicted	-.120	-.036	-.109	-.144	-.135	-.062
II. 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
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 5, sample means of conditioning variables in Table A-4, and projections of child mortality described in appendix B.

the educational achievements of men, which appear to be offsetting. Taken together, education's impact 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 percent of the predicted declines in cohort fertility over age 30. Although these point estimates of the impact 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 would suggest 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 activity.

Another way to test the stability of the 1966 stock equation estimates is to reestimate these equations in 1971 as shown in Table 10. Several changes may be noted between 1966 and 1971 coefficients. The elasticity of fertility with respect to child mortality has increased and become more significant statistically speaking after age 25; educational elasticities of both men and women increased in later ages; the coefficients on family planning inputs are more significant statistically and of roughly similar magnitude as in 1966, though the level of accumulated inputs increased four fold 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 percent level.[27]

Accounting for changes in stocks is predictably more difficult than explaining variation in levels. Reproductive behavior for a cohort approaching the end of its childbearing period may be predicted with a reasonably

Table 10

Stock Reduced Form Equation for Children Ever Born 1971[a]

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

See Table 5 for Notes.

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 data appendix), and since each year's cross section of birth rates 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 birth rates to decline (i) for a cohort after age 25, and (ii) 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 activity in a region. In Table 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 8 to identify the influence of the lagged stock variable.[30]

Coefficients in Table 11 should be compared with an analogous average of the age specific equations in Table 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 difussion cycles,

Table 11

Stock Adjustment Equation: Relative Change in Stock of Children Ever Born, 1967-1974[a]

Instrumental Variable Estimates[e]	Constant Term	Period Child Mortality[b] t-2	Proportion with Some Jr. High Schooling: Women	Proportion with Some Jr. High Schooling: Men	Family Planning to t-1[c]	Calendar Year -1900[e]	Children Ever Born t-1[f]	SEE[d]
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

Notes:

[a] Asymptotic t values reported in parentheses beneath regression coefficients. See c for definition of dependent variable and e for identifying instruments and

[b] Reciprocal of child survival rate derived from age specific death rates from birth to age 15 two years prior in 1965. The choice of the two year lag is discussed in Schultz 1974a.

[c] Family Planning inputs per woman summed to the prior year as an accumulative stock of nondepreciating knowledge.

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

(notes continued)

Notes to Table 11 continued:

[e]Linear time trend introduced by the variable of the last two digits to the calendar year, i.e., 66, 67 etc.

[f]The dependent variable in this equation is the first difference of the logarithms of children ever born, i.e., $\ell n\ C_{t-1} - \ell n\ C_t$, so that the regression coefficient on lagged children is an estimate of δ.

[g]The identifying excluded exogenous variables are the cohort's child mortality to t-2, and Family Planning inputs summed to t-2.

though the allowance of a linear trend in time may understate the program's role in the secular down trend of birth rates. The effect of child mortality, which is also strongly trended downward, appears somewhat larger in the entire period 1967-1974 than it was in 1967, but a stable elasticity of about .2 to .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 child-bearing until the woman is in her mid to late 30's, 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 exceed 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 only reflect urban/rural differences in amenities that approximately parallel without causing differences in reproduction. As expected, a city/noncity dummy variable, defined equal to one for the five major cities and zero for 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 -.6 to -.8 in both 1966 and 1971; the city dummy variable is less highly correlated with birth flows in 1967 among older women, namely -.2 to -.3. Including this city dummy variable in the birth stock equation often increases significantly the explanatory power of the equation, particularly for older women (See appendix Tables C-1 and C-3), whereas it is not important in partially explaining regional differences in the flow of births (Table C-2). The only variable whose coefficient is altered notably 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 confirmed, 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 alledged 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 ten percent fewer children if they lived in the five major cities of Taiwan rather than elsewhere on the island (Table C-3), 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 for the same four seemingly crude proxies for child mortality, educational status of women and men, and prior family planning activity.

