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The City University of New York  
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1975

**FERTILITY BEHAVIOR IN DEVELOPING ECONOMIES:  
AN INVESTMENT APPROACH**

by

**DOV CHERNICHOVSKY**

A dissertation submitted to the Graduate  
Faculty in Economics in partial fulfillment  
of the requirements for the degree of Doctor  
of Philosophy, The City University of New York.

1975

This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

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## Abstract

Fertility Behavior in Developing Economies:  
An Investment Approach

By

Dov Chernichovsky

Advisers: Professor Robert J. Willis  
Professor Robert Evenson (Reader)  
Professor James P. Smith  
Professor Finis Welch

In this thesis I develop and test a model on the behavioral consequences of investment-motivated fertility behavior in developing economies. These economies are marked by general lack of specialization, including the lack of organized capital markets (and institutions) which facilitate low-cost intertemporal transfers of consumption opportunities. In such an environment, children are assumed to function as a means to even out the parents' economic opportunities over the latter's life cycle.

Parents, by rearing children, forego current consumption opportunities, which are transformed into services from children at the time of the parents' retirement. Future income from offsprings, which is a function of their own well being, can be treated as a stochastic variable that depends on an underlying distribution of each child's survival probability (which can be generalized to include other relevant parameters).

In the first part of the model, children's mortality rates and their anticipated relative wages are assumed to be exogenous to the parents. Under this assumption, parents can determine their future income distribution by fertility only, *ceteris paribus*. In the second part, it is assumed

that parents can also affect their future income distribution by investment in their children's health and education. An expected utility analysis is applied to determine how much is invested in each "asset".

The theoretical structure produces the following major implications:

A. An increase in parents' income during the childbearing part of their life cycle will increase desired fertility.

B. Decreased child mortality or increased adult wages of children will increase the expected return to the parents per child. This will increase (decrease) the number of births if the price elasticity of demand for future consumption is greater than (less than) one. It is plausible that continuous decreases in mortality or increases in wages will initially increase and later decrease fertility.

C. Development of institutions that secure future income will reduce desired fertility. This effect will be stronger if the institutions are financed by taxing income during the most productive part of the parents' life cycle.

D. Increasing real lending rates and reducing borrowing rates will reduce desired fertility.

E. Investments in children's health and education are complementary; investment in health is a means to secure the investment in education.

The model is tested on survey data of two Indian villages. It is apparent in both villages that the elderly are supported by their children and that children contribute to family income at ages as early as 11-15. The pure income effect on the demand for children and their education is positive. The demand elasticity for child services as revealed by the demand for survivors is less than unity.

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The Workshop was an excellent forum where I could explore directions, shape my thoughts and focus on issues. But even at the times when all seemed clear-cut to me, I benefited from the clear and critical minds of Professors Smith and Willis. They read innumerable drafts and provided invaluable comments on issues of substance and organization.

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## I. INTRODUCTION

The concept of fertility as a form of economic behavior is based on the notion that the parents gain satisfaction from their children. But the choice for children, vis-a-vis other arguments in the parents' utility function, is made in an environment of scarce resources. Because children are a nonmarketable commodity, the parents are the "producers" of children as well as the "consumers" of their children's services. This implies that any hypotheses about the parents' fertility behavior depend on the kind of services children are believed to render and on the "technology" that the parents employ to raise their children.

Liebenstein pointed out that children render direct consumption services to their parents in addition to indirect services as factors of production and insurance for old age.<sup>1</sup> All three sources of satisfaction, in their broad definitions, are apparent in every society; but they may differ in their relative importance in each society. Children are apparently reared and educated to provide the service that is of particular importance in a given socio-economic environment.

It is realized that the parents' preferences are not necessarily revealed by number of births or number of surviving children. Biological and certain behavioral determinants may limit the scope of economic analysis. The outcome of a decision to have a child within a given period can be judged in probabilistic terms only. On the other hand,

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<sup>1</sup>Harvey Liebenstein, Economic Backwardness and Economic Growth: Studies in Theory of Economic Development (New York: Wiley, 1957).

in an environment with positive contraception costs, some observed fertility may be undesired and derived from the demand for sex. Nevertheless, these considerations can be built into economic models, primarily by assuming that the parents respond to prior perceptions about the uncertainties as well as to actual outcomes.

Becker and Lancaster provided the analytical framework that is suited to analyzing the demand and supply of nonmarketable commodities.<sup>1</sup> Willis utilized this framework to develop a basic model using the assumption that children yield consumption services to their parents.<sup>2</sup> Rosenzweig, along similar analytical lines, regarded children as substitutes for hired labor.<sup>3</sup>

The forthcoming model utilizes, in part, the same framework to investigate and test the behavioral implications of the notion that the parents' fertility--and investment in children's human-capital--decisions are motivated by investment, savings, and insurance considerations, when a capital market fails to facilitate intertemporal consumption transfers at relatively low cost. This interpretation of fertility behavior, which is applicable primarily to developing economies, is controversial on

---

<sup>1</sup>Gary S. Becker, "The Theory of Allocation of Time," Economic Journal 75 (September 1965): 493-517; and Kelvin J. Lancaster, "A New Approach to Consumer Theory," JPE 74 (April 1966): 132-157.

<sup>2</sup>Robert J. Willis, "A New Approach to Economic Theory of Fertility Behavior," JPE 81, Part 2 (March-April 1973): 14-64. See also: Becker, "An Economic Analysis of Fertility," in Demographic and Economic Change in Developed Countries, Universities N.B.E.R. Series No. 11 (Princeton, N.J.: Princeton University Press, 1960), pp. 209-240.

<sup>3</sup>Mark R. Rosenzweig, "The Economics of Fertility in the Agricultural Sector of the U.S.," (Ph.D. dissertation, Columbia University, 1973).

empirical grounds and has received relatively little attention in terms of systematic analysis.<sup>1</sup> However, its validity is supported by household survey data.

The motivation underlying the demand for children is similar to the one posited by Neher, who refers to the "pension motive".<sup>2</sup> Neher applied a macro-economic approach to the transfers among three generations in a household. He did not, however, consider the changes in fertility behavior that result from changes in the household's socio-economic environment except for changes that relate to the development of the capital market under risk-neutral conditions. On this particular issue, Neher's conclusion is identical to the one produced by this model.

Concerning the supply of children, this discussion attempts to isolate the price effects on fertility of the extended family--a common institution for intergenerational support--in a rural and cottage industry environment. The model falls short of being a "Becker type" in the strict sense; it does not distinguish between (market) goods and (nonmarket) commodities except for the commodity children. Becker's distinction reflects a degree of specialization that seems unsuited to the environment that this model is presumed to describe--the basically self-sufficient household. Not drawing the goods-commodity distinction leads to somewhat different conclusions about the possible income effects on fertility than the ones that can be obtained by applying the Willis model.

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<sup>1</sup>Goran Ohlin, "Population Pressure and Alternative Investments," International Population Conference Proceedings, vol. 3 (London, 1969), pp. 1703-1738.

<sup>2</sup>Philip A. Neher, "Peasants, Procreation and Pensions," AER 61 (June 1971): 380-389.

My model of family behavior utilizes a two period "Fisherian" framework and consists of two parts. The first is a basic model where services from children are treated as a deterministic variable. Its behavioral implications are derived by the method of comparative statics. The second is an extension of the basic model to include the implications of uncertainty--services from children being a stochastic variable--and investment in children's human capital. It utilizes an expected utility analysis. Some aspects and conclusions of the discussion can be generalized because any services from children, vis-a-vis the decision to have children, are in a temporal context.

The empirical discussion is based on household survey data from two Indian villages. The regression results support some basic hypotheses, which are derived from the model, and provide empirical determination for others.

The basic approach, even if micro-economic in scope, has important implications within the context of growth theory. It implies that two basic variables, population and savings, are substitutes under certain capital market conditions. Hence, high rates of population growth are consistent with low levels of financial savings--on the macro level--because the family views children as a means of savings.

## II. THE CAPITAL MARKET FAILURE

. . . The average Hindu wants sons, an understandable attitude in a country where there is neither social security nor old age pensions, sickness benefits nor unemployment insurance for an overwhelming majority of population.

While the quotation refers to India, its general implication is clear. Caldwell reported from Ghana how different communities value the services children provide.<sup>2</sup> While 33 percent of the respondents in the least developed region justified many children because of children's productive capacity, only 4 percent viewed this as a sufficient reason in the most developed region. Overall, 5 percent indicated that children are a form of insurance and security. Heisel, in a report from Kenya, found that 7 percent of the respondents justified children as a means for old age security.<sup>3</sup>

The problem of securing a flow of income over one's life cycle, which is only in part productive, is universal. It is solved in developed economies through various forms of voluntary and involuntary savings for retirement. The financial market provides marketable assets that are

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<sup>1</sup>S. Chandrasekhar, India's Population; Facts, Problems and Policy (India: Meenakshi Prakashan, Meerut, 1967), pp. 55-56.

<sup>2</sup>John C. Caldwell, "Fertility Attitudes in Three Economically Contrasting Rural Regions in Ghana," Economic Development and Cultural Change 15 (January 1967): 217-238.

<sup>3</sup>Don F. Heisel, "Fertility Limitation Among Men in Rural Kenya," Studies in Family Planning 4 (December 1973): 351-355.

claims for future consumption, and tax-financed welfare institutions provide a similar function. In developing economies, the market apparently fails to provide either the financial means or the welfare institutions for intertemporal transfers of consumption.

The capital market in developing economies reflects the lack of specialization that characterizes these economies. Savers, financial intermediaries, and investors do not exist as specialized sectors.<sup>1</sup> Hence, investment tends to be self-financed--just one dimension of the prevailing economic self-sufficiency.<sup>2</sup> W.A. Lewis argues that: "The chief institutional requirements of an easy flow of savings from lenders to borrowers are limited liability and easy marketability of assets."<sup>3</sup> The two requirements are apparently missing in developing economies.

The imperfect capital market implies, in general, risk-averse behavior.<sup>4</sup> Lending in this market is on a personal basis and repayment takes various forms, including commitments of labor services that have a low degree of marketability. As a result, the fear of bankruptcy eliminates the small lender, especially for long term lending. Hence, lending cannot be considered a general, viable source for future consumption.

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<sup>1</sup>John G. Gurley and Edward S. Shaw, "Financial Development and Economic Development," Economic Development and Cultural Change 15 (April 1967): 257-265.

<sup>2</sup>McKinnon labels this condition "The Fragmented Economy" in this particular context. Ronald I. McKinnon, Money and Capital in Economic Development (Washington, D.C.: The Brookings Institution, 1973), pp. 5-21.

<sup>3</sup>W.A. Lewis, Theory of Economic Growth (New York: Harper & Row, 1970), pp. 264-266.

<sup>4</sup>Robert T. Masson, "The Creation of Risk Aversion by Imperfect Capital Markets," AER 62 (March 1972): 77-86. A more detailed discussion on the effects of risk is forthcoming.

Investment offers another mechanism for reallocating consumption over the life cycle. T.W. Schultz argues that the demand for investment in the "traditional agricultural economy" is limited because "traditional sources of income" yield very low rates of return.<sup>1</sup> Rates of return are higher on "modern factors" of production. These factors, however, require complementary investment in human capital and may require large lump sums because of indivisibilities. Lump-sum investments are assumed to be out of the reach of the average farmer because he is a poor collateral.<sup>2</sup> Thus, while the demand for funds to finance consumption may be relatively high, the demand for investment is limited and cannot be matched by the available supply of funds.

A household can save-invest in this environment by abstaining from current consumption in the following ways:

1. Investing in "traditional" factors of production, primarily land,
2. Accumulating consumer goods for the short run and precious metals for the long run, and
3. Various forms of self investment.<sup>3</sup>

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<sup>1</sup>Theodore W. Schultz, Transforming Traditional Agriculture (New Haven, Connecticut: Yale University Press, 1964).

<sup>2</sup>Lewis, Economic Growth, pp. 264-266. Financing investments in human capital is subject to capital market imperfections in developed economies as well, especially for lower income groups.

<sup>3</sup>It may take the form of abstaining from current production when land is left fallow in one period to increase its productivity in the following one. This was a common practice in the old world (see Leviticus 25:1-7) and is still used in underdeveloped areas as a substitute for fertilizing. The rate of return to this practice is not clear. McKinnon Money and Capital, p. 13, argues it is very low but the rate of return clearly depends on the relative costs.

The first alternative has low rates of return, inherent in the nature of this economy, and may require lump-sums that the financial market does not provide. The second opportunity may be a form of turnover capital in the short run. The long run accumulations may yield capital gains or losses if the goods can be traded in the market. Gold and jewelry have been common forms of holdings, apparently as a means to maintain a high degree of liquidity for security purposes. Investment in children for future income is one special form of self investment, the third alternative, that can be financed by small payments over time. It also requires a complementary investment in human capital. This, however, can be accomplished primarily through learning by doing--in a farm environment--at rather low relative costs.

#### Children as Means for Savings-Investment

My model is based on a fundamental assumption that the parents assume an expected level of support from any child born. Two basic issues emerge from this assumption. The first concerns the quid pro quo that makes children support their parents. The second concerns the relative rate of return on children versus other investments.

The model does not consider explicitly the children's economic motives to support their parents. Such motives may be related to the investment in children's human capital and the parents' property rights. The human capital component can take the form of a set of moral obligations instilled in children through education. These may be enforced by some form of social punishment mechanism--a mechanism that is derived from a common social consensus about the economic hazards for the aged when children do not support them, and the subsequent social

costs.<sup>1</sup> The parents' holdings of property rights for nonhuman wealth may be an additional inducement to children to support their parents.

The relative rate of return on children, or the degree to which parents can "exploit" their children, is controversial on empirical grounds, and is discussed explicitly in another section. It is important, however, to note the realization of the following:

1. Children also provide psychic consumption services.
2. Children may contribute to the parents' income before providing old age support.
3. A particular household may have, literally, no other transformation opportunities into the period of retirement.<sup>2</sup> It was previously noted that intertemporal long term transfers are at relatively high prices; children may be the lower cost means of transfer.

Any of these arguments can be consistent with an ex-ante negative rate of return to children as an investment. Although this model is primarily concerned with the last argument which relates to the capital market failure notion, it does not necessarily imply a negative rate of return on children.

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<sup>1</sup>S.N.S. Cheung, "The Enforcement of Property Rights in Children, and the Marriage Contract," Economic Journal 82 (June 1972): 641-657. Some legal systems in the developed economies make the children's obligation mandatory under certain conditions. The Israeli law, which usually follows the spirit of the British one, states: ". . .A person is liable for the maintenance of other members of his family. . .his parents and the parents of his spouse; . . ." Family Law, Amendment (Maintenance) Law 5719-1959, Laws of the State of Israel, vol. 13 (Israel: Government Printer).

<sup>2</sup>In a sense this can be equivalent to the price of liquidity in the monetary context, where one of the motives is security.

When other investment opportunities exist, the aged should seemingly be indifferent to the following alternatives: selling or renting their property, having hired labor work their land, or having their children cultivate it.<sup>1</sup> This reasoning follows from the assumption of a competitive market where each factor receives the discounted value of its marginal product. This assumption, however, may be unrealistic. Children may willingly accept less than their marginal product, at a certain point of time, knowing that the parents have property rights on some non-human wealth, which can be handed down to children. Even when the children receive the value of their marginal product, they may provide a "rent" to their parents because they are more easily monitored than hired labor.<sup>2</sup> Furthermore, the transaction costs associated with capital transfers to children may be considerably lower than otherwise in this particular environment. In traditional economies, where land is the major asset, one should add the apparent high psychic costs of land transfers among families.

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It is implicitly assumed that any other assets can be converted into land, which is a major asset in developing areas.

<sup>2</sup> Armen A. Alchian and Harold Demsetz, "Production, Information Costs, and Economic Organization," AER 62 (December 1972): 777-795.

### III. THE BASIC MODEL

The utility function is assumed to combine the preferences of both the husband and his wife into a single "well-behaved" set. The parents maximize this function by a consumption flow over a two-period life cycle. The first period ( $T_1$ ) is a productive one; the parents produce income and children ( $N$ ), for whom the parents forego part of their own potential  $T_1$  consumption opportunities ( $C_1$ ). The parents are assumed to make adjustments for child mortality during this period to the extent it is biologically feasible.<sup>1</sup>

The second period ( $T_2$ ) is assumed to be an unproductive retirement period. Consumption ( $C_2$ ) in it is assumed to be provided primarily by the children, who are the agents for intertemporal transfers of consumption because of the absence of an appropriate capital market.<sup>2</sup>

Formally, the model is based on three relationships that are outlined at this point by three implicit functions. The first is the utility function that contains the two consumption flows:

---

<sup>1</sup> Deviations of the actual number of children from the desired number, because of relatively high contraception costs are not considered in the model. Costly birth control methods are apparently not the basic cause of high fertility rates in developing areas. People in these countries wish to have more children than in developed economies (see: Heisel, "Fertility Limitation"). Even when birth control devices are offered free or at negative costs, there is apparently no dramatic change in fertility rates, unless such a program is accompanied by other socio-economic changes (see: Chandrasekhar, India's Population).