VI. CONCLUDING NOTES AND QUALIFICATIONS

How should disequilibrium be characterized and 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 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 measure, in the household sector, and those used in the last section of this paper, though tenable, can be easily criticized for belonging in the current period distributed lag function. Moreover, the stock adjustment framework is only the most simple 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 clarify how social institutions respond to environomental 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 impact on the marginal productivity of labor, and hence the opportunity value of time (T.W. Schultz, 1974). But education surely has other conseuqences for behavior and the abstraction of a single "price of time" may mislead if its 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 interes to market oriented activities and less time to child rearing, how can one get at directly the mechanisms by which education influences fertility ? A variety of subtler predictions can 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 physical 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.

FOOTNOTES

[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 their 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 been formulated usually 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 was 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 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 marriagable age, and assured the adopting couple a loyal and servile daughter-in-law (Wolf, 1972, chapter 11). Over half of the marriages in the Taipei area prior to 1925 did not require the transfer of a young women into her spouses household (Wolf, p. 171). Adoptions are today 50% more common for girls than for boys, and equal about three percent 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 birth rates reveals a greater reproductive replacement response when a male infant dies than when a female infant dies (Schultz, 1969), and male offspring preferences are well documented in contemporary Taiwan surveys (Coombs and Sun, 1976).

[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 which are attributable to differences in reproductive capacity or supply (Chen and Mosley, 1976). See also Easterlin, Pollack and Wachter's paper in this volume.

[7]Children as a producer durable expand the household's budget constraint (See Kelly's paper in this conference), but not indefinitely, given imperfectly elastic supplies of complementary 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 thus require an increasing risk premium on such a loan.

[8]See U.N. (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. 154-165) suggests life expectancy increasing from 25-29 around the turn of the century to 40-45 by 1936-1940, but surprisingly little reduction occurred in infant mortality. Infant mortality declined from levels of 160 around 1940 to 32 by 1960 and 14 in 1974. (1974 Taiwan-Fukien Demographic Factbook). 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. (1964 Taiwan Demographic Factbook).

[10] I have since found a reference by Chien-shen Shih (1976, p. 296) to a mimeographed study on "Rates of Return to Education in Taiwan, Republic of China, July 1972" 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 percent 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 which 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 Data Appendix; except for a variety of smoothing procedures to interpolate individual years values, 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 by 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 .84 and having reached 15 the chance of reaching age 30 was .95. In 1960 these survival rates had increased to 193 and .97 respectively, and by 1974 they stood at .96 and .98. See Taiwan Demographic Factbooks 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 previous footnote). 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 a multiplicative model of demand for births is assumed, and child survival rates are an explanatory argument, terms can be rearranged and the hypothesis tested directly 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 5 can be written

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

where CEB is the number of children ever born per women, CA is the number of those children still living per women, SF and SM are the proportions of women and men with some junior high schooling, FP is family planning inputs per women, u is a normally distributed constant variance disturbance, and $\alpha, \beta, \gamma, \delta$ and ε are estimated response elasticities. Rewritten in terms of the number of living children per women, one has

$$\ln CA = \alpha\ \beta + \left(\frac{\beta - 1}{\beta}\right) \ln (CEB) + \frac{\gamma}{\beta} \ln SF + \frac{\delta}{\beta} \ln SM + \frac{\varepsilon}{\beta} FP + u/\beta.$$

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, i.e., $\beta = 1$.

[14] The measures of education and the inverse of the child survival rate (either based on 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 this 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, 1974, and Potter, 1975.

[16] Another estimation approach was explored for three age groups (30-44). An interative 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. 248-254) in his classic study of Taiwan up to 1945 disparages 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 were 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 confounded greatly 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 generally 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 (Table 6 and 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 but not absent from Taiwan, but remarriage appears to occur promptly (Barclay, 1954, Chp. VIII). Presumably an increasing share of the time since first marriage is spent without a husband as the cohort ages due 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 the case of 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 (Schultz, 1974b). Therefore, a two tailed t-test of significance would seem appropriate in evaluating the male schooling regression coefficients.