<sup>2</sup> The scope of the model can be broadened by defining  $C_2$  to be any services obtained from children. These services, by definition, lag fertility decisions.

$$U = U(C_1, C_2) \quad (1)$$

where  $C_1$  and  $C_2$  are normal goods. The second is the transformation relationship between children and consumption in  $T_2$ :

$$\tau(C_2, N) = 0. \quad (2)$$

The third is the production possibility relationship between consumption and the production of children in  $T_1$ :

$$H(C_1, N) = 0. \quad (3)$$

The implications of the model depend on the explicit behavioral and production relationships that are represented in (1) - (3).

### The Temporal Transformation Opportunities

Relationship (2) is the one most crucial to this model. It indicates the relation between the number of children born and the services they yield to their parents. As such, it embodies the nature of the "social contract" between the parents and their children and is determined by natural as well as behavioral factors.

Any stock of  $N$  children produced in  $T_1$  generates a distribution of possible surviving stocks in  $T_2$ . The density function associated with this distribution is assumed to be determined by the binomial parameter  $P$ .<sup>1</sup> This parameter depends basically on child mortality

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<sup>1</sup>This assumption is made because of its simplifying mathematical properties, at the expense of some generality.

rates, but it can be generalized to include any other random factors that may affect children's probability of supporting their parents, such as migration and sex distribution of surviving children.

The level of each surviving child's support to his parents ( $W$ ) can be determined by a variety of factors. The major ones are: the number of surviving children ( $PN$ ), the level of each surviving child's income ( $A$ ) and the parents' ability to "exploit" the child, and the sources of future income ( $Y_2$ ) that are independent of the parent's savings-fertility behavior.

The general relationship between fertility and consumption in  $C_2$  can be formalized by

$$C_2 = \bar{T} \left[ N, P, W (A, PN, Y_2) \right]. \quad (4)$$

The relationship

$$W = W (A, PN, Y_2) \quad (5)$$

represents the nature of each surviving child's obligation to his parents.  $W$  is realistically assumed to be (a) inversely related to the number of surviving children  $\frac{\partial W}{\partial (PN)} < 0$  and (b) other sources of income  $\frac{\partial W}{\partial Y_2} < 0$ , and (c) positively related to the level of the child's own income  $\frac{\partial W}{\partial A} > 0$ . (a) and (b) indicate the elements of insurance provided by children. Each child's level of support is inversely related to other available sources of support to the parents. More siblings can share in supporting their parents because the level of total support apparently does not increase proportionately with the number of children. When the parents are supported by social security and pension schemes, it

is realistic to assume that the level of children's support is inversely related to the level of the support that is external to the family. In such a case, children may act as a buffer guaranteeing the parents a certain standard of living. (c) can be interpreted as follows: Parents who hand over to their children more human and non-human capital can "exploit" them better; but then, each child has more income to support his aged parents.<sup>1</sup>

The first part of this model utilizes a less generalized formulation than relationship (4) and a set of restricting assumptions, which simplify the analysis at the expense of some generality. The functional relationship (4) is re-written as

$$C_2 = T(N, P, W) + Y_2, \quad Y_2 \geq 0, \quad (6)$$

where  $P$ ,  $W$ , and  $Y_2$  are exogenous and known to the parents, who are assumed to be risk neutral.<sup>2</sup>

$W$  is assumed to be falling as  $N$  increases, *ceteris paribus*, because of any of the above arguments; but  $T$  is positive and monotonic with respect to  $N$ .<sup>3</sup> The implicit relationship  $T$  can be assumed to embody

---

<sup>1</sup>The parents' ability to affect  $W$  and  $P$  is considered explicitly in a forthcoming chapter that discusses investment in children's human capital. On the allocation of intergenerational transfers between children's human and non-human capital, see Winston C. Bush, "A Model of Family Size and Intergenerational Transfers and Its Implications for Economic Growth," (Ph.D. dissertation, Washington University, 1971).

<sup>2</sup>This permits us to ignore the distribution effect of  $P$  until a later discussion.

<sup>3</sup> $\frac{\delta T}{\delta N} > 0, \quad \frac{\delta^2 T}{\delta N^2} < 0$

the parent's optimal solution to their investment in children, child survival rates, and each child's education. Children are assumed to be homogenous, and their age and sex distributions are ignored.<sup>1</sup>

#### The Production-Consumption Opportunities during $T_1$

The household is assumed to be endowed with two vectors of productive resources that can be employed in production during  $T_1$ . These resources are defined to comply with the reality of a household-farm production unit and the concept of the extended family. The nuclear unit--the husband, wife, and children--may reside with other relatives who do not bear children, but participate in the household's production and consumption activities.<sup>2</sup> The first vector (L) combines all females' labor endowments. Other females' labor is assumed to be a good substitute for the mother's labor. This type of input can be used in either the production of children or in the production of an all-purpose heterogeneous and intermediate commodity X. The other vector (K) combines all the other inputs that can be used in the production of X only, such as males' labor endowments and land, in the context of developing rural communities. The allocation of the labor endowments, contained in the two vectors, to productive activities is regarded as the reduced form solution of the

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<sup>1</sup>In many traditional societies, particularly in the Middle and Far East, parents who marry off their daughters are entitled to a "Bride's Gift." This can be regarded as a capitalization by the parents for "giving up" daughters, while the sons assume the responsibility to support their parents as long as the latter live.

<sup>2</sup>The concept of the extended family should not be confused with the concept of the extended household. The household may have more than one family in reproductive ages. The model can be applied to the extended household if fertility decisions are made mutually among families, which is plausible. See: Edwin D. Driver, Differential Fertility Rates in India (Princeton, N.J.: Princeton University Press, 1963), pp. 34-56.

household's pooled labor supply during  $T_1$ . Formally, the household's factors constraints are

$$L = (l_1, l_2, \dots, l_n) \quad (7)$$

and

$$K = (k_1, k_2, \dots, k_k). \quad (8)$$

The other constraints relate to two production technologies employed by the household. These concern the production of consumption opportunities in  $T_1$  and the technology of rearing children. The commodity  $X$ , whose price is a numeraire, is produced by a linear homogeneous farm-household production function:

$$X = X(L - \ell, K), \quad (9)$$

where  $(L - \ell)$  is the part of females' time that is not employed in the production of children and  $X$  is regarded as gross income from the nuclear unit's viewpoint.<sup>1</sup> Some of this gross income may be foregone to support relatives who may reside in the household and whose potentially productive labor endowments are listed in  $L$  and  $K$ . The real expenditures that relate to these potential factors, relatives, are summarized by

$$R = R(L, K); \quad (10)$$

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<sup>1</sup>In the special case that productive household members are subject to market money wages, according to Euler's Theorem,  $X$  becomes

$$X = W_l^* (L - \ell) + W_k^* K,$$

where  $W_j^*$  ( $j = l, k$ ) stands for the corresponding factor's market rental rate --  $j$  value of marginal product.

and consequently, the nuclear unit's income--net of supporting relatives-- is

$$F = X(L-\ell, k) - R(L, K). \quad (11)$$

Relatives in the household are assumed an exogenous factor to the parents' decision making. Supporting the relatives ( $\frac{dF}{dJ} < 0, J \in K, L$ ) is regarded as a fixed cost factor; the nuclear unit does not optimize with regard to them, since relatives are not hired in the same sense that domestic workers or lodgers are.<sup>1</sup>

The production function of children is given by

$$N = G(\ell, S). \quad (12)$$

It employs as factors, the part of females' time ( $\ell$ ) that is not utilized in producing  $X$  and part of the parents' current consumption opportunities ( $S$ ).<sup>2</sup> The function  $G$  is assumed to be linear and homogeneous. This may be a strong assumption in the context of rearing children, but is kept because of its mathematical properties. It is quite plausible that

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<sup>1</sup>The relationship between supporting relatives and income may be the reverse; income may be the determinant of whether to support them. The incentives to support relatives are not considered in this discussion. It is not easy to identify those who actually make the decisions in an extended household. There seems to be a kind of mutual relationship. It is often the elderly who "retain" the younger married couples and may even be involved in fertility decisions. See: Driver, Differential Fertility Rates.

<sup>2</sup>When children are considered factors of production, i.e., children make a net contribution of income in  $T_1$ , then  $S < 0$ . This case is not considered explicitly in the discussion.

the production of children is subject to economies to scale, within a certain range. The implications of this possibility are outlined at a later stage of the discussion.

From the above specification follows:

$$F \equiv C_1 + S. \quad (13)$$

Hence,  $C_1$  is completely "goods-intensive", in the space of  $N$  and  $C_1$ , because  $C_1$  and  $S$ , which is an input in  $G$ , are identical. This implies that children are of necessity "time-intensive" relative to parents' consumption.

#### Optimal Fertility and Lifetime Consumption

The parents' optimal allocation of resources is determined by the preceding functional relationships that provide the basic structure of the model. The model and its optimal solution are illustrated in figure 1. The opportunities set of  $T_1$  is bound by the production-consumption possibility curve  $AB$ , in the first quadrant. This set is determined by the factor endowments (7) and (8), and the production relationships (11) and (12), and can be expressed by the single constraint

$$I_1 = C_1 + \Pi_N N, \quad (14)$$

which represents the parents' "full income" in period  $T_1$ .

$$\Pi_N = \frac{X_2 \lambda + S}{N} \quad (15)$$

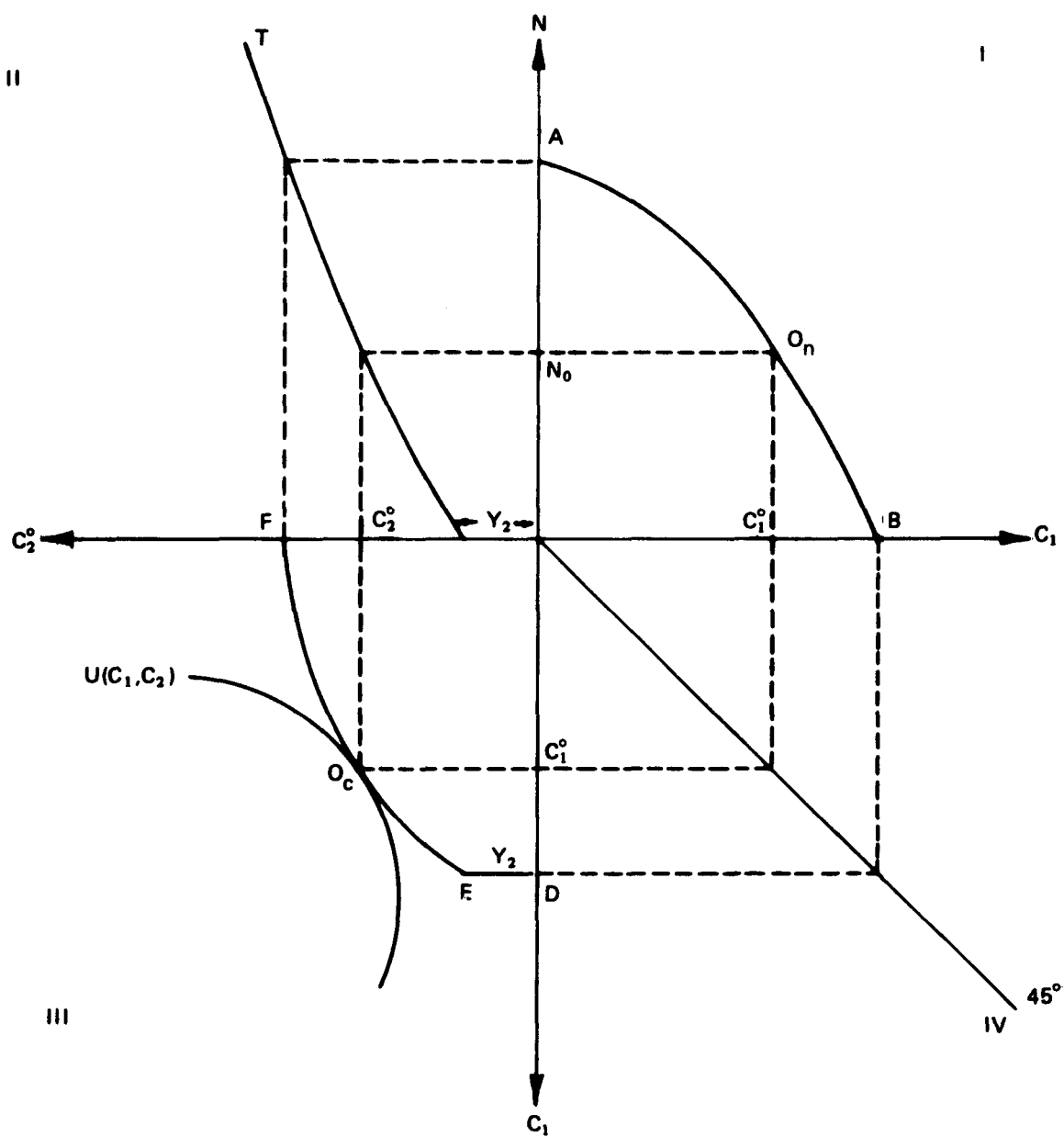


Figure 1

is the average unit cost of producing a child at the minimum cost point and can be treated as a parameter indicating the shadow price of producing children.<sup>1</sup>

The intertemporal transformation relationship, (6), is illustrated in the second quadrant of the figure. The curve T "transforms" any number of children (N) into a consumption flow for retirement ( $C_2$ ), in addition to  $Y_2$  whenever  $Y_2 > 0$ .

The opportunities set of period  $T_2$  is illustrated by the consumption possibility curve DEF in the third quadrant, which is also the utility space. This set is determined by relationships (6) and (14), and it can be expressed by the single constraint

$$I_2 = C_1 + \Pi_2 C_2, \quad (16)$$

which represents the parents' "full wealth" over their life cycle.  $\Pi_2$  is the shadow price of producing future income and is defined in a manner similar to  $\Pi_N$ .

Relationships (1), (11), (12), and (16) or (14) constitute the basic structure of the model. The parents are assumed to maximize the utility function, (1), subject to the productive endowments available to them in  $T_1$ , (7) and (8), and the production and intertemporal transformation opportunities, (11), (12), and (6). The optimal number of children ( $N_0$ ) is derived from the optimal allocation of consumption between the two

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<sup>1</sup>Note that the price of  $C_1$  ( $\Pi_1$ ) is the numeraire in this system. Thus,  $\Pi_1 = 1$ .  $X_0$  is the marginal productivity of females' time in X and is equal to the marginal contribution to net income ( $F_0$ ). The parents' outlays to support relatives (R) are not affected by the internal allocation of resources--the optimal solution.

periods-- $C_1^0$  and  $C_2^0$ -- as shown in the figure.  $\Pi_N$  and  $\Pi_2$  are given by the slopes at the points  $O_N$  and  $O_C$  respectively.

The properties of this solution are essential to derive the behavioral implications of the model. The constraints on the parents' lifetime production-consumption opportunities can be expressed by the implicit form

$$V(C_1, C_2, W, P, L, K) = 0. \quad (17)$$

This constraint implies that the parents must optimize their allocation of resources in  $T_1$  to select the optimal  $\lambda$  and  $S$ , the resources devoted to child production, that maximize the number of offspring--future consumption ( $C_2$ )--for any given level of current consumption ( $C_1^0$ ). The optimal allocation of resources in production and consumption sets, as the dual solution, the shadow prices  $\Pi_N$  and  $\Pi_2$ .

A two stage maximization procedure establishes mathematically the optimum condition for this system. It has the advantage of facilitating separate demand and supply analyses of the simultaneous solution and involves:

- (A) maximizing utility, (1), subject to the parents' lifetime wealth constraint, (16), using the shadow price of future consumption ( $\Pi_2$ ) as a given parameter,
- (B) minimizing the parents' lifetime expenditure on consumption, (16), subject to the production-transformation opportunities constraint, (17).

The utility analysis (A) yields the demand conditions for  $C_2$  at the optimum point. The demand for children is derived from the demand for

future consumption. The cost analysis (B) produces the supply conditions for future consumption and for children at the optimum point, the  $\Pi_2$  that minimizes (16) or the  $\Pi_N$  that minimizes (14).

The first stage yields the following optimum condition:

$$-\frac{dc_1}{dc_2} = \frac{Uc_1}{Uc_2} = \Pi_2^* \cdot 1 \quad (18)$$

Hence, the subjective rate of substitution between the consumption flows of both periods must equal the shadow price in production. In the second stage the following optimum condition is established:

$$-\frac{dc_1}{dc_2} = \frac{Vc_2}{Vc_1} = \Pi_2 \cdot 2 \quad (19)$$

Thus,  $\Pi_2$  measures the opportunity costs of one unit of future consumption in terms of current consumption. This is the marginal rate of objective transformation between the types of consumption. The marginal rate of return ( $r$ ) to savings via children is implied by

$$\Pi_2 = \frac{\Pi_N}{T_N} = (1 + r)^{-1}, \quad (20)$$

since  $T_N$  is the marginal benefit from children and  $\Pi_N$  their shadow price. The shadow price of children follows by definition from (14),

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<sup>1</sup>See appendix A.

<sup>2</sup>See appendix B.

$$\pi_N = - \frac{dc_1}{dN}, \quad (21)$$

and can be established by minimizing (14) subject to period  $T_1$  production opportunities, (11) and (12). It states the amount of current consumption the parents forego to produce a child. The optimal allocation of resources associated with  $\pi_N$ , as the dual solution, is given by

$$\pi_N = \frac{X_\ell}{G_\ell} = \frac{1}{G_S}, \quad (22)$$

where  $G_S$  and  $G_\ell$  are the corresponding marginal productivities of the factors  $\ell$  and  $S$  in  $G$ .

This condition implies that at the optimum point, the value of the marginal product of each factor, in each activity, equals this factor's price, which is measured in constant current consumption-equivalent units.

The Pareto optimum for the system implies an equalization of the objective and subjective rates of substitution:

$$\frac{Uc_2}{Uc_1} = \frac{Vc_2}{Vc_1} = \pi_2 = \pi_N^T \pi_N^{-1}. \quad (23)$$

Two additional optimum conditions can be incorporated in the model. When females are employed outside the household-farm unit for a real wage ( $W_\ell^*$ ), then:

$$\pi_N = \frac{W_\ell^*}{G_\ell} = \frac{1}{G_S}. \quad (24)$$

The second market opportunity, which can prevail, is an objective rate of

transformation between current and future consumption.

$$\Pi_2 = (1 + r^*)^{-1}, \quad (25)$$

where  $r^* > 0$  is a market rate of return. This opportunity is discussed in a succeeding chapter.

An internal solution, which satisfies the optimum conditions, is guaranteed by a set of previously stated assumptions that imply a downward sloping demand curve and an upward sloping supply curve for children. Some of these assumptions, however, are not necessary for a stable internal solution of the kind illustrated in figure 1 and can be replaced, provided that others are maintained.

A downward sloping demand curve,

$$\frac{dN}{d\Pi_N^*} < 0, \quad (26)$$

follows from assuming that the lifetime consumption flows,  $C_1$  and  $C_2$ , are normal goods, and that the subjective elasticity of substitution between the two is sufficiently low for any given temporal consumption possibility curve DEF (figure 1).<sup>1</sup>

An upward sloping supply curve,

$$\frac{d\Pi_N}{dN} > 0, \quad (27)$$

or alternatively, a concave to the origin production-consumption possibility

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<sup>1</sup> See appendix A.

curve AB, results from postulating (a) that at least the children-production function is linear and homogeneous and (b) that the mother's time is involved in child rearing ( $\lambda > 0$ ).<sup>1</sup> The first assumption rules out economies to scale in child production; but that is not a necessary condition for a stable internal solution. It is a sufficient condition as long as the intertemporal transformation function is linear or concave to the origin ( $T_{NN} \leq 0$ ). On the other hand, even if a downward sloping supply curve for children ( $\frac{d\pi_N}{dN} < 0$ ) is implied because of the realistic assertion of economies to scale in child production, diminishing returns from children--the concavity of T--can still assure a stable internal solution by transforming a convex production possibility curve (AB in figure 1) into a concave consumption possibility relationship (ED). Even if the consumption possibility curve is convex to the origin, an internal solution will exist if the subjective rate of substitution between  $C_1$  and  $C_2$  is sufficiently small.

The second assumption, with the first, implies that the marginal productivities of both factors are positive but diminishing, and that these productivities depend on the factor ratio ( $\Omega = \frac{S}{K}$ ). The marginal productivity of S falls ( $G_{SS} < 0$ ) as the ratio  $\Omega$  increases, increasing the shadow price of children and vice versa. If children are produced by S only, the production possibility curve (AB) between  $C_1$  and N is linear; i.e., the supply curve for children will have an infinite elasticity and still can provide an internal solution.

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<sup>1</sup>See appendix B.

#### IV. THE DETERMINANTS OF VARIATIONS IN THE DEMAND FOR CHILDREN

Variations in the demand for children result from price and income effects that are caused by changes in the exogenous variables. These variables are grouped into two categories for analytical purposes. The first contains the endowments  $L$  and  $K$ , and their potential corresponding wages  $W_L^*$  and  $W_K^*$ . Changes in these occur during  $T_1$ , altering the parents' income ( $I_1$ ) as well as the shadow price of children. The second category contains  $P$ ,  $W$ , and  $Y_2$ . Changes in these alter the parents' wealth ( $I_2$ );  $P$  and  $W$  also alter the shadow price of  $C_2$ --for any given  $C_1$ . The changes caused by the variables in the second category change the opportunities during  $T_2$  without affecting those of  $T_1$ .<sup>1</sup>

The following discussion summarizes and illustrates the variations in the demand for children because of changes in these exogenous variables by the method of comparative statistics.

##### Variations in Income: Period $T_1$

An increase in the parents' income during  $T_1$  ( $I_1$ ) brought about by changes in  $L$ ,  $K$ ,  $W_L^*$ , or  $W_K^*$  increases the parents' wealth ( $I_2$ ). The pure income effect on the demand for children, in this case, is positive:

$$\frac{dN}{dI_2} > 0.^2 \quad (28)$$

---

<sup>1</sup>The relationship between income ( $I_1$ ) and wealth ( $I_2$ ), which are defined in (14) and (16) respectively, is fundamental to the structure of the model. While a change in  $I_1$  also alters  $I_2$ , the reverse does not hold because of the absence of a capital market.

<sup>2</sup>See appendix A, relationship (19).

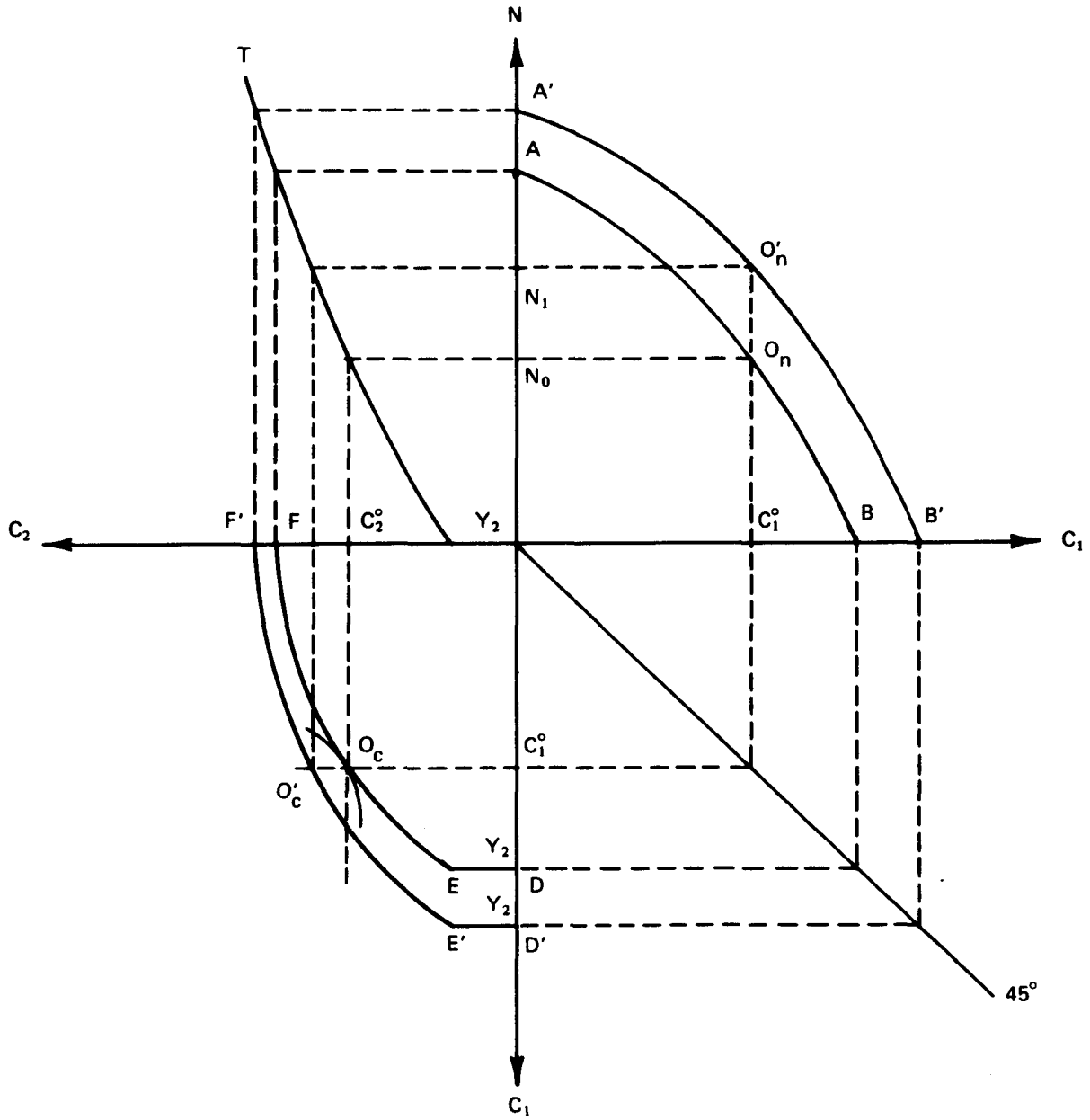


Figure 2

A change in income during  $T_1$  implies a homothetic shift of the implicit function  $H(C_1, N)$ . It is illustrated in figure 2 by a homothetic shift of the period  $T_1$  production-consumption opportunities curve  $AB$  to  $A'B'$ . This shift is transformed into a corresponding change in the lifetime consumption opportunities curve, which is illustrated by the curve  $D'E'F'$ .<sup>1</sup>

The effect on the demand for children is derived from the positive income effect on consumption for retirement ( $C_2$ ). The parents can transfer part of their gain in income during  $T_1$  into more consumption of  $C_2$ , which is a normal good, by means of more fertility.

The relative change in the demand for children is given by

$$\frac{dN}{N} = \frac{E_{C_2 I_2}}{E_{C_2 N}} \eta_{I_2 J} \frac{dJ}{J}, \quad (J=K, L, W_K^*, W_L^*) \quad (29)$$

It is a positive function of the income elasticity of  $C_2$  ( $E_{C_2 I_2}$ ) and the share of the factor  $J$  in wealth ( $\eta_{I_2 J}$ ). It is a negative function of the elasticity of  $C_2$  with respect to children ( $E_{C_2 N}$ ). The latter indicates that the more efficient children are in providing future income, the lower is the number required to satisfy a given increment in the demand for  $C_2$ .

The positive pure income effect in my model is not related to the direct utility from children, which is the basis of the income effect in other models.<sup>3</sup> Instead, it is derived from the demand for consumption in  $T_2$ . As we shall see, the income effect may differ from the above, as

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<sup>1</sup>Note that the change in  $DEF$  is not homothetic unless  $\frac{\partial T}{\partial N} = 1$ .

<sup>2</sup>See appendix C, section II.

<sup>3</sup>Becker, "An Economic Analysis of Fertility," and Willis, "A New Approach to the Economic Theory of Fertility Behavior."

outlined in a later section dealing with variation in income (wealth) during  $T_2$ .

### The Opportunity Costs of Children: Period $T_1$

Changes in the endowments  $L$ ,  $K$  and their potential corresponding wages  $W_L^*$ ,  $W_K^*$  are also likely to change the shadow price of children ( $\pi_N$ ).<sup>1</sup> This implies a price effect, in addition to the income effect, on the demand for children. Since the two effects do not always operate in the same direction, some empirical considerations are given as to the possible combined effect.

An exogenous change that carries a price effect implies a non-homothetic shift of the function  $H(C_1, N)$ , i.e., a non-homothetic shift of the consumption-production possibility curve  $AB$  to  $A'B'$  (figure 2). The relevant  $\pi_N$  on the new curve is given by the slope at the point  $O_N'$  where  $C_1 = C_1^0$  is a fixed parameter.<sup>2</sup>

The effect on  $\pi_N$  of an increase in any factor of the vectors  $L$  or  $K$  depends on how this factor affects the marginal productivity of the mother's time in producing income ( $X_{LJ}$ ,  $J \in K, L$ ), and on how this factor affects the parents' net income ( $F_J$ ). The change in  $\pi_N$  is inferred from a change in the ratio  $\frac{S}{\bar{x}}$  ( $=\Omega$ ), since  $\pi_N$  is inversely related to the marginal productivity of  $S$  in  $G$ .<sup>3</sup>

A change--an increase or decrease--in  $J$  that increases the mother's

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<sup>1</sup>  $\pi_N$  is measured in real terms of constant current consumption-equivalent units as outlined before.

<sup>2</sup> This is an application of the Rybczynski Theorem. T.N. Rybczynski, "Factor Endowments and Relative Commodity Prices," Economica 22 (November 1955): 336-341.

<sup>3</sup> See relationship (22).

marginal productivity in  $X$  ( $X_{LJ} > 0$ ) increases the shadow price of her time in child care. This induces her to reallocate time from child care to production of income, thereby increasing the relative intensity of  $S$  in child production ( $d\Omega > 0$ ) and consequently increasing  $\Pi_N$ . This effect is magnified when the parents' net income increases ( $F_J > 0$ ), which may further increase  $\Omega$ . The increase in  $\Pi_N$  holds even when females are engaged only in child care ( $L - \ell = 0$ ) if  $F_J > 0$ . However, a drop in the parents' net income ( $F_J < 0$ ) may offset and invert the positive effect on  $\Pi_N$  of the increase in  $X_L$ .

Hence, the price effects are undetermined, but depend on a few parameters about which empirical conjectures can be made. The relative change in the demand for children, because of the price and income effects brought about by changes in  $K$ ,  $L$ ,  $W_K^*$ , and  $W_L^*$ , is summarized by

$$\frac{dN}{N} = \left[ E_{NI_2} \eta_{I_2J} - |E_{N\Pi_N}| \left( -\frac{G_{SS}}{G_S} \eta_{FJ} F + \frac{1}{\sigma_{s\ell}} \frac{d\ell}{\ell} \frac{J}{dJ} \right) \right] \frac{dJ}{J} \quad (30)$$

The expression  $E_{NI_2} \eta_{I_2J}$  relates to relationship (29), and stands for the determinants of the pure income effect of changes during  $T_1$ .

The price effect depends on the given demand elasticity for children ( $E_{N\Pi_N}$ ) and on the factors that determine the relative change in  $\Pi_N$  as the endowments change. The rate of change in  $\Pi_N$  is positively related to: the level of net income ( $F$ ), the share of  $J$  in  $F$  ( $\eta_{FJ}$ ), and the relative change of the marginal productivity of  $S$  ( $\frac{G_{SS}}{G_S}$ ) in production of children. The increase in the price will be intensified (offset) if  $L$  and  $J$  are gross complements (gross substitutes) in  $X$ ,  $\frac{d\ell}{dJ} < 0$  ( $> 0$ ), indicating a decrease

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<sup>1</sup>See appendix D, section III.

(increase) in the mother's time devoted to child care.<sup>1</sup> The size of this particular effect is positively related to the rate of decrease (increase) in female time devoted to child rearing ( $\frac{d\ell}{\ell}$ ) and the share of female time in child production ( $\eta_{G\ell}$ ). It is inversely related to the elasticity of substitution between S and in  $G(\sigma_{S\ell})$  and the relative change in J ( $\frac{dJ}{J}$ ).

The possible effects of variations in endowments that relate to agricultural and extended household settings on the demand for children can be considered empirically. Land and livestock holdings contribute to the household's income and are assumed to be complements of females' labor. The complementarity and the positive effect on income mean a higher shadow price for children in households with more holdings; but, the implied negative price effect on fertility is coupled with a positive income effect. According to relationship (30), the size of the price effect is relatively large since the relative change in price is a positive function of the level of income, and the share of these particular endowments in income. Hence, households with more holdings that have higher incomes and higher shares of these holdings in income face a higher  $\Pi_N$ , ceteris paribus.

On the other hand, the income effect may be small. According to relationship (29), households with more holdings may have a lower income elasticity for children, ceteris paribus. Parents with assets may have higher returns from their children, because the latter will eventually have higher incomes, and because the parents have rights on more property which enables them to better "exploit" their children. This income effect, however, is not definitely lower since the lower income elasticity is

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<sup>1</sup>Note that  $d(L-\ell) = -d\ell$  which stands for more time in activities other than producing children.

weighted by the relative share of these particular endowments in income. According to this conjecture, holders of non-human wealth have higher shadow prices for children, and possibly lower income elasticities.

Relatives in the households may or may not contribute to income, but depending on their ages and sex, may substitute the mother to various degrees in various activities. As such, they affect the demand for children. Young males are likely to contribute to the parents' net income, and substitute the mother in income producing activities. This implies a positive pure income effect on the demand for children but an ambiguous price effect. The higher income increases  $\pi_N$ , but this may be offset by the reduction of the marginal productivity of females in producing income. Older male relatives, who reduce the parents' net income but substitute the mother in some income producing activities, produce a negative income effect but positive price effect on the demand for children.