[23]The proportions literate, primary schooled (or more) and senior high schooled (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 mother's (or a given age) may be somewhat older, on average, in regions where fertility is higher. Being older, 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 fn. 25). There are clearly many difficult to disentange 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 footnote 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 child outgrows 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/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 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 degress of freedom are .98, .45, .52, 1.55, 1.59 and .95 for the age groups 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49, respectively. At the 10 percent 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, i.e. 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 Table 8 and 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 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 data appendix. The latter period specific variable is obtained from the region's age specific death rates (for all cohorts) two years prior to the dependent variable birth rate.

[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, 1969b) and interaction effects between the woman'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 (Table 8 and 11), the interaction coefficients were positive (as expected if woman's schooling substitutes for extension effort in diffusing modern birth control technology), but not quite statistically significant from age 35-44. 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).

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Appendices

TABLE A-1

Age Specific Annual Birth Rates for Taiwan: 1949-1974

(Births per Thousand Women of Child-bearing Age)

Births Registered in Year[a]	Total Fertility Rate[b]	Number of Births Per 1000 Women of Specific Ages[c]						
		15-19	20-24	25-29	30-34	35-39	40-44	45-49
1949	5900	61	241	290	263	186	111	27
1950	6030	61	246	297	269	191	112	30
1951	7040	68	287	349	311	226	132	35
1952	6615	53	272	342	294	220	113	29
1953	6470	48	265	336	292	218	108	27
1954	6425	48	263	334	292	218	104	26
1955	6530	50	273	341	295	219	103	25
1956	6505	51	264	340	296	222	105	23
1957	6000	45	249	325	275	197	92	17
1958	6055	43	248	336	281	199	90	14
1959	5990	46	258	334	270	190	86	14
1960	5750	48	253	333	255	169	79	13
1961	5585	45	248	342	246	156	71	10
1962	5465	45	255	338	235	145	65	10
1963	5350	41	252	337	231	139	60	10
1964	5100	37	254	335	214	120	52	8
1965	4825	36	261	326	195	100	41	6
1966	4815	40	274	326	188	91	38	6
1967	4220	39	250	295	158	70	28	4
1968	4325	41	256	309	161	68	26	4
1969	4120	40	245	298	151	63	23	4
1970	4000	40	238	293	147	59	20	3
1971	3705	36	224	277	134	51	16	3
1972	3365	35	208	257	117	41	13	2
1973	3210	33	203	250	105	37	12	2
1974	3045	34	197	235	96	35	10	2

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

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

[c] Births by age of mother divided by the mid-year estimate of the number of women of that age.

Source: 1949-1964, Demographic Fact Book 1964
1964-1974, Demographic Fact Book 1974

TABLE A-2

Percentage of Women Ever Married in Taiwan by Age, 1940-1974

Period and Source	PERCENT 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. II, No. 3, Table 2, p. 125
1970 Census, extract, Table 9, p. 135.
1974 Taiwan-Fukien Demographic Factbook, Table 9, p. 366.

TABLE A-3

Selected Demographic Time Series for Taiwan, 1906-1974

Period	Natural Rate of Population Increase (percent per year)	Crude Vital Rates Birth (per Thousand Population)	Crude Vital Rates Death (per Thousand Population)	Infant Death (per thousand live births)	Life Expectan Male (years at bir	Life Expectan Femal (years at bir
1906-1920	1.02[a]	42	31	172	25-30	
1921-1940	2.32[a]	45	22	155	35-45	
1947-1949	2.5	40	15	b	b	b
1950-1954	3.58	45.9	10.1	37	56.1	60.2
1955-1959	3.49	42.9	8.0	37	60.5	65.9
1960-1964	3.08	37.2	6.4	30	62.7	68.0
1965-1969	2.44	29.7	5.3	22	64.4	70.0
1970-1974	2.01	24.8	4.8	16	66.5	71.8

Notes: [a]Taiwanese geometric rate of growth between censuses (Barclay, 1954, p. 13).