Female relatives in the household are assumed to be good substitutes for the mother in production of children as well as of income, although the degree of substitution in the two activities may not be the same. Old female relatives as well as daughters tend to care for children when the mother is engaged in other activities.<sup>1</sup> This implies that the two: the time the mother devotes to producing income (labor force) activities ( $L-l$ ) and the time she devotes to child care ( $l$ ), may increase at the same time. If additional females cause a reduction in the parents' net income ( $F_L < 0$ ) in addition to substituting the mother, the shadow price

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<sup>1</sup> It may be a major duty of girls to care for their younger siblings. Lack of compulsory schooling may encourage this behavior. However, the cause and effect are not obvious. This particular duty of girls, which is home oriented training, may involve higher costs of sending girls than boys to a formal school.

of children definitely falls.<sup>1</sup> But the implied positive price effect on fertility may be offset by the negative income effect. When the mother gains from higher participation in productive activities, and this gain outweighs the support to the female relatives (i.e.,  $F_L > 0$ ), the price of children is likely to increase only if income producing activities have a larger share of female time than child production, ceteris paribus. This particular discussion suggests a possible positive correlation between mothers' labor force participation and fertility in regions where daughters do not attend schools and older relatives--in particular females--reside in the household.

The relative effect of an increase in the real wage of any of the factors depends on the parameters outlined in expression (30), one of which is the mother's (females') labor supply elasticity ( $|E_{LW}|$ ).<sup>2</sup> An increase in  $W_L^*$  is an increase in the females' marginal productivity in income producing activities, and has the same positive effect on  $\pi_N$  as when  $X_{LJ} > 0$  and  $F_J > 0$ . The increment in  $\pi_N$  is positively related to  $|E_{LW}|$ ; the larger the latter, the more of females' time is reallocated from child care to labor force participation.<sup>3</sup> An increase in productivity (wages)

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<sup>1</sup>This implies that girls born first induce a lower price for an additional child. This can be an incentive to parents who have first daughters to have more children, in addition (or as an alternative) to the incentive to have sons.

<sup>2</sup>When  $J \equiv W^*$ , then in expression (30)

$$\frac{dJ}{dW^*} \frac{J}{L} \equiv \frac{dJ}{dW^*} \frac{W^*}{L} \equiv E_{LW}.$$

The elasticity of labor supply is the absolute value of this term since  $d(L-L) = -dL$ .

<sup>3</sup>It is assumed that child care is a non-leisure activity. Yet, the trade that is implied by the females' labor supply elasticity is between children and "other activities", which can include leisure. A backward bending supply curve in this context may reverse the above conclusions.

of other factors implies an increase in household income, which has the above mentioned implications of an increase in  $\Pi_N$  and income on the demand for children.

The specifications of the model rule out a fall in the shadow price of children because of an increase in the household's income, since the model does not distinguish between the mother's (females') household activities other than rearing children and income producing activities. This loss of generality can be qualified by adapting to this discussion the Willis model that makes this distinction. According to Willis, mother's (females') time can be allocated to: child rearing, other household activities, and income producing activities (labor force participation.)<sup>1</sup> This kind of specialization in activities may mark a different stage of economic development, and provides for the possibility of a fall in  $\Pi_N$  because of an increase in income when the production of children is relatively "goods intensive." This issue, however, remains to be resolved empirically.

The more general issue is to consider a priori which of the two, the price effect or the income effect, is likely to dominate in this particular setting. It seems plausible to assume that the elasticity of substitution between  $C_1$  and  $C_2$  is relatively small. If this is the case, it is probable that the income effect will dominate. Hence, an increase in income during  $T_1$  is likely to induce more consumption of  $C_2$ , i.e. more fertility.

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<sup>1</sup>Willis, "A New Approach to the Economic Theory of Fertility Behavior."

Variations in Income (Wealth): Period  $T_2$

The income effect on fertility of a change in opportunities during  $T_2$ --that do not relate to a change in opportunities during  $T_1$ --can be illustrated by a change in  $Y_2$ . A change in future income, which does not relate to savings--fertility--behavior ( $Y_2$ ), does not change the shadow prices in the system, and has a negative effect on fertility,

$$\frac{dN}{dY_2} < 0.^1 \quad (31)$$

This change is illustrated in figure 3 by the parallel shift to the left of the T curve by  $\Delta Y_2$  and the shift in the lifetime consumption opportunities frontier to  $DE'F'$ .<sup>2</sup> The parents reduce the demand for children from  $N_0$  to  $N_1$  by increasing their lifetime consumption as indicated by  $O_c'$  in the figure. This effect is clear intuitively. The parents transfer part of their increase in wealth into  $T_1$  by increasing the demand for the normal good  $C_1$ . They can do so only by lowering the demand for children because consumption during  $T_1$  ( $C_1$ ) and children ( $N$ ) are substitutes, and in the absence of a capital market they cannot capitalize the gain that occurs in  $T_2$ .

The relative change in the demand for children because of a

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<sup>1</sup>See appendix A, relationship 20.

<sup>2</sup>This is a non-homothetic shift in the lifetime opportunity curve because of the non-linearity of this curve. Hence, it does not represent a "pure" income effect as defined for shifting period  $T_1$  opportunities. However, the linearity can be assumed for an infinitesimal change.



relative change in  $Y_2$  is

$$\frac{dN}{N} = E_{C_1 I_2} \left(1 - \frac{I_1}{\pi_N N}\right) \frac{\pi_2 Y_2}{I_2} \frac{dY_2}{Y_2} \cdot^1 \quad (32)$$

It is a positive function of the wealth elasticity of  $C_1$  ( $E_{C_1 I_2}$ ) and the share of  $Y_2$  in full wealth ( $\frac{\pi_2 Y_2}{I_2}$ ), and a negative function of the share of children in the first period's full income ( $\frac{\pi_N N}{I_1}$ ).<sup>2</sup> The latter two actually indicate weighted values of children in the provision of future income. The higher the first and the lower the second, the stronger is the negative effect on the demand for them because of an increase in  $Y_2$ . Clearly, the demand for children ceases to be a function of the demand for future consumption after a certain  $\bar{Y}_2$ , assuming a homogeneous utility function.

The conclusions of this section and the one dealing with the pure income effect in  $T_1$  point to the particular way income affects fertility in this model. Income has opposing effects on fertility depending on its timing without assuming that either of the commodities,  $C_1$  or  $C_2$ , is inferior.

The Returns from Children: Survival Rates (P),  
and the Returns from a Surviving Child (W)

The parameters  $P$  and  $W$  determine the parents' returns in  $T_2$  from children born in  $T_1$ . An increase in either of the two, ceteris paribus, increases the marginal benefits from children ( $T_N$ ), and has an ambiguous

<sup>1</sup>See appendix C, section IV.

<sup>2</sup>The range of the inverse of children's share in full income,  $I_1$ , is by definition  $1 \leq [I_1 (\pi_N N)^{-1}] < \infty$ . Thus,  $0 \geq [1 - I_1 (\pi_N N)^{-1}] > -\infty$ . The two limits indicate corner solutions of which the plausible one is when  $C_1$  and  $C_2$  are positive, i.e., point E in figure 3.



effect on fertility:

$$\frac{dN}{dJ} \begin{matrix} > \\ < \end{matrix} 0, \quad (J = W, P).^1 \quad (33)$$

A change in P or W is illustrated in figure 4 by the rotation to the left of the curve T from T to T', and the corresponding rotation of the lifetime consumption opportunities frontier from DEF to DEF', which combines the wealth and price effects. The price effect is illustrated by the differences between the slopes at the points  $O_c$  and  $O_c''$ .

The critical parameter that determines the direction of the change in the demand for children is the demand elasticity of future consumption ( $E_{C_2 \Pi_2}$ ), which can be treated in a special case as the demand elasticity for survivors.

The increase in the marginal benefits  $T_N$  from children reduces the shadow price of future consumption ( $\Pi_2 = \frac{\Pi_N}{T_N}$ ) since the price of children ( $\Pi_N$ ) remains unaffected. This implies an increase in the parent's wealth in addition to the change in the relative prices of the two consumption streams,  $C_1$  and  $C_2$ . The substitution and wealth effects have conflicting effects on the demand for consumption ( $C_1$ ) in  $T_1$ , i.e., on the demand for children. The wealth effect induces more consumption in both periods since  $C_1$  and  $C_2$  are normal goods. The substitution effect, however, induces less consumption of  $C_1$  because of the increase in its relative price. Hence, the wealth effect induces less fertility while the substitution effect induces more. The total effect on fertility can be inferred from the total effect on the demand for  $C_1$  since  $\frac{dN}{dC_1} < 0$ , and is

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<sup>1</sup>See appendix A, relationship 21. For a specific account of the effect of an increase in age-specific mortality rates on "benefits" from children, see Donald J. O'Hara, Changes in Mortality Levels and Family Decisions Regarding Children, R-914-RF, (Santa Monica, California: The Rand Corporation, February 1972).

summarized by

$$\frac{dN}{N} = E_{C_1 I_2} \left(1 - \frac{I_1}{\pi_N N}\right) (1 - |E_{C_2 \pi_2}|) \frac{C_2 \pi_2}{I_2} E_{\pi_2 J} \frac{dJ}{J},$$

(J = P, W).<sup>1</sup> (34)

The price elasticity of  $C_2$  ( $E_{C_2 \pi_2}$ ) indicates the change in total expenditure on  $C_2$  ( $\pi_2 C_2$ ) as the price of the commodity falls. When  $|E_{C_2 \pi_2}| > 1$  the total real outlays of this commodity in terms of  $C_1$  increase, decreasing the demand for  $C_1$ , i.e., increasing the demand for children. The change is reversed when  $|E_{C_2 \pi_2}| < 1$ . The relative size of the effect on  $C_1$  is positively related to: the wealth elasticity of  $C_1$  ( $E_{C_1 I_2}$ ), the share of  $C_2$  in wealth ( $\frac{C_2 \pi_2}{I_2}$ ), and the term  $(1 - \frac{I_1}{\pi_N N}) < 0$ , all having a pure wealth effect as in the case of a change in  $Y_2$ . The total effect is clearly larger the higher the elasticity of  $\pi_2$  with respect to either of the two exogenous changes ( $E_{\pi_2 J}$ ).<sup>2</sup>

Since the income and substitution effects operate in opposite directions on  $C_1$  and the upper bound of  $C_1$  is constant, it is possible to adapt the analysis of labor supply to derive the effect on the demand for children. At low levels of survival rates or benefits from children,

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<sup>1</sup> See appendix C, section V.

<sup>2</sup>  $\pi_2$  can be interpreted as the cost of a survivor in the special case where  $C_2 = PNW$  and  $W$  takes the standardized value of 1. Under this assumption  $E_{\pi_2 P}$  is the effect of a relative change in mortality ( $j=p$ ) on the relative costs of a survivor. Ben Porath and Welch assumed it is less than unity. This model does not provide any a priori reason for a similar assumption, unless one considers a low elasticity of substitution between  $C_1$  and  $C_2$ . Yoram Ben Porath and F. Welch, Chance, Child Traits, and Choice of Family Size, R-1117 (Santa Monica, California: The Rand Corporation, 1972).

the substitution effect may be dominant. Hence, an increase of either of the variables will cause a reduction in consumption of  $C_1$ , i.e., an increase in the demand for children. As the levels of  $P$  or  $W$  increase, the wealth effect on  $C_1$  becomes dominant, increasing the demand for  $C_1$  and consequently reducing the demand for children. This pattern is illustrated by the price-consumption curve (PCC)  $E_0 C_1 C_2'$  (figure 4). Where  $dc_1/dc_2 < 0$  on this particular curve, the substitution effect on  $C_1$  is dominant, indicating an increased demand for children. The pattern reverses where  $dc_1/dc_2 > 0$ , passing through a critical point  $dc_1/dc_2 = 0$  where the demand for children is unaffected.

An increase in fertility that levels off subsequently--resulting from increasing survival rates--is often suggested as the common behavioral pattern. O'Hara reaches a similar conclusion.<sup>1</sup> He suggests that the wealth effects will induce demand for more educated children at the expense of less children. This model implies a higher demand for more of all other commodities, which are "normal" and subject to a dominant wealth effect.

The effect of compulsory schooling can be analyzed with the variable  $W$ . Compulsion means that the parents' rate of return ( $W$ ) from children decreases because of schooling. The discussion suggests a decrease in fertility at initial stages, but may increase it later on as the parents' compensate for the lowered wealth by more fertility.

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<sup>1</sup>O'Hara, Mortality Levels and Family Decisions.

## V. UNCERTAINTY, AND INVESTMENT IN HUMAN CAPITAL

The preceding discussions assumed that future income ( $C_2$ ) is a deterministic choice variable. Fertility behavior has been derived from the demand for  $C_2$  and  $C_1$  under conditions of certainty and risk neutrality. The following discussion introduces the element of uncertainty into the analysis by assuming, more realistically, a stochastic  $C_2$  and risk averse parents.

This discussion is combined with an extension of the basic model to eventually make  $P$ , a child's probability of supporting his parents, and  $W$ , the level of support, endogenous to the parents' decision making.  $P$  and  $W$  are assumed to be affected independently by investment in children's health and education, respectively. Introducing the opportunity of investing in human capital under conditions of uncertainty can be viewed as an extension of existing analyses dealing with the issue of "child quality."<sup>1</sup>

The discussion adapts and applies the analytical framework that has been developed by A. Sandmo, whose analysis suits this discussion.<sup>2</sup> It utilizes a two period consumption model, and risk is defined in a temporal context; the outcomes of various prospects are unknown until after the savings-consumption decisions have been made. Some of the

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<sup>1</sup>R.J. Willis, "A New Approach to Economic Theory of Fertility Behavior." Also: Dennis N. DeTray, "Child Quality and the Demand for Children," JPE 81, Part 2 (March-April 1973): 70-95; and G.S. Becker and H. Gregg Lewis, "On the Interaction between Quantity and Quality of Children," JPE 81, Part 2 (March-April 1973): 279-288.

<sup>2</sup>A. Sandmo, "The Effect of Uncertainty on Savings Decisions," Review of Economic Studies 37 (July 1970): 353-360.

arguments are supported by the more generalized analysis by J. Dreze and F. Modigliani.<sup>1</sup> The discussion is subject to some restrictive assumptions and the general limitations of the theory of behavior under uncertainty.

The discussion below redefines the utility function (1), and considers the determinants of risk averse behavior in developing economies. It retains initially the assumptions of exogenous P and W, and considers the effects of risk on fertility when risk relates to future income that is independent from fertility-savings behavior ( $Y_2$ ) as well as when risk relates to benefits from children (T). This is followed by allowing P and W to be endogenous. For analytical purposes, only one income stream--  $Y_2$  or T--is assumed to be a stochastic variable at a time.

#### Restatement of Assumptions and Redefinition of the Utility Function

The discussion depends critically on certain assumptions primarily concerning the utility function. The basic assumption of imperfect markets for assets and insurance is maintained. Under this regime the parents must make consumption-savings (fertility) decisions in period  $T_1$  before knowing the outcomes in terms of  $C_2$ .

The parents are assumed to maximize the expected utility function

$$U = EU^* (C_1, C_2), \quad (35)$$

where  $C_1$  is a deterministic variable and  $C_2$  is a stochastic one which will be defined below. This function complies by assumption with Sandmo's

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<sup>1</sup>Jacques H. Dreze and Franco Modigliani, "Consumption Decisions Under Uncertainty," Journal of Economic Theory 5 (1972): 308-335.

definition; its basic properties are the existence of risk aversion and decreasing temporal risk aversion with respect to  $C_2$ . The latter implies that the risk aversion function  $\left[ -\frac{U_{22}(C_1, C_2)}{U_2(C_1, C_2)} \right]$  decreases with  $C_2$  and increases with  $C_1$ .<sup>1</sup>

The assumption about risk aversion may be universal. It is, however, especially valid for this particular analysis because it concerns investment in children, and because of certain conditions that apply to parents in developing economies. The consumption-saving--fertility--decisions are made prior to establishing  $C_2$ . This implies that parents, in general, are more likely to be risk averse regarding investment in children, because people are willing to pay a larger insurance premium to avoid temporal risk than to avoid equivalent timeless risk.<sup>2</sup> Dreze and Modigliani add that the willingness to bear temporal risk is inversely related to the consumer's marginal propensity to consume, and positively related to the absolute rate of substitution between  $C_1$  and  $C_2$ .<sup>3</sup> Masson also attributes risk aversion to the

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<sup>1</sup>Sandmo, "Uncertainty on Savings," pp. 354-355. See also: Dreze and Modigliani, "Consumption Decisions," pp. 313-315, 324. Of the class of utility functions which satisfy this definition, the quadratic one with respect to  $C_2$  is ruled out because of its limiting implications. This utility function may imply increasing risk aversion with respect to wealth, which may not be too realistic. See: J.W. Pratt, "Risk Aversion in the Small and in the Large," Econometrica 32 (1964): 122-126. This functional relationship has further limitations on the generality of the analysis. See: Michael Romchild and Joseph E. Stiglitz, "Increasing Risk II: Its Economic Consequences," Journal of Economic Theory 3, (1971): 66-84.

<sup>2</sup>The following articles relate to this point: (a) Michael Spence and Richard Zeckhauser, "The Effect of the Timing of Consumption Decisions and the Resolution of Lotteries on the Choice of Lotteries," Econometrica (March 1972): 401-403. (b) Sandmo, "Uncertainty on Savings." (c) Dreze and Modigliani, "Consumption Decisions," pp. 311-316. They argue that a temporal uncertain prospect is never preferred to a timeless one which bears the same risk.

<sup>3</sup>Dreze and Modigliani, "Consumption Decisions," pp. 311-316.

imperfect capital market.<sup>1</sup> All these underlying reasons for higher risk aversion are believed to apply to populations in developing economies: high marginal propensities to consume, imperfect capital markets, and apparently a low absolute rate of substitution between  $C_1$  and  $C_2$ , given the lack of institutional arrangements to support the aged. These conditions set a relatively high "penalty" for not securing income for old age.

### The Effect of Uncertainty on Fertility

The following discussion utilizes Sandmo's concepts of "income risk" and "capital risk", which are defined below, as well as the notion of "increase in risk". Sandmo's two concepts correspond to the two possible future income flows  $Y_2$  and  $T(N, P, W)$ . The general function  $T$  is assumed linear, for analytical purposes, with some loss of generality. Hence, the temporal transformation relationship (2) is now

$$C_2 = Y_2 + NPW \quad Y_2 \geq 0, NPW > 0. \quad (36)$$

Each of the terms on the right can be assigned a probability distribution, making  $C_2$  a stochastic variable. The discussion infers the effects of risk, which relates to each term at a time, on the demand for children from the effects of risk on period  $T_1$  consumption ( $C_1$ ), since  $dC_1/dN < 0$ .

"Income risk is concerned with uncertainty concerning future non-capital income . . . .In case . . .of income risk the role of savings is that of a buffer providing a guarantee that future consumption will not

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<sup>1</sup>Masson, "Creation of Risk Aversion," pp. 77-86.

fall below a minimum level."<sup>1</sup> The model's specifications imply that  $Y_2$  is non-capital future income, children being the capital good. The parents are assumed to assign a subjective probability distribution to  $Y_2$ , but know with certainty the value PNW, which they can affect by fertility behavior. Sandmo defines an "increase in risk" in this case as a multiplicative shift in  $Y_2$  ( $\gamma Y_2$ ), counteracted by an additive shift ( $\gamma Y_2 + \theta$ ) that keeps the mean constant, since  $Y_2 \geq 0$ .<sup>2</sup> He proves that an increase in risk will decrease consumption in  $T_1$ , given the sufficient condition of decreasing temporal risk aversion. This implies more savings--a higher demand for children--than in the risk neutral case. The rise in savings--fertility--is an attempt by the parents to compensate with a higher expected value for the increase in risk concerning  $Y_2$ .

Capital risk, according to Sandmo, deals with the uncertain yield on capital investment. It complies with the notion that "the more one saves, the more one stands to lose."<sup>3</sup> This type of risk can be applied to the investment in children, assuming a deterministic  $Y_2$  and utilizing the distributional effects of the parameter  $P$ , which stands for each child's probability to survive from  $T_1$  to  $T_2$ .

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<sup>1</sup>Sandmo, "Uncertainty on Savings," p. 353. The "introduction" of risk is considered equivalent to an "increase" in risk. One can assume that in previous discussions  $Y_2$  was known with certainty. Now it is exposed to uncertainty, and its<sup>2</sup> expected value equals its deterministic value in the riskless case.

<sup>2</sup>An increase in risk is not to be implied from an increase in the variance of  $C_2$  only, since a distribution with a higher variance also has a higher mean<sup>2</sup> and dominates one with a lower variance, as long as the left tails of both distributions start at the same point. See also: Rothchild and Stiglitz, "Increasing Risk: I Definition," Journal of Economic Theory 2 (1970): 225-243. The third definition of risk by Rothchild and Stiglitz --that a shift of the above nature increases the weights in the tails of the distribution--is consistent with Sandmo's above definition.

<sup>3</sup>Sandmo, "Uncertainty on Savings," p. 353.

The expected number of survivors (SR) from  $N$  children born, each with a probability to survive  $P_i (i=1. . . N)$ , is

$$E(SR) = PN; \quad (37)$$

since when  $P_i = P_j (i \neq j)$ ,  $E(P) = P$ .

The variance is given by

$$\text{VAR} (SR) = NP (1-P), \quad (38)$$

since  $\text{VAR}(P) = P(1-P)$ .<sup>1</sup> Consequently, the expected value of services from children is

$$E(C_2) = WPN + Y_2, \quad (39)$$

and the variance is

$$\text{VAR}(C_2) = W^2NP(1-P), \quad (40)$$

while  $Y_2 \geq 0$  is assumed a deterministic variable.

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<sup>1</sup>In the more general case when  $P_i \neq P_j$ :

$$\begin{aligned} \text{and,} \quad E(SR) &= \bar{P}N, & \bar{P} &= \frac{1}{N} \sum_1^N P_i; \\ \text{VAR}(SR) &= \sum_1^N \bar{P}_i(1 - P_i) \\ &+ \sum_{\substack{J=1 \\ J \neq I}}^{N-1} \sum_{\substack{I=1 \\ I \neq J}}^{N-1} \text{COV}(SR_i, SR_j) \end{aligned}$$

The co-variance term indicates the dependence between survival rates of any two children. It is realistically assumed that  $\text{COV}(SR_i, SR_j) > 0$ , indicating that mortality rates of any two children are positively correlated in any given household.

The introduction of risk, which is defined as before, has an ambiguous effect on fertility in this case. It carries, according to Sandmo, an "income effect," which is identical to the effect of income risk, and a "substitution effect," which follows from the necessary and sufficient condition of risk aversion that makes the consumer "less inclined to expose his resources to the possibility of loss."<sup>1</sup> Hence, the "income effect" induces more savings--more fertility--and the substitution effect less. A feature of this argument is that the higher fertility increases the expected value as well as the variance of  $C_2$ , leading to the conflicting tendencies in the parents' behavior.<sup>2</sup>

It is possible, however, to make some conjectures about the possible dominant effect on fertility based on the idea that the "income effect" operates to protect against low levels of  $C_2$ . Suppose that  $\bar{Y}_2 > 0$  is a threshold level of guaranteed future income not from children, that the parents strive to surpass. Hence, whenever  $Y_2 < \bar{Y}_2$ , the "income effect" is likely to dominate, i.e., inducing more fertility for a higher expected  $C_2$ , even though at higher risk. Whenever  $Y_2 \geq \bar{Y}_2$ , the substitution effect is likely to dominate, i.e., inducing less fertility to expose less

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<sup>1</sup> Sandmo, "Uncertainty on Savings," p. 357. For a generalized approach on this issue, Dreze and Modigliani, "Consumption Decisions." Approaching the same problem, Rothchild and Stiglitz show that the mean-variance analysis, or quadratic utility function, leads to a limited conclusion that savings in  $T_1$  must decrease. Stiglitz and Rothchild, "Increasing Risk II," pp. 66-84.

<sup>2</sup> The increase in the expected value and variance of  $C_2$  is shown by deriving expressions (39) and (40) with respect to  $N$ . See <sup>2</sup>appendix D.

current ( $T_1$ ) resources to risk, regardless of some loss in the expected value of  $C_2$ .<sup>1</sup>

The major conclusion of this section concerns the effect on fertility of non-savings future income ( $Y_2$ ), and it complements the conclusion that followed the discussion of the effect of  $Y_2$  on fertility in the riskless case. It suggests that higher assurance (lower variance) of a given level of  $Y_2$  will lower the demand for children, producing the same effect as an increase in the level of  $Y_2$ .

#### Investment in Human Capital under Conditions of Uncertainty

Investment in a child's human capital is defined in terms of the parents' real outlays to increase a child's probability to survive ( $P$ ) and his anticipated income ( $W$ ) above some endowed levels,  $P_0$  and  $W_0$ . Since human capital is embodied in children, it is reasonable to assume diminishing returns on investment in either health of a child or his education.<sup>2</sup> Under conditions of certainty, optimal behavior implies

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<sup>1</sup>This particular discussion is based on the assumption that each surviving child's contribution to his parents ( $W$ ) is not a function of  $Y_2$  ( $\frac{\partial W}{\partial Y_2} = 0$ ). This assumption, however, is not a necessary condition for the conclusion.

<sup>2</sup>T.W. Schultz, The Economic Value of Education (Columbia University Press: New York, 1963). G.S. Becker, Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education, (National Bureau of Economic Research, New York, 1964). Michael Grossman, The Demand for Health: A Theoretical and Empirical Investigation, (National Bureau of Economic Research, New York, 1972). Education is defined here in the broad sense. It may include, in addition to formal education, non-formal education--home and farm, on-the-job training--as well as instilling ethical values, which may be important for this particular discussion.  $W$  can also be increased by other assets as outlined before. This case is not considered explicitly in the discussion because such assets are not embodied in children and the parents do not stand to lose them with child mortality. However, for a discussion of investment in child quality vs. other investment opportunities, See: Bush, "The Economic Analysis of Fertility: Two Extensions." (mimeograph, Virginia Polytechnic, 1973).

investment according to the marginal rates of return, either by investment at the intensive margins--in human capital of the marginal child--or at the extensive margins--by having an additional child. The following discussion of investment in children's human capital (quality) under conditions of uncertainty leads to the conclusion, which has an intuitive appeal, that investment in a child's health is a means to insure higher investment in education, and that the two types of investment are complementary.

The parents' "portfolio" contains four assets; one of these-- $Y_2 \geq 0$ --continues to be deterministic and exogenous, and the other three-- $N$ ,  $W$ , and  $P$ --are endogenous and determine the distribution of  $C_2$ . The parents can change the distribution by  $W$  and  $P$  when  $N \geq 1$ , and by  $N$ . Hence, risk is endogenous to the household and so is the rate of return from children. The discussion is constrained by the argument by Dreze and Modigliani that ". . .in the absence of perfect market(s) for assets and insurance, separability between consumption and portfolio decisions is rather implausible."<sup>1</sup> Thus, the composition of the parents' "portfolio" must be linked to the possible effect on  $C_1$ , i.e., on fertility.<sup>2</sup> It is assumed that the income effect, as defined in the previous section, dominates. Hence, parents wish to compensate for higher risk by a higher expected value of services from children ( $C_2$ ).

The behavioral implications of the endogenous variable are based on the differential effects each has on the distribution of  $C_2$ , and on the expected utility function. Both an increase in the number of children ( $N$ )

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<sup>1</sup>Dreze and Modigliani, "Consumption Decisions," p. 328.

<sup>2</sup>Note that this is not a portfolio problem in the regular sense since the three assets are interactive. A more general approach can treat  $Y_2$  as an alternative market investment opportunity with a fixed return. The consequences of this possibility are discussed in the following chapter.

and an increase in each one's education ( $w$ ) have additive and multiplicative effects on the distribution; the mean increases along with an increase in the variance. Differentiating expressions (39) and (40) with respect to  $N$  and  $W$  establishes that a change in the latter will increase the variance of  $C_2$  more than a change in  $N$ , for a given change in the mean.<sup>1</sup> This implies, according to the previous definition, an increase in risk. Children are therefore less risky than education. This argument has an intuitive appeal; it suggests that attaining a given expected level of  $C_2$  via fewer children with higher education is more risky than having more children with less education. Alternatively, given a child's survival probability, the expected loss is higher when the child is more educated. This loss is even higher when  $N > 1$ , and the children's possibilities to survive are interdependent,  $\text{COV}(SR_j, SR_i) > 0$ .

Increasing a child's probability to survive by investment in health increases the expected value of  $C_2$ , and reduces the variance whenever  $P > 0.5$ .<sup>2</sup> This effect is magnified when the health status of one child affects the other children,  $\text{COV}(SR_j, SR_i) > 0$ .

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<sup>1</sup>See appendix D. The ratio between the mean and the variance does not change in the case of variation in  $N$ . It falls when  $W$  increases. Note, however, that the above discussion does not employ a mean-variance analysis.

<sup>2</sup>See appendix D. Postulating the endowed  $P > 0.5$  is a realistic assumption in the Indian context. Bounds on the probabilities of the parents to reach age of support can be established based on the following assumptions: (a) Fathers' prime fertility years are between 20-35 years of age. (b) A parent (father) expects to be supported after age 45. (c) A son can start supporting his parents at age 15. The joint probability of the father reaching age 45 (from 20) and the elder son reaching 25 is .6396, assuming that their probabilities to survive are independent. For having a child at age 35, the joint probability of the son reaching 15 and the father age 50 is .6205. The joint probabilities of at least one of the parent surviving with a child are higher. Computed according to life tables (males) from: O.B. Saxena, India, Population in Transition (New Delhi: Commercial Publication Bureau, 1971.)

At the optimum point, the marginal expected utilities from the prospects must be equal. This requires differentials in the shadow prices,  $\Pi_j$  ( $j=N, P, W$ ), of the prospects as a necessary condition for a non-corner solution, i.e., zero investment in one of the assets, given  $N \geq 1$ .<sup>1</sup> An increase in  $EC_2$  by  $W$  coincides with a smaller increment in  $EU(C_1, C_2)$  than the same increase by  $N$  or  $P$ . Hence, increasing  $EC_2$  by  $W$  must have a lower shadow price ( $\Pi_W$ ) than increasing  $EC_2$  by the two other opportunities. Following this argument the relationship among the prices should be

$$\Pi_W < \Pi_N < \Pi_P; \quad (41)$$

namely, the marginal costs in terms of  $C_1$  must equal the marginal benefits in terms of the gain in expected utility.

Keeping the ranking of shadow prices as outlined and assuming ratios that avoid a corner solution, it is possible to conceive that, within a certain range, the parents can combine (linearly) investment in health and education:

$$\alpha \Pi_W + (1-\alpha) \Pi_P = \Pi_N, \quad (42)$$

where  $\alpha$  is the share of a given gain in  $EC_2$  attributed to  $W$ . Thus the parents can invest in the two forms of human capital in existing children for a certain gain in expected utility, rather than having an additional child. This implies, first, that investment in health and education are complementary; the parents "insure" the higher investment in a child's

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<sup>1</sup>  $\Pi_j = \frac{\partial C}{\partial J}$  ( $J = N, P, W$ ).

education. Second, investment in human capital continues up to the equality point in relationship (42), which defines optimal investment in human capital per child. From that point the parents prefer to have an additional child.

Another notable implication is that the demand for health has the highest price elasticity. Any decrease in its relative price has a "premium" not only in terms of real income, but also in terms of reduced risk whenever  $P > 0.5$ . A decrease in the relative price of health will primarily induce substitution away from education within the human capital "package." It may also induce less fertility because of the implied reduction in risk. A corner solution would imply that the parents will invest all in health and none in education ( $\alpha = 0$ ) at a sufficiently low relative price of health. However, the marginal benefit from a unit of spending ( $C_1$ ) on  $P$  must fall relatively fast since  $P \leq 1$ .

According to this discussion, income does not have an effect on the amount invested in the human capital of a child, unless the decrease in risk aversion is considered. The specification of the utility function indicates that wealthier parents may be willing to take higher risks. This may suggest, within this framework, that higher income groups may be willing to invest more in the risky asset--education.

## VI. THE DEVELOPMENT OF A CAPITAL MARKET

Economic development is marked by an increase in the rate of return to capital, brought about by investment in "modern sources of income," and the emergence of financial intermediaries, resulting from specialization of labor between saving and investment. These changes are assumed to increase the return on financial savings; the borrowing rate, which the capital's marginal productivity determines, is the upper limit that the lending rate for investment approaches as competitiveness increases in the capital market. Furthermore, the development of financial intermediaries reduces the risk that is associated with lending.<sup>1</sup> This encourages potential lenders to save in the form of financial assets, including insurance. The following discussion concludes that these developments reduce the demand for children and increase the household's welfare as well as the level of financial savings.<sup>2</sup> This may also be associated with more investment in children's education.

### The Effects on Fertility - The Lending Household

Optimal behavior must equate the marginal rate of return on

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<sup>1</sup> K.J. Arrow, "The Role of Securities in the Optimal Allocation of Risk-Bearing," Review of Economic Studies 31 (April 19, 1964): 91-95.

<sup>2</sup> The same conclusion is produced by Neher, who assumes in his model the same trade-off between children and financial assets, as vehicles of old age income. Neher, "Peasants, Procreation", p. 387.



investment in children to the marginal return on other saving-investment opportunities under conditions of certainty. This is indicated by the first order condition (25) and is illustrated by the tangency point L in figure 5.  $r^*$  is a positive market discount rate that determines the slope of the segment MLD'.

The household allocates savings to investment in financial assets and investment in children. The two are correspondingly illustrated by the segments  $\overline{GG'}$  and  $\overline{BB}$  in figure 5. The improvement in the household's welfare because of the transactions in the financial market is illustrated by the point  $O'_C$  on a higher indifference curve  $\psi_1$ .

An increase in the market rate of return is equivalent to improving the household's "terms of trade." It becomes more efficient to trade current for future income by means of financial assets than by children, within a given range. This causes substitution away from children up to the point where the marginal rates of return on both investments are equalized.<sup>1</sup> A corner solution is plausible when the market interest rate is higher than any feasible marginal rate by the temporal transformation via children. It implies that children cease to be investment commodities, and savings for future consumption is in the form of financial assets only. The particular case can be illustrated in figure 5 by converting the tangency point L to E.<sup>2</sup>

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<sup>1</sup>Even in the case where the rate of return on children accounts for the psychic utility from them, an increase in market opportunities makes these "consumption services" more costly. Yet, it is not clear what will happen to the demand for children because of opposing price and wealth effects on consumption.

<sup>2</sup>This can be viewed as a threshold to a socio-economic realm where children are consumer durables only.