[b]not available.

Sources: 1906-1940, Barclay, 1954, pp. 13, 161, 241.
1947-1949, 1959-1961 Household Registry Statistics of Taiwan, Table 1.
1950-1964, 1972 Demographic Factbook Taiwan, Table 1, 1970 Demographic Factbook, Table 15.
1965-1974, 1974 Taiwan-Funkien Demographic Factbook, Tables 61, 74 and 76.

TABLE A-4

Means and Standard Deviations of Variables Used in Regressions on Fertility*

Variable	AGE GROUP OF WOMEN						
	15-19	20-24	25-29	30-34	35-39	40-44	45-49
1. 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)
2. Log (C_{66})	-2.86 (.410)	-.174 (.175)	.912 (.0818)	1.37 (.0653)	1.59 (.0766)	1.69 (.0934)	1.73 (.105)
3. Log (C_{67}/C_{66})	.781 (.0920)	.296 (.0297)	.105 (.00743)	.0362 (.00522)	.0137 (.00440)	.00431 (.00181)	.00056 (.00028)
4. Log (Reciprocal of cohort child survival 1966)	.0238 (.00817)	.0262 (.00718)	.0352 (.00931)	.0514 (.0120)	.0744 (.0164)	.110 (.0221)	.152 (.0277)
5. Log of child death rate 1965 +	.0521 (.0112)	**not age specific variable, i.e., identical for all age groups**					
6. **Log (proportion women with Jr. High School)**	-1.16 (.339)	-1.55 (.355)	-2.19 (.442)	-2.42 (.477)	-2.36 (.511)	-2.50 (.586)	-2.89 (.713)
7. Log (proportion men with Sr. High School)	-.692 (.184)	-.870 (.217)	-1.25 (.259)	-1.39 (.300)	-1.14 (.314)	-1.15 (.301)	-1.43 (.386)
8. Family planning per woman to 1965	.00161 (.00063)	not age specific variable, i.e., identical for all ages					
9. Family planning per woman in 1966	.00268 (.00081)	not age specific variable, i.e., identical for all ages					

*** The standard deviations of the variables are reported in parentheses beneath the means.** Values are unweighted over sample of 21 regions.

+ The natural logarithm of the reciprocal of the product of the age specific rates within the region from birth to age 15.

DATA 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 ith region is defined

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

where p refers to all women and s 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 19:

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

I then define alpha (α) as a marriage deflator for each region, year and for 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 as follows for, say, age 18 as follows:

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

The second step is to estimate birth rates for women by individual ages, though birth rates are reported from The Household Registry only by five year intervals. Using initial arbitrary estimates of marital fertility reported in Table B-1,denoted as F_j, that are not untenable at the national level for the base year of 1966, a similar procedure of deflation is performed to obtain estimates of individual year birth rates that are roughly consistent with the changing age composition of regional populations, marriage patterns and age-aggregated birth rates as recorded in the household registration system by date of registration. The base year estimate of the birth rate would become:

$$ {}_{19}B_{15,i}(t) = [\sum_{j=15}^{19} P_{ji}(t) * {}_{j+1}\hat{m}_{j,i}(t) * F_j] / \sum_{j=15}^{19} P_{ji}(t) $$

and a birth rate 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 birth rate for women of age 15 to 19 in region i in calendar year t. Similarly, a final estimate of the birth rate for women of individual ages is obtained:

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

Women are then followed by individual years in the 1966 Census age distribution, attributing to them their estimates birth rate 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 for the effects of internal migration. Thus the 35 to 39 year old women in

Table B-1

Initial Estimate of Marital Fertility Rate by Age of Woman Used to Calculate Beta

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

region 2 (Ilan Hsien) had 5.11 children on average in 1966 and in 1971 were estimated to have at age 40 to 44 5.34 children ever born. In contrast, those women age 35 to 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 to 4, 5 to 9, and 10 to 14. Based on national levels of age specific mortality between 1965 and 1970, the mortality rates for children age 15 to 19, 20 to 24, and 25 and over are arbitrarily assumed to be proportional to the death rate for children 10 to 14 in the region, where the factor of proportionality is 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 survive the cohort's living offspring to the next period one needs to know the age of their 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 B-2, chosen to be roughly consistent with national birth rates in the early 1960's. But if absolute differences in infant mortality remain substantial by region, as is the case in Taiwan in the 1960's, it seems appropriate to use regional household registry birth rates in 1966 to estimate directly the number of infants (age 0) by region and age of mother, and use the relative proportions in Table B-2 to distribute only living children age one and over. For example, women 20 to 24 in region 1

Table B-2

Initial Proportions of Children Living by Current Age, and Age of Mother in 1966

Age Group of Mothers	Age of Children						
	0	1-4	5-9	10-14	15-19	20-24	25 or more
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

(Taipei Hsien) registered a birth rate of .287 in 1966, and reported in the Census .938 children living. Ignoring infant mortality, the balance of children living, .651, are distributed between the age groups 1-4 and 5-9 in proportion to their cell values in Table B-2, or 90.8 and 9.2 percent, respectively.[1] Clearly, further refinements and more extensive checks for consistency could be introduced by using information on registered birth 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.[2]

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 birth rates in recent years in Taiwan. As the age at marriage has increased, the marital birth rate increased among those who still got 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 would also be consistent with a selectivity process by which those getting married are increasingly

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[1]The convention is followed of subjecting the calendar year's registered births to mortality of that year on December 31 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 accumulative, though it will overrepresent infants in these demographic accounts.

[2]Methods could be applied at the regional level based only on current period fertility and mortality schedules by age, see p. 8 of K. Maurer and T.P. Schultz, A Population Projection Model, R-953, Santa Monica CA: The Rand Corp., August 1972. Using more information about recent levels of birth and death rates would seem superior, though perhaps more complicated.

fecund, either because they were pregnant before marriage (perhaps unusually fecund for their age) or inclined to start immediately their childbearing, and hence marrying at an atypical 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, this defect in my calculations may not, hopefully, 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 B-3). 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

Table B-3

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 more
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	
35 and more					X

Source: 1966 Taiwan Census, Vol. 3, Table 6.

(Vol. 3 , Table 2). In the second case, two different procedures are used. Among women age 25 or more, the majority 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:

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

where the regional subscript is suppressed, j refers to current age interval, and k to age at marriage interval. A relation over age cohorts between AM and current age would be affected by the tendency of older age 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 20th century (Goode, 1960; Barclay, 1954). Linear regressions are fit within regions to the four current age groups over age 24 with t mean age at marriage expressed either in arithmetic of 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, i.e., coefficients of determination were between .8 and .9.

For younger women, a different approach was needed, given the form of the age at marriage tabulations (see Table B-3).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

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

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 runs from age 20 to 24.

To determine if the first method of direct observation yields similar results to 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 to 24 are correlated at .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 B-4 by region along with the logarithm of the cohort's birth rate per year of exposure to marriage. The sum of these logarithmic variables is, of course, the logarithm of the cohort's average number of birth per woman.

TABLE B-4

Logarithms of Estimated Marital Duration in Years and Marital Fertility Rate Per Year