A positive marginal rate of return on children as an investment is now a necessary, but not a sufficient, condition for an internal solution. The existence of this condition is empirically disputed; but the relevant findings must be qualified.

The most notable empirical exercise on this issue was performed by Goran Ohlin, who compared the real expenditures, in adult equivalent terms, on children aged 0-15 to various discounted values of the parents' gains at ages 60-85.<sup>1</sup> Ohlin concluded that the rate of return of children as an investment is actually negative. This finding must be qualified on several grounds, however. A less fundamental issue is the choice of the specific age intervals, which clearly affect Ohlin's particular results. A more fundamental issue is the validity of such an exercise as a proof of the existence of the pension motive. Ohlin based his conclusions on ex post averages across households. This implies that some particular households may, nevertheless, have positive marginal (and average) rates of return on children, at least ex ante. The mere fact that survey data indicate that parents have a pension motive should be evidence of a priori positive rates of return or no better alternatives than children. The issue of alternatives is critical to the argument of investment-motivated fertility as a form of economic behavior, and must be addressed in any exercise of computing rates of return, since it is the relative rates that matter. At the outset, it has been realized that the pension motive

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<sup>1</sup>Ohlin, "Population Pressure," p. 1728. For additional comments see: W.C. Robinson, "Peasants, Procreation and Pensions: Comment," *AER* 62 (December 1972): 977-978; and Philip A. Neher, "Peasants, Procreation and Pensions: Reply," *AER* 62 (December 1972): 979. Rosenzweig also disputes that children can be a profitable factor in US farming (Rosenzweig, "Economics of Fertility").

clearly does not hold for the entire universe and it is not the only motive, even in developing countries.

My model implies that the marginal rate of return is inversely related to the number of children.<sup>1</sup> Thus, the first-born child may have a positive rate of return as an investment.<sup>2</sup> Furthermore, "lower quality children" may involve a relative saving in costs vis-a-vis the returns and, consequently, yield a positive rate of return.

When the risky asset children is considered and compared to a risk-free asset with a given rate of return, children must yield a higher expected rate. This condition suggests a decrease in fertility when the return on the safe asset increases, as outlined before. However, the risky asset--children--offers a distribution of rates of return, some of which are higher than the returns on the safe assets. Thus, some parents may wish to "gamble" by more fertility for these higher returns.

Parents may trade children not only for financial assets but also for human capital of existing children. For a net lending household the income effect of an increase in  $r^*$  may induce more investment in the riskier asset, education of fewer children, if higher incomes decrease risk aversion.

The macro-economic implications of this discussion are significant in the context of economic growth. This model implies a change at least in the form of savings from the household's viewpoint: from children to financial assets and probably human capital. This is an increase in the

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<sup>1</sup>If economies of scale exist within a range--enough to offset the diminishing returns--the returns to children may increase within that range.

<sup>2</sup>This point may relate to the special status of the first born son in many cultures.

level of savings from the macro point of view, where children are not regarded as a form of savings for capital accumulation. This conclusion holds even if the income effect induces more consumption of  $C_1$ .

#### The Effect on Fertility--The Borrowing Household

This discussion focuses on the lending household since lending is the common way to transfer incomes into the future. However, this need not be the case, especially when children are considered as a form of self-investment. Some households may find it profitable to borrow in the emerging financial market to finance current consumption as well as to invest in children.<sup>1</sup> In this case children are used as a collateral.

The increase in wealth induces a higher demand for the "normal good"  $C_2$ . On the other hand, the price of this commodity has increased, thereby reducing the quantity demanded of it. Identical effects apply by definition to the derived demand for children. No a priori statement can be made about the dominant effect on fertility. An increase in the demand for children will follow a dominant income effect, if that does not induce more investment in their education as a consequence of decreasing risk aversion.

The same argument follows concerning the effect on fertility of a change in the market discount rate. However, it is clear that an increase in this rate is likely to convert the borrowing household into

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<sup>1</sup> Whether a particular household is borrowing or lending at a given market rate depends on that household's time preferences set, and on its own intertemporal transformation opportunities. For analytical purposes, the discussion assumes a homogeneous preference set across households. Hence, lending or borrowing is determined by variable intertemporal transformation opportunities.

a lending one. This case, which is plausible, will have a deterrent effect on fertility, as outlined before.

## VII. WELFARE AND POLICY IMPLICATIONS

Policies to induce less fertility are common in numerous developing economies.<sup>1</sup> These policies have been directed primarily toward family planning and were motivated by budgetary considerations as well as the belief that family planning is the solution to high fertility rates.

Clearly, some observed fertility is due to costly methods of contraception, especially in developing areas. However, this model asserts that high observed fertility is caused by a capital market failure to provide other savings opportunities for old age in a traditional agricultural environment. The following discussion utilizes the model to derive the implications of a common policy principle to induce family planning by material incentives. This principle is compared to old age pension programs. The basic conclusions of this chapter depend on the specific assumptions made about the financial market.

### Welfare Implications of Family Planning

The model is based on notion that the parents maximize their welfare from lifetime allocation of consumption via fertility decisions. It predicts that inducing less fertility may require relatively large compensations to the parents or otherwise, may impose a loss in the parents'

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<sup>1</sup> Dorothy Nortman, "Population and Family Planning Programs: A Factbook," Reports on Population and Family Planning, no. 2 (The Population Council of New York, December 1974).

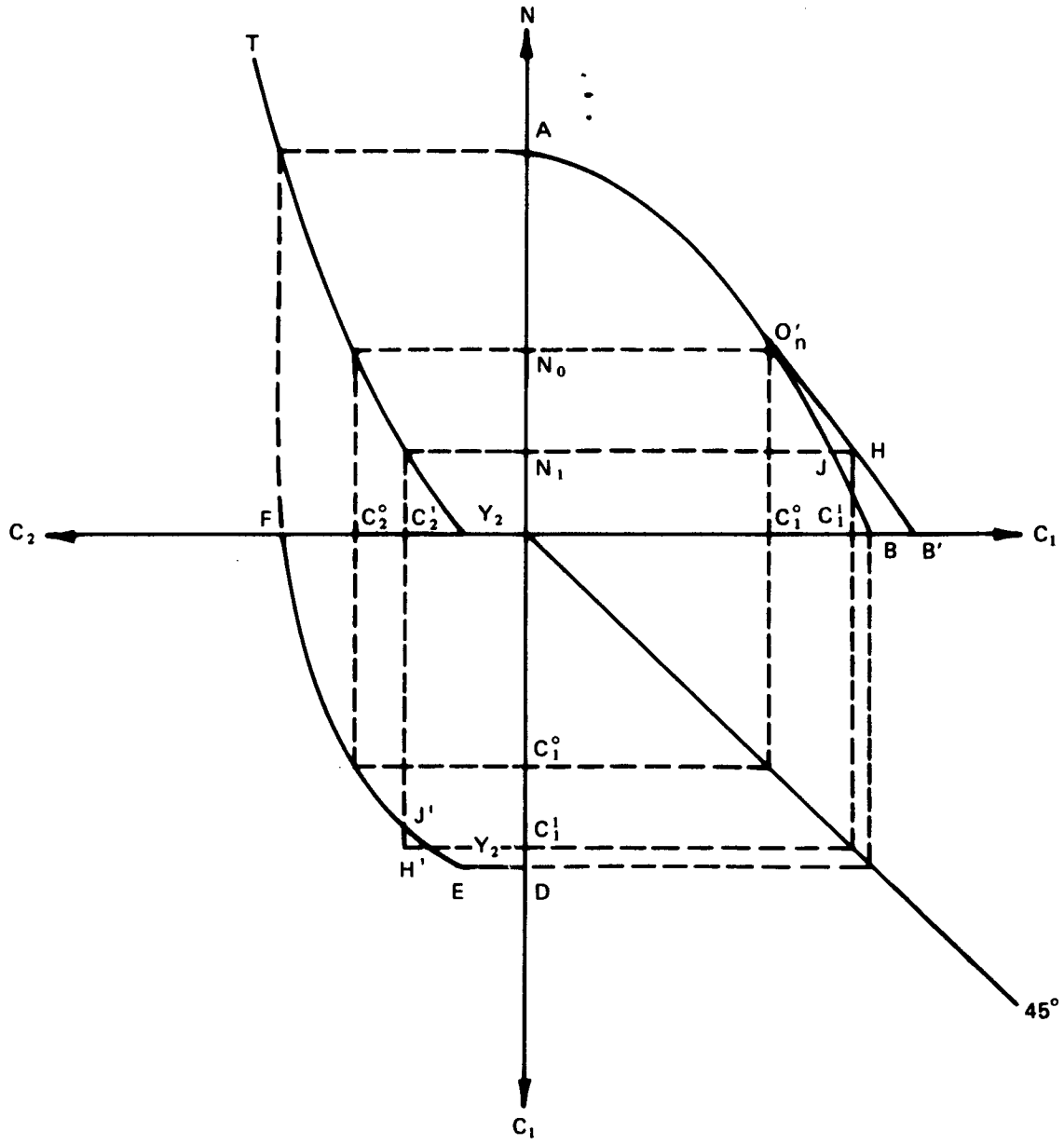


Figure 6

welfare. It does not predict an increase in savings as a result of an induced decrease in fertility, given the underdeveloped capital market. This particular conclusion may bring the economic validity of the family planning program into question.

A policy that would make it mandatory to have fewer children than the optimum number,  $N_0$  (figure 1), will reduce the parents' welfare under any regime, regardless of the structure of the capital market. A less hypothetical case is where parents are offered a price for each unborn child below  $N_0$ . In this case, the parents can "sell" any amount of children ( $N_0 - N_1$ ) for a constant premium  $P_r$  in terms of current consumption.<sup>1</sup> The revenue from this trade  $P_r (N_0 - N_1)$  should be higher than their own "trade" opportunities as indicated by point H in figure 6. The parents' net gain  $JH$  during  $T_1$  from this trade is transferred into  $J'H'$ , in quadrant III, and provides them with higher consumption opportunities in  $T_1$  but less in  $T_2$ , because children are the only means of savings; therefore, the parents have no means to increase the level of their savings.

The required compensation to maintain the parents' level of welfare depends on the subjective rate of substitution between  $C_1$  and  $C_2$ , or the parents' time preference. The lower the two are, the higher should be the level of compensation  $JH$ . Given that people are concerned with their old age incomes, the marginal rate of subjective substitutions between  $C_1$  and  $C_2$  will probably depend, among other things, on the available social welfare system for the aged. It is realistic to assume that the less developed this system, the lower the rate of subjective

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<sup>1</sup>Clearly, the parents can "exploit" the system under these simplified assumptions since  $N_0$  is unknown to the authorities.

substitution between  $C_1$  and  $C_2$ , ceteris paribus. This implies that the compensations required to induce less fertility may approach infinity, given the underdeveloped capital market and the lack of institutional arrangements for the aged. Furthermore, when such programs are undertaken, total savings in the system will drop, ceteris paribus. These arguments may offer one explanation of the nondramatic changes in fertility behavior, and the presumed consequences, due to various family planning programs in developing economies.<sup>1</sup>

#### The Effect of Transfer Payments during $T_1$ and $T_2$

Material incentives to fecund couples to be advised about birth control methods can be considered as transfer payments to parents during  $T_1$ . These may enable the parents to control the number of children they have, but may not modify the desired number of offsprings. On the contrary, the model predicts that the demand for children increases.<sup>2</sup>

A transfer payment of this nature will result in a higher income in  $T_1$ . This will necessarily increase the demand for children, ceteris paribus, as long as the parents wish to transfer part of the increase in current wealth into the future by an increase in the demand for  $C_2$ .

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<sup>1</sup>In this context, the Chinese (Mainland) experience may be of interest. The Communist system provides old age security as a matter of definition. This may be an important factor in explaining the observed decline in fertility in China as opposed to neighboring India. On population trends in China: Pi-Chao Chen, "China's Population Program at Grass Root Level," Studies in Family Planning, Vol. 4, No. 8., August 1973.

<sup>2</sup>It is hard to tell a priori what will happen to observed fertility. Although there is the incentive to increase fertility, the fact that fertility is contingent on more control may reduce the number of unwanted children, at least in the short-run. This may be one possible explanation of the controversy about the success of such programs.

The opposite result is predicted if the transfer is given in  $T_2$ , as predicted by the effects of increasing  $Y_2$  under conditions of certainty and uncertainty. In the latter case, just the assurance of a certain level of  $Y_2$  reduces the demand for children.

#### Old Age Benefits Financed by Taxes

The common institutional scheme is where the benefits paid out during period  $T_2$  are financed by taxing the potential beneficiaries' incomes (the parents) during  $T_1$ . This has effects on fertility that are different from the effects produced by old age benefits ( $Y_2$ ).

The tax produces opposing price and income effects. The price effects follow because the tax discriminates between market and non-market activities, the production of income and of children, respectively. The tax reduces the marginal productivity of the mother's time in producing income by a factor equivalent to the tax rate. This will cause a shift of part of her productive time into production of children and lower their shadow price. Thus, the tax carries a pro-fertility price effect. This effect is intensified when the tax system provides allowances for children. These allowances are actually an additional "premium" to any factors used in the child production. The income effects of the tax on fertility are negative, as is the effect of the pension programs per se.

### VIII. INTRODUCTION TO THE STATISTICAL ANALYSIS

The theoretical discussion produced these testable hypotheses:

1. An increase in income (pure income effect) during the reproductive part of the parents' life cycle increases the demand for children.
2. An increase in anticipated (expected) income during retirement reduces the demand for children.
3. The development of institutions that secure income for old age reduce desired fertility. The effect is expected to be enforced when these institutions are financed by taxing income during the reproductive part of the parents' life cycle.
4. The extended family, one with more female relatives in particular, may involve a negative income but a positive price effect on the demand for children.
5. Lower child (age specific) mortality rates are likely to reduce fertility. The critical parameter is the demand elasticity for child services (survivors). If it is greater than |1| fertility will increase.
6. Reducing the relative costs of education and health services may reduce desired fertility.

The empirical testing of these hypotheses calls for certain data requirements. First, households that are believed to make their fertility decisions in a traditional agricultural environment, characterized by limited intertemporal investment opportunities, must be identified. Second, fertility must be measured properly. The model itself is specified in a static framework, using the unobservable concept of "desired fertility." For empirical purposes, completed fertility may be the best proxy for desired fertility. However, since fertility is a life cycle phenomenon, the marginal birth can be related to the

same set of explanatory variables that is believed to determine completed fertility; in particular, when data do not provide for the best proxy. Another data requirement is a complete socio-economic picture and history of the households; however, the forthcoming empirical discussion is based on data that deviate from this last requirement. Hence, the discussion is subject to certain biases, which will be discussed.

The findings support some of the hypotheses outlined. Income has a positive effect on fertility. Estimating the effect of this variable was problematic because of the evidence that children contribute to family income at relatively early ages. Households that receive income from sources that are relatively stable over space and time tend to have fewer children.

Elderly persons in the households do not account for variation in income. Hence, it is very likely that their children support them. The presence of elderly female relatives in the household has a positive effect on fertility. Mother's education seems to have the same effect, in an environment where females' education is negatively correlated to their labor force participation.

The household's stock of financial assets, in particular, is negatively related to the "stock" of younger children who are at home. The relationship reverses as children grow up. While this may be consistent with the hypothesis that the two "assets" are substitutes, it may also reflect regular savings behavior in this setting.

It is evident that children's education is a positive function of parents' income and education. The results suggest that the parents discriminate against the education of daughters. Furthermore, there seems to be less incentive to replace daughters, in regimes of high child mortality, than to replace sons. The evidence that the parents

Table 1  
General Socio-Economic  
Indicators for the Two Villages

Indicator	VILLAGE			
	Ankodia		Naurangdeshar	
<u>Population:</u>	1,718		1,807	
Females 15-44	404		341	
Children 0-14	682		873	
<u>Households:</u>	298		291	
Extended:	131		125	
<u>Income:</u>				
Per Household (in Rupees)	4,836		4,695	
% from Agriculture	75.38		83.40	
<u>Education:</u>				
	<u>Males</u>	<u>Females</u>	<u>Males</u>	<u>Females</u>
% Literate	77.70	66.49	36.50	4.70
Mean years of schooling of literate	4.8	3.9	4.8	3.9
% Children 6-14 in school	71		27	
<u>Assets*</u>				
Value of land per household (Rupees)	21,412		38,432	
Value of financial assets per household (Rupees)	2,143		2,302	
% of Gold and jewelry of financial assets	50.2		52.3	

\*Based on the data that do not include the entire population of households; but the ones included in statistical analysis (discussion forthcoming).

replace children who died indicates that the demand for child services is inelastic.