Region	Current Age of Women: 15-19 Duration	15-19 Rate	20-24 Duration	20-24 Rate	25-29 Duration	25-29 Rate	30-34 Duration	30-34 Rate	35-39 Duration	35-39 Rate	40-44 Duration	40-44 Rate	45-49 Duration	45-49 Rate
1. Taipei Hsien	-2.10382	-0.37907	0.55780	-0.60008	1.72252	-0.81382	2.36912	-1.01742	2.75858	-1.20307	3.03816	-1.43261	3.25641	-1.64611
2. Ilan Hsien	-2.32702	-0.31383	0.45386	-0.56378	1.82714	0.88363	2.42640	-1.01091	2.79850	-1.16805	3.06907	-1.32586	3.28181	-1.51797
3. Taoynan Hsien	-2.19788	-0.30315	0.52947	-0.59850	1.75780	-0.81288	2.38573	-0.99612	2.76848	-1.15355	3.04460	-1.34002	3.26075	-1.52457
4. Hsinchu Hsien	-2.53190	-0.44011	0.27596	-0.53876	1.52539	-0.62567	2.25035	-0.86078	2.66619	-1.06082	2.95903	-1.25094	3.18525	-1.44524
5. Miaoli Hsien	-2.95563	-0.37978	0.15718	-0.51614	1.69647	-0.81278	2.35351	-0.96674	2.74529	-1.10062	3.02657	-1.25766	3.24586	-1.43801
6. Taichung Hsien	-2.79355	-0.32774	0.22025	-0.55726	1.72383	-0.83792	2.37108	-0.98711	2.76076	-1.14050	3.04046	-1.30656	3.25878	-1.47185
7. Changhwa Hsien	-3.20471	-0.38523	0.09867	-0.55769	1.76350	-0.89020	2.39278	-1.01548	2.77602	-1.16066	3.05240	-1.31516	3.26870	-1.48560
8. Nantou Hsien	-2.57412	-0.39012	0.42442	-0.61280	1.75533	-0.82081	2.38276	-1.00161	2.76533	-1.15637	3.04136	-1.31001	3.25744	-1.48560
9. Yunlin Hsien	-3.05406	-0.34214	0.42273	-0.63939	1.76606	-0.81746	2.39439	-1.00955	2.77728	-1.16172	3.05348	-1.30157	3.26967	-1.43490
10. Chiayi Hsien	-2.79355	-0.41044	0.36615	-0.59859	1.71474	-0.78803	2.36939	-0.98332	2.76169	-1.14882	3.04272	-1.31312	3.26185	-1.45404
11. Tainan Hsien	-2.85851	-0.39600	0.33541	0.56633	1.71127	-0.77974	2.36981	-0.99729	2.76347	-1.15425	3.04519	-1.31108	3.26475	-1.44204
12. Kaohsiung Hsien	-2.40954	-0.33907	0.48844	-0.60049	1.69939	-0.77058	2.35495	-0.97507	2.74756	-1.13297	3.02875	-1.30340	3.24798	-1.49287
13. Pingtung Hsien	-2.36250	-0.33907	0.54631	-0.64095	1.73837	-0.78945	2.36853	-0.98359	2.75209	-1.13727	3.02864	-1.30868	3.24504	-1.46783
14. Taitung Hsien	-1.46114	-0.43598	0.93131	-0.69679	1.87130	-0.77446	2.43966	-0.94375	2.79982	-1.09924	3.06405	-1.28396	3.27285	-1.49504
15. Hualien Hsien	-1.80229	-0.40681	0.76965	-0.62858	1.89169	-0.84556	2.45088	-0.98566	2.80739	-1.14138	3.06966	-1.30299	3.27724	-1.50264
16. Penghu Hsien	-2.22124	-0.40681	0.51707	-0.67512	1.68380	-0.72545	2.34374	-0.89526	2.73788	-1.02009	3.01985	-1.21238	3.23956	-1.40605
17. Taipei City	-2.87916	-0.14497	0.10938	-0.50213	1.58571	-0.86141	2.30452	-1.09198	2.71839	-1.32313	3.01025	-1.56729	3.23589	-1.77588
18. Keelung City	-2.31328	-0.29855	0.58543	-0.54755	1.74900	-0.80420	2.38227	-1.01284	2.76695	-1.23370	3.04407	-1.42552	3.26083	-1.73593
19. Taichung City	-2.97814	-0.07310	0.21069	-0.47258	1.63904	-0.80583	2.33181	-1.02575	2.73715	-1.22409	3.02477	-1.42552	3.24787	-1.59262
20. Tainan City	-2.58319	-0.06786	0.15804	-0.53521	1.59571	-0.82723	2.31230	-1.04113	2.72546	-1.23271	3.01696	-1.42930	3.24239	-1.58972
21. Kaohsiung City	-2.58319	-0.19582	0.46793	-0.63304	1.61767	-0.78990	2.31519	-1.05075	2.72211	-1.25518	3.01052	-1.45753	3.23410	-1.64437