### The Data

The empirical discussion is based on cross-sectional household surveys of two Indian villages: Naurangdeshar (N.D.), in the district of Rajasthan, and Ankodia, in the Gujarat district. The entire populations of the two villages were surveyed, the former during 1968-69 and the latter during 1967-68.<sup>1</sup>

Some major comparative characteristics of the villages are reported in table 1. The two communities are agricultural. The share of agriculture in total income is somewhat smaller in Ankodia, which is more developed, primarily because of the development of small scale industry. The most significant difference between the two is in the educational status of the populations. The composition of asset holdings point out the limited investment opportunities for modern financial assets. The following is a first-hand description of these conditions:

. . .For instance, forms of investments like small savings which include post office savings bank deposits, prize bonds, etc., and other Government securities were not popular. The idea of life insurance had percolated to only an insignificant number of villagers, mostly among those in government service . . .Thus, on account of lack of alternative investment channels coupled with the considerations of

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<sup>1</sup>For extensive statistical summary reports on the villages, see: R.M. Patel, Ankodia: Change in Economic Life in a Tobacco Village (Agro-Economic Research Center, Sadar Pate University, Vallabh Vidyanagar, 1970); and D.M. Brahmhatt, Naurangdeshar: Impact of Irrigation on a Rajasthan Canal Village (Agro-Economic Research Center, 1974).

Table 2

Distribution of Multigenerational Extended Households  
by the Age of the Eldest Parent or Relative  
in the Household and Generational Relationship  
to the Head of the Household

Generational Relationship of Head of the Household	VILLAGE					
	ANKODIA			NAURANGDESHAR		
	Age of Elder Parent or Relative		Total	Age of Elder Parent or Relative		Total
50 and above (1)	Below 50 (2)	50 and above (1)		Below 50 (2)		
Head of Household - Living with a Parent or Relative ----- (1)	37	21	58	39	3	42
Head of Household - a Parent living with Married Children ----- (2)	50	17	67	46	12	58
Total	87	38	125	85	15	100

social prestige and traditional values,  
people generally invested their money  
in gold and silver ornaments and jewelry. <sup>1</sup>

The joint or extended household is a dominant socio-economic institution in both villages. The distribution of multi-generational joint households, i.e., married couples or widowed persons of at least two generations living together, is reported in table 2. The households are classified by the assumed relationship of support and the age of the older generation in the household. The illustrated relationships in the table support the assertion that the older generation is supported by the younger one. The first row in the table seems to indicate children supporting their parents or relatives. The second row shows parents living with married children; the father maintains the status of "head" as long as he lives, though he is likely to be supported by his children. Only nine households in Ankodia and one in N.D. consist of persons 50 years old or more living alone.

The data for the regression analysis are of mixed quality, especially the dependent variable. The data from Ankodia include the number of children ever born (NCB), the number of children alive (NCA), and the number of children at home (NCH), across all age cohorts. The data from N.D. provide only the number of children at home. The data from Ankodia allow for the selection of females over age 49 who completed fertility; however, this procedure was not followed because of the limited degrees of freedom, and because most of these women were living with married children, in a socio-economic environment that is believed to

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<sup>1</sup>M.L. Bhat, Naurangdeshar, A Village in Rajasthan Canal Zone (Agro-Economic Research Center, Vallabh Vidyanagar, 1964), p. 226.

differ from the one underlying their fertility decisions.

A basic problem was to establish a unit of observation in an environment of extended households. The rule was to associate individual couples, preferably in child-bearing ages, to an observed socio-economic environment that is assumed to underlie their fertility decisions. In the case of N.D., the additional problem was to minimize the downward bias in the available dependent variable NCH, since some of the children born most likely migrated or died. Sixty-two households were deleted from the original N.D. data for one of the following reasons:<sup>1</sup>

- (a) No children were reported living in the household.
- (b) The gap between the reported age of the eldest child home and the duration of parent marriage exceeded 15 years.
- (c) More than one family of the same age group shared the same house and other economic endowments.
- (d) Widowers and widows.
- (e) Singles (not married).
- (f) Inconsistent and missing data.

Seventy-six households were deleted from Ankodia for reasons (c) - (f).

For each observation included in the statistical analysis, the data are the age, sex, and education of each household member, as well as the household's income by sources, asset holdings, and the household's

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<sup>1</sup>For a detailed distribution, see appendix E. The selection procedure used for N.D. when applied to Ankodia produces a simple correlation of .825 between NCA and NCH, which indicates the bias of the N.D. data.

caste schedule.<sup>1</sup>

### Specification of the Estimation Procedure

The estimation procedure is based on an Ordinary Least Squares (OLS) regression analysis of the equation:

$$Y_j = \alpha_0 + \beta_1 \text{Ln}(\text{Duration of Marriage})_j + \sum_{i=2}^M \beta_i X_{ij} + U_j \quad (j = 1, \dots, n),$$

where Y is either NCB or NCH, with the corresponding values for boys, NBB, NBH, and girls, NGB, NGH.<sup>2</sup> The functional form and the vector  $\{X_j\}$  were established by a priori theoretical considerations and the estimates themselves. Some variables significant to the analysis, for example, land holding and financial assets, are included in the reported equations even though they are statistically insignificant.<sup>3</sup>

Clearly, the use of OLS to determine one aspect of the household's behavior, while using others as regressors, may lead to inconsistent

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<sup>1</sup>For means and standard deviations of included variables, see appendix F.

<sup>2</sup>Part of the dependent variable is included as an independent variable, when NCB is used as a regressand and number of children died (NCD) as a regressor. The implication of this procedure is discussed Chapter XII.

<sup>3</sup>"Caste," a significant variable in the Indian environment, was deleted because of statistical insignificance. Some studies explain variation in fertility by "caste" schedules, but actually attribute the differentials to income and education, which are included explicitly in this discussion. Richard Anker, The Effect of Group Level Variables on Fertility in a Rural Indian Sample, (International Labor Organization Working Paper, Geneva, 1974); and J.R. Rele, "Fertility Differentials in India, Evidence from a Rural Background," The Milbank Memorial Fund Quarterly 41, no. 2. (April 1963).

estimates. The relationships among the variables are simultaneous and belong to a more complicated structural system. The quality of the data, however, did not permit the use of more elaborate statistical techniques. Insight into possible biases because of simultaneous relationships is gained by applying OLS to sub-groups with biases that are believed to be minimal.

### The Life-Cycle Effects

The variable that accounts for natural life cycle effects on fertility is the natural logarithm of the duration of (mother's) marriage.<sup>1</sup> It is viewed as a measure of years of exposure to the risk of having children. Duration of marriage is defined as the difference between the mother's age at the time of the survey and her age at the time of marriage minus years of marriage before age 12 and after 49.<sup>2</sup>

Naturally, "duration of marriage" produces a positive effect on fertility and it is also statistically the most significant variable, as reported in table 3 and subsequent tables. This variable, however, may incorporate additional effects. Mother's age, which is included in

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<sup>1</sup>This functional form assumes that the timing of children is concentrated at earlier stages of marriage (young age cohorts), which may not be true in this setting. It was tested against the linear form and provided a better fit.

<sup>2</sup>In the case of Ankodia, "years of sterility" were also subtracted.

Table 3  
Regression Coefficients with No. of Children Home (NCH); No. of Boys Home (NBH)  
and No. of Girls Home (NGH) as Dependent Variables for H.D.  
and with No. of Children Born (NCB); No. of Boys Born (NBB)  
and No. of Girls Born (NCB) as Dependent Variables for Ankodia

Equation	Village	Dependent Variable	Constant	LN (Duration of Marriage)	Mother's Education		Father's Education		Occupation Service (=1)	Income From			Number of Child. Died	Other Family			Value of Land	Value Financial Assets	R <sup>2</sup>	F (degrees of freedom)
					Literate (=1)	No. of Yrs. of School	Literate (=1)	No. of Yrs. of School		Agriculture	Unskilled Occupation	Skilled Occupation		In the House (=1)	Mar Age	(Age) <sup>2</sup>				
1	H.D.	NCH	0.84896	1.03067 (6.357) <sup>*</sup>	-0.15876 (-0.330)	-----	-0.55634 (-2.134)	-----	-1.02932 (-2.085)	0.00016 (3.848)	-0.00005 (-0.399)	0.00014 (1.564)	-----	-2.48071 (-2.167)	-----	0.00056 (1.980)	-0.00283 (-0.884)	-0.00001 (-0.467)	.36	10.97 (11,213)
2	H.D.	NBH	0.62966	0.56235 (6.184)	-0.25902 (-0.649)	-----	-0.42963 (-1.987)	-----	-0.77846 (-1.902)	0.00013 (3.876)	-0.00003 (-0.354)	0.00014 (1.837)	-----	-1.19900 (-1.263)	-----	0.00018 (0.787)	-0.00425 (-1.593)	-0.00001 (-0.543)	.24	6.38 (11,213)
3	H.D.	NGH	0.21930	0.46831 (3.776)	0.10027 (0.272)	-----	-0.12671 (-0.636)	-----	-0.25086 (-0.664)	0.00003 (0.829)	-0.00001 (-0.138)	0.00000 (0.055)	-----	-1.28171 (-1.464)	-----	0.00037 (1.733)	0.00140 (0.570)	0.0000 (0.000)	.15	3.39 (11,213)
4	Ankodia	NCB	-1.18983	1.49499 (7.434)	0.47987 (1.742)	-----	-----	-----	-----	0.00012 (2.196)	0.00039 (2.100)	0.00006 (1.162)	0.80401 (9.941)	-1.15106 (-0.930)	0.02125 (1.019)	-----	-0.00183 (-0.366)	0.0000 (0.197)	.60	30.3 (10,213)
5	Ankodia	NBB	-0.11507	0.59661 (4.547)	0.13665 (0.749)	-----	-----	-----	-----	0.00008 (2.185)	0.00014 (1.143)	0.00005 (1.600)	0.97505 <sup>+</sup> (12.018)	-1.39237 (-1.696)	0.02708 (1.956)	-----	-0.00192 (-0.377)	-0.00001 (-1.147)	.56	25.60 (10,213)
6	Ankodia	NCB	0.97611	0.78594 (5.556)	0.29624 (1.482)	-----	-----	-----	-----	0.00004 (1.021)	0.00025 (1.890)	0.00002 (0.447)	0.90168 <sup>++</sup> (10.446)	0.28608 (0.319)	-0.00530 (-0.351)	-----	0.00115 (0.318)	0.00001 (0.866)	.52	22.08 (10,213)
7	Ankodia	NCB	1.43155	1.49073 (7.454)	0.30869 (1.065)	-----	-----	0.09749 (1.809)	-----	0.00010 (1.831)	0.00047 (2.466)	0.00003 (0.558)	0.81615 (10.113)	-1.00645 (-0.816)	0.01861 (0.895)	-----	-0.00150 (-0.300)	0.00000 (0.214)	.61	28.08 (11,213)
8	Ankodia	NCB	-1.07445	1.60505 (8.295)	-----	0.10869 (1.787)	-0.33491 (-1.185)	-----	-----	-----	0.00010 (2.249)	-----	0.80719 (10.152)	-----	-----	-----	-0.00173 (-0.247)	-0.00002 (-0.230)	.61	44.68 (7,207)

Note: "Value of Land" is given in units of 1,000 Indian Rupees. The notation "1" below a variable in this and the following tables indicates the use of dummy variables, and stands for the occurrence of the event.

\* t statistic in parentheses, in this and the following tables.

+ Number of boys died.

++ Number of girls died.

the definition of the variable, carries possible cohort effects.<sup>1</sup> The estimated coefficient may be biased also because the mother's age at marriage is an endogenous variable. This bias is apparently not serious in this particular environment. The mean age at marriage of the mother is 14.8 in N.D. and 13.2 in Ankodia, with corresponding standard deviations of 4.2 and 6.9. Hence, age at marriage is likely to be determined by the married couples' parents. The coefficient is negatively biased when NCH is used as an independent variable, as in the case of N.D., because child mortality and migration are positively correlated with mother's age. This is verified by the estimated coefficient when the number of girls at home, NGH, is used as a dependent variable. The coefficient's level and its statistical significance are lower, consistent with the fact that daughters marry off and sons stay with their parents.<sup>2</sup>

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<sup>1</sup>A possible cohort effect could be established according to ages of all children born, by computing the number of children a woman of age  $A_i$  ( $> A_j$ ) had at age  $A_j$ , and comparing this number to the fertility level of a woman of age  $A_j$  at the time of survey. However, these data are not available. A regression of NCH born during first five years of marriage on mother's age produced a negative and statistically significant coefficient, which clearly accounts for the bias in the dependent variable NCH. But it is impossible to account for cohort effects, which are concealed in this result.

<sup>2</sup>Other possible sources of biases that relate to the variable:  
 (a) Under-reporting, especially of children who died, is positively correlated to the mother's age, due to forgetfulness. (b) A natural selection bias: women with lower fertility rates may live longer.  
 (c) Family planning practices: younger age cohorts, who are more efficient practitioners of family planning may have more children at younger age (less spacing) because of a change in the risk of having unwanted children.

## IX. THE EFFECT OF INCOME

The model predicts a positive pure income effect on fertility. The parents are assumed to transfer part of a gain in current income into future consumption opportunities via more living children (*ceteris paribus*). On the other hand, it predicts that parents who anticipate other sources of income at old age will behave in the opposite way. The empirical discussion supports these hypotheses, although their statistical confirmation was problematic because of the data and the particular setting.

### The Estimated Income Effect<sup>1</sup>

The estimated coefficients of income by sources are positive, as reported in table 3 and subsequent tables. The various sources of income are not mutually exclusive; typically in an unspecialized agricultural community almost every household reports income from more than one source. For each of the major income sources--from agriculture, and from skilled occupations for N.D. and unskilled occupations for Ankodia--the income effect is positive and statistically significant. Income from unskilled occupations is statistically insignificant in N.D. where this source of income is primarily associated with agricultural labor. Part of this group's income is most likely in kind, which apparently

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<sup>1</sup>For definition of the income variable and sources of income see appendix G.

is subject to substantial reporting errors.<sup>1</sup> The relatively lower statistical significance of the coefficient of "income from skilled occupation" for Ankodia is attributed to colinearity between father's schooling and "occupation services," which will be discussed.

Unfortunately, the definition of income includes the contribution of children. In N.D., children have earnings at ages as low as 11-15, and in Ankodia at ages 16 and above. Thus, the validity of the positive income effect may be questionable since the causality may in fact be reversed. This argument is supported by the lower levels and statistical significance of the income coefficients when either the number of girls born (NGB) or, particularly, the number of girls home (NCH), is used as a dependent variable.<sup>2</sup>

Nevertheless, the positive income effect can be established in two ways: running regressions on households with children younger in age than the specified productive ages, and observing the effect of father's years of schooling. The estimated coefficients, which are reported in table 4, are based on households where the eldest child (home) is less than 11 for N.D., and households where the eldest child

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<sup>1</sup>In a separate regression using only 65 households who reported income from unskilled occupation, the positive income effect (total or by sources) is established with considerably higher statistical significance. This may indicate that the statistically insignificant result noted is associated with this source of income and not its recipients.

<sup>2</sup>In the case of NGH, there is an apparent serious bias in the dependent variable, as mentioned in Chapter IX.

Table 4  
 Regression Coefficient with NCB (for Ankodia)  
 and NCH (for N.D.) as Dependent Variables,  
 Including Only Families with Young Children

Equation	Village	Dependent Variable	Constant	LN (Duration of Marriage)	Income	Mother's Yrs. of School	Mother Literate (=1)	Father Literate (=1)	Occupation Services (=1)	Financial Assets	Number of Children died	R <sup>2</sup>	F (degrees of Freedom)
1	Ankodia	NCB (ECA* less than 16)	-0.60932	1.25433 (5.867)	0.00009 (1.389)	0.10718 (1.371)	-----	-0.51831 (-0.576)	-----	0.00011 (1.005)	0.89503 (8.846)	-.62	34.0 (6,12)
2	Ankodia	NCB (PM** less than 17)	-1.4556	1.60836 (6.159)	0.00016 (1.402)	-----	0.32928 (0.854)	-0.23561 (-0.589)	-----	0.00003 (0.277)	0.66194 (3.510)	.62	14.1 (6,52)
3	N.D.	NCH (ECA less than 11)	-0.63742	1.24280 (5.755)	0.00008 (1.894)	-----	-0.3419 (-0.908)	-0.11950 (-0.496)	-0.52018 (-1.557)	-0.00003 (-0.661)	-----	.39	9.3 (6,87)

\* Eldest child's age

\*\* Parents married

is less than 16, and where couples have been married less than 17 years in Ankodia.<sup>1</sup> The underlying assumption for these estimates is that only children at home contribute to household income. The cases of children away from home supporting their parents cannot be established with the available data. The positive income effect is retained in all the equations, although the absolute values of the coefficients and their levels of statistical significance are lower.

"Father's years of schooling" is a common proxy for permanent income. The education coefficient in equation 7 of table 3 is positive and statistically significant at .93 level.<sup>2</sup> It reduces, as anticipated, the effects of income from skilled occupations and, to a degree, income from agriculture.

Some insight can be gained from relating the father's literacy and sources of income--especially in an environment where schooling is a rather distinct phenomenon, as in the village of N.D. The dichotomous variable "literacy," which carries the grouping effects, has a statistically significant negative effect on the NCH in N.D. (table 3), but is omitted from the Ankodia equations because of statistical insignificance unless all sources of income are aggregated, as in

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<sup>1</sup>An attempt to estimate an equation for couples married less than 12 years for N.D. produced insignificant results in statistical terms. In fact, the only significant coefficient was that of income, which was positive.

<sup>2</sup>The result can be established only with the Ankodia data where most of the fathers (72.4 percent) are literate and the variable "years of schooling" is rather continuous unlike the case of N.D.

equation 8.<sup>1</sup> This effect in the case of N.D. may indicate that children (sons) of the literates vis-a-vis others' children have a higher propensity to leave home, and operates in addition to the apparent lower fertility of literates as a group. The two phenomena indicate that literates rely less on children as a means for old age security. Furthermore, the educated people in the villages, some being government paid service workers, apparently have relatively stable incomes and available pension programs. Hence, according to the model, they have a relatively lower incentive to have children. This argument is also supported by the negative coefficient of the "occupation services" (table 3)--a variable representing people working in services including uneducated persons (i.e., the school janitor).<sup>2</sup> The mere existence of human capital generally indicates a prolonged earnings capacity over one's life cycle, compared with physical labor, and may stand for a relatively higher rate of return on non-human capital.

Those with incomes from skilled occupations are more likely than others to have a consumption motive in their fertility behavior. They are less inclined to have children as substitutes for hired labor, and as sources of future income. This may be the reason for the low marginal effect of income from this source for N.D., and its insignificant effect,

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<sup>1</sup>The opposite effects of literacy versus years of schooling are consistent, considering the apparent non-linear effect schooling. In the regression only on households with literate fathers, schooling tends to have a U-shaped effect, but with relatively few observations at the lower levels of schooling. Hence the positive effect is dominant as schooling increases. Literacy has a smaller correlation with income (.35 vs. .55 in this case--Ankodia), and has the effect of the grouping. Father's schooling has no statistically significant effect in N.D.

<sup>2</sup>The simple correlation between the two variables in N.D. is .23 and in Ankodia .05.

in statistical terms, for Ankodia.<sup>1</sup>

The income coefficient may be biased upward when NCH is used as a dependent variable because of the negative effect income may have on mortality rates and possibly on migration of children. Two equations tested the two possibilities. The first was an attempt to account for the variation in child mortality rates (NCD/NCB) by income and parents' education. The results were statistically insignificant, even when only income was used in the equation.<sup>2</sup> The second equation used as a dependent variable the ratio of children home to those alive (NCH/NCA) as an index of migration. In this case too, the income coefficient was statistically insignificant.<sup>3</sup>

#### Evidence of the Income Effect in Less Developed Economies

The effect of income on fertility is controversial. Income may produce a negative effect on fertility unless the estimated models are specified to isolate a pure income effect. Many factors are positively correlated with income, but have an adverse effect on fertility, especially across countries and over time. Aggregate data from developing economies indicate that the partial correlation between fertility and income is positive and stronger in the underdeveloped areas.<sup>4</sup> Other evidence

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<sup>1</sup>On the other hand, children also contribute less to family income at younger ages.

<sup>2</sup>The simple correlation between income and NCD is .064.

<sup>3</sup>"Mother's age," as anticipated, accounts for almost all of the explained variation, with a negative coefficient. This is another indication of the bias in the dependent variable NCH.

<sup>4</sup>David M. Heer, Society and Population (New York: Prentice-Hall, Inc., 1968) pp. 59-60. I.I. Ekanem, "A Further Note on the Relation Between Economic Development and Fertility" Demography, Vol. 9, No. 3 (August 1972).

based on country-specific data from various developing economies supports, at least implicitly, a positive income effect. But the results depend on specification of the models. E. Driver concluded, based on Indian data and controlling for the age of marriage, that there is no effect of income on fertility.<sup>1</sup> On the other hand, Rele analyzed caste schedules, which account for variation in socio-economic status in general, and reported lower fertility rates among lower income groups.<sup>2</sup> Abu-Loghud observed in Egypt higher rates of childlessness among women married to unemployed men. A possible explanation of this observation may be the positive income effect on fertility.<sup>3</sup> Y. Ben Porath and T.P. Schultz reported from Israel and Egypt, respectively, that fertility rates among Arab populations were inversely related to the percentages of population employed in agriculture.<sup>4</sup> Ben Porath offered a pure positive income effect as a possible explanation.

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<sup>1</sup>Driver, Differential Fertility in Central India, (Princeton, N.J.: Princeton University Press, 1963), p. 96.

<sup>2</sup>Rele, "Fertility Differentials in India."

<sup>3</sup>Janet Abu-Loghud, "The Emergence of Differential Fertility in Urban Egypt." Milbank Memorial Fund Quarterly 43, no. 2. (April 1965): 235-253. Alternative explanations: (a) They are supported by their working wives. Women's labor force participation may have deterrent effect on fertility. (b) They have sources of income other than from their own labor. If these are permanent, the desire for children as old age security is diminished.

<sup>4</sup>Ben Porath, "Fertility in Israel, An Economists' Interpretation: Differentials and Trends 1950-70" in Charles A. Cooper and Sidney S. Alexander (ed.), Economic Development and Population Growth in the Middle East (New York: American Elsevier, 1972), pp. 502-538. T. Paul Schultz, "Fertility Patterns and their Determinants in the Arab Middle East," in Economic Development and Population Growth, pp. 400-442.

## X. THE HOUSEHOLD'S LABOR SUPPLY AND THE PRICE OF CHILDREN

The discussion of the household's labor supply bears on three interrelated issues: the shadow price of children, the ages at which children start to contribute to the household's income, and the contribution of elderly people to income.

The data do not provide information on the household members' allocation of time among various economic activities. Further, it is impossible to infer unambiguously about family labor supply from a household's level of income or from the number of members in each age and sex category, because of problems in determining a clear cause and effect relationship. In general, higher incomes may result from more labor supply of any given number of potential workers. On the other hand, higher income may induce a reduction of labor supply, primarily of secondary workers: children, who attend more schooling, and females. Because of the limited information, the forthcoming discussion is based on the number of potential workers in the household.

Inference about the mother's allocation of time, and thereby about the shadow price of children, is made from three variables: the presence of additional adult relatives in the household, land holdings, and mother's education. The last variable is discussed separately because of the variety of possible effects it is believed to have on fertility.

Table 5  
Regression Coefficients with Income  
As a Dependent Variable

Equation	Village	Constant	Value of Land	Father's Age	(Father's Age) <sup>2</sup>	Father's Education		No. of Sons by Age Group			No. of Daughters By Age Group		Male Relative in the Household		Other Assets	Holding a Tractor (-1)	R <sup>2</sup>	F (degrees of freedom)
						Literate (-1)	(Years of School)	11-15	16-25	26 And Above	11-15	Age	(Age) <sup>2</sup>					
1	Ankodia	937.288	80.830 (15.975)	-----	0.192 (0.785)	-----	37.876 (4.614)	-----	781.653 (2.770)	3661.577 (3.979)	-----	-----	0.253 (1.396)	-----	-----	0.73	90.3 (6,201)	
2	N.D.	2990.493	40.336 (9.864)	- 32.892 (- 1.793)	-----	796.064 (1.998)	-----	1209.415 (4.297)	767.906 (2.498)	-----	483.748 (1.628)	77.105 (1.481)	-1.148 (-1.508)	0.0180 (0.140)	3163.276 (2.894)	0.57	29.0' (10,218)	
3	N.D.	4091.171	43.000 (10.059)	- 93.185 (- 1.300)	1.123 (1.418)	849.019 (1.999)	-----	-----	-----	-----	-----	58.332 (1.072)	-0.869 (-1.092)	0.029 (0.669)	3460.886 (3.030)	.51	29.6 (8,220)	
4	Ankodia	3248.042	-----	-201.289 (- 1.484)	3.169 (1.997)	-----	685.096 (6.438)	-----	1713.823 (3.962)	3839.161 (2.905)	-----	-----	0.404 (1.674)	-----	-----	0.38	21.5 (6,208)	
5	N.D.	3126.728	-----	- 30.343 (- 1.379)	-----	993.685 (2.082)	-----	1503.500 (4.418)	728.772 (1.976)	-----	805.939 (2.275)	55.395 (0.887)	-0.689 (-0.756)	0.199 (4.625)	6214.063 (4.939)	0.38	14.9 (2,219)	
6	N.D.	3455.405	-----	- 27.872 (- 1.136)	-----	1803.84 (3.498)	-----	1587.240 (4.226)	1412.546 (3.524)	-----	1175.684 (2.999)	3.797 (0.055)	0.139 (0.137)	-----	-----	0.21	8.5 (7,221)	

Note.— Value of Land is given in units of 1,000 Rupees. "Other Assets" include the value of livestock and farm implements, other than a tractor.

### An Account of Variation in Household Income

The discussion is based on estimates of six equations, utilizing income as the dependent variable (table 5).<sup>1</sup> The estimates suggest that children--in particular sons--contribute to household income. The results for Ankodia (equations 1 and 4) suggest that sons aged 16 and over contribute to income and that the contribution is positively related to age. Equations 2, 5, and 6 based on N.D. data suggest that children aged 11 to 15, including girls 11 to 15, contribute to family income. The coefficients in the equations for N.D. suggest that the children's marginal contribution falls with age. This is very unlikely; so is the relative size of the daughters' contribution to income. These particular results can be attributed to the bias due to the positive income effect on fertility, assuming that current income is positively correlated with past income. However, the U-shaped income profile by father's age (equation 3) can support the more realistic assertion that children's contribution to income increases with age, even in N.D. The coefficients of father's age in equations 2, 5, and 6 suggest that income falls with age. This may be a cohort effect, but may also be the effect of the decline in physical strength, a major determinant of income in an agricultural setting, that is not offset by on-the-job training. Equation 3 implies an upturn in the father's income profile after age

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<sup>1</sup>The first three equations include value of land as a regressor. The variable is omitted from the other three to test the stability of the other coefficients, given the high correlations between the value of land and income.

41 that can be attributed to children's contribution to income.<sup>1</sup>

The contribution of other adult relatives to the household's income was explored by selecting households with one adult male relative and one adult female relative. Introducing the male relative's age and age squared into the equation produced the best results. The coefficients for N.D. (equations 2 and 3) suggest that male relatives contribute to income only up to age 33. This relationship is not maintained when "value of land" is omitted (equations 5 and 6). The coefficients for Ankodia (equation 1 and 4) suggest that the marginal contribution increases with the age of male relatives. This result may suggest a reversed cause-and-effect relationship: families with higher incomes bring in more relatives. Both interpretations, based on the findings, suggest that additional relatives in the household, especially at old age, are supported by the nuclear unit. According to the model, old male relatives should have a negative income effect on fertility but a positive price effect. However, unlike the introduction of female relatives in the fertility equations (table 3), the introduction of males did not have any statistical effect on fertility.

#### The Shadow Price of Mother's Time

Additional adult females in the household, when introduced in the fertility equations (table 3), produce a positive effect on fertility in

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<sup>1</sup>Introducing "father's age" cubed in equation 3 achieved some degree of statistical significance, which may suggest a rather irregular pattern. The U-shaped income profile is apparent also in Ankodia when land is omitted from the equation (4), even though children are included in the equation. This can be attributed to the pattern of asset accumulation (Chapter XII) and illustrates the general problems in these estimates--the high correlations between assets and income and between the number of children and father's age.

both villages. Thirty-five households in N.D. and thirty-three in Ankodia reported adult female relatives above age 50.<sup>1</sup> The estimated coefficients indicate a positive effect of these females on fertility after age 65 in N.D., the marginal effect increasing with age, and a positive effect after age 54 in Ankodia. Given that the corresponding age means were 60 and 55 in the two villages respectively, a positive effect on fertility is expected in both villages. Data on female labor force participation rates from the Gujarat state, Kaira district (the one of Ankodia), indicate a peak in participation between ages 40-44 (32.5 percent of the female population in this category) and a relatively sharp decline thereafter.<sup>2</sup> If the behavior in Ankodia and N.D. is consistent with this evidence, the regression results are consistent with the hypothesis that the elderly females reallocate time from market activities into household activities. More females in the household other than the mother and daughter imply a decrease in income per capita--if real income is held constant. This, according to the model, has negative income and price effects on fertility. These effects, however, can be offset if the additional females substitute the mother in child rearing. The findings suggest that this, in fact, may be the case.

The negative--though insignificant--coefficient of land holdings in the fertility equation (table 3) may indicate that on larger farms the marginal productivity of females' time is higher, and so is the shadow

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<sup>1</sup>These pertain to the data that are used for the regression. Three cases reported females below age 50. These were deleted because of the "inflating" effect they had on the intercept term.

<sup>2</sup>Pravin Visaria, "Labor Force Participation by Age, Sex, and Marital Status, in India by states and Districts," (unpublished working tables).

price of children, *ceteris paribus*. This is based on the assumption that the agricultural labor market is not competitive in villages of the size of Ankodia and N.D.

### The Effect of Mother's Education

Mothers' education is presumed to have a negative impact on fertility because of the following behavioral effects:

- (a) The price effect associated with an increase in the relative productivity of females' time in activities other than child rearing.
- (b) Better knowledge and practice of contraception.
- (c) Late marriage.<sup>1</sup>

The underlying assumption for the first effect is that females' education is an investment commodity, or alternatively, that their market wages correspond to the level of their education, and that child production is intensive in mother's time. The statistical results indicate that mother's literacy has no effect on the NCH in N.D. (tables 3 and 4) and has a positive effect on the NCB in Ankodia, especially when income from all sources is aggregated (table 3, equation 8). This can be a price effect attributed to females' labor supply behavior.

A forthcoming chapter proves that higher income groups provide more education for their children--including their daughters, who usually marry husbands of corresponding income groups. Evidence from India shows that labor force participation rates of women below levels of matriculation

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<sup>1</sup>In addition, there may be biases in reporting and changes in taste.

decrease with education.<sup>1</sup> Hence, there is a dominant income effect on females' labor supply, especially if their market wages in fact increase with their education. The model suggests that the shadow price of children changes in the same direction as female wages. However, if the reduction in the labor supply moves into child production, it may reduce the shadow price of children as the evidence seems to suggest. Alternatively, it may imply that the children are "goods intensive."

The scattered statistical evidence from developing economies about this variable is generally consistent with these findings. T.P. Schultz's analysis of fertility behavior in rural Egypt found no differentials in fertility among various educational classes.<sup>2</sup> There was even an apparent positive correlation between fertility and females' education. This finding was supported by Rele using Indian data.<sup>3</sup> Even in a multivariate analysis with data from Taiwan, T.P. Schultz reported what seemed to be a paradox-- the lack of negative price effects of females' education on fertility.<sup>4</sup> In his analysis with Egyptian data the negative effect appeared in aggregate data that also included cities, where women apparently have more opportunities. This result is supported by Abu-Loghud in an analysis of data from Cairo, Egypt.<sup>5</sup> The negative effect was related to the husband's

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<sup>1</sup>Visaria, "Labor Force Participation by Age, Sex and Educational Level in India," Journal of the University of Bombay, Vol. XL, 76 (October 1971) pp. 178-204.

<sup>2</sup>T.P. Schultz, "Fertility Patterns," pp. 425-431.

<sup>3</sup>Rele, "Fertility Differentials in India," p. 194.

<sup>4</sup>T.P. Schultz, "Explanation of Birth Rate Changes over Space and Time: A Study of Taiwan," JPE 81, Part 2 (March-April 1973) pp. 238-274.

<sup>5</sup>Abu-Loghud, "Emergence of Differential Fertility."

socio-economic class, which is apparently a better proxy for the wife's market opportunities.

The other hypotheses related to female education tend to be supported by the data, but do not modify the previous conclusions. The relationship between family planning and mother's education can be established for Ankodia only. The simple correlation between sterilization and literacy of the mother is .275. This supports the hypothesis that more educated females are more efficient users of contraception. This implies that the education coefficients, which have been discussed, are downward biased; namely that the positive education effect on fertility via opportunity costs of children is higher than suggested before. However, this assertion is subject to the definition of "duration of marriage," which does not account for "sterile" years.

A downward bias may generally be associated with the "duration of marriage" variable, considering the populations under investigation. Abu-Loghud points out that it is likely that less fecund women marry later and these women may be the ones who achieve higher educations.<sup>1</sup> Thus, a simultaneous relationship is involved. A serious bias may be built into any statistical evidence on the negative effect of education in underdeveloped economies. Lower educated groups in developing areas may exclude childless women and ones with lower child-bearing ability from the population of married women. Hence, it is likely that any sample of married women based on less educated populations tends to be biased toward more fertility.

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<sup>1</sup> Abu-Loghud, "Emergence of Differential Fertility."

## XI. SAVINGS AND ASSETS ACCUMULATION

Asset holdings--a product of accumulated savings--have a direct bearing on the major hypothesis, that children are an alternative form of savings. This relationship, however, is complex and must be considered in a life cycle context, in which the parents are likely to modify their asset holdings according to fertility outcomes, and according to their reassessment of the likelihood of their children supporting them.

The data report the holdings of land, livestock, farm implements, and so-called financial assets, which account for 5.3 percent of total assets held in N.D. and 8.8 percent of the total held in Ankodia.<sup>1</sup>

One approach to test the hypothesis incorporates the two distinct forms of holdings, land and financial assets, in the fertility equations.<sup>2</sup> Financial assets are, according to the model, an alternative to children as means of old age security. However, a negative estimated relationship is consistent with regular savings behavior: larger families save less, controlling for income. An alternative approach focuses on the pattern of asset holdings over the parents' life cycle.

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<sup>1</sup>The financial assets consist of: cash, gold and jewelry, insurance, small bank deposits, small savings, loans and shares in local cooperatives. The