Table C-1

Regressions on Cohort Fertility or Stocks: Logarithm of Children Ever Born per Women by Age in 1966[a]

(Including Urban-Rural Component)

Age of Women	Constant Term	Cohort Child Mortality	Proportion with Some Jr. High Schooling		Family Planning up to 1965[c]	Urban-Rural Variable[e]	R^2 (SEE)[d]
			Women	Men			
15-19	-2.53 (3.99)	21.5 (1.86)	1.41 (1.79)	-1.57 (1.14)	-125. (.94)	-.343 (.99)	.4022 (.3665)
20-24	-.551 (2.30)	22.1 (5.40)	-.232 (1.11)	.662 (2.25)	14.2 (.34)	-.035 (.33)	.6812 (.1138)
25-29	.722 (8.23)	5.83 (5.53)	-.079 (1.52)	.155 (1.62)	16.0 (1.21)	-.0826 (2.20)	.8534 (.0362)
30-34	1.19 (25.0)	3.32 (7.18)	-.0681 (2.97)	.0952 (2.87)	-1.65 (.21)	-.0592 (2.86)	.9297 (.0200)
35-39	1.37 (29.8)	1.76 (4.89)	-.0973 (4.01)	.0959 (3.25)	-7.33 (.83)	-.0691 (3.28)	.9339 (.0027)
40-44	1.42 (24.3)	.704 (1.94)	-.124 (3.82)	.0805 (1.48)	-6.59 (.56)	-.0759 (2.72)	.9180 (.0309)
45-49	1.45 (17.5)	-.237 (.56)	-.0998 (2.57)	-.0193 (.28)	4.45 (.25)	-.0599 (1.43)	.8612 (.0452)

Notes:

[a-d]See Table 5

[e]Urban-rural variable equals 1 for 5 cities (Tainan, Taipei, Keelung, Taichung and Kaohsiung), 0 for 17 rural areas.

Table C-2

Stock Adjustment Equation: Relative Change in Children Ever Born in 1967[a]

(Including urban-rural component)

Age of Women	Estimation Method[d]	Constant Term	Period Child Mortality[b] t-2	Proportion with Some Jr. High Schooling		Family Planning[c] t-1	Children Ever Born t-1	Urban-Rural Variable	R^2 (SEE)[d]
				Women	Men				
16-20	OLS	.308 (1.99)	-1.07 (.62)	-.315 (2.83)	.354 (2.05)	34.7 (2.57)	-.111 (2.82)	-.00902 (.21)	.8306 (.0453)
	IV	.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)
41-45	OLS	.00589 (.50)	.133 (4.71)	-.00174 (1.19)	.00415 (2.24)	-.789 (2.57)	-.00354 (.43)	.000138 (.13)	.7843 (.00101)
	IV	-.00125 (.05)	.126 (3.39)	-.00115 (.46)	.00385 (1.79)	-.769 (2.40)	.00148 (.08)	.000474 (.30)	(.00102)
46-50	OLS	.00420 (2.47)	.0181 (3.54)	-.000274 (1.32)	.000036 (.12)	-.00700 (.12)	-.00308 (2.73)	.000035 (.18)	.6581 (.00195)
	IV	-.00516 (.27)	.0247 (1.54)	.000274 (.28)	.000126 (.22)	-.0170 (.15)	.00329 (.25)	.000463 (.50)	(.000352)

Table C-3

Stock Reduced Form Equation for Children Ever Born 1971[a]

(Including Urban-Rural Component)

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

Notes:

[a-d] See Table 5.

[e] See Table C-1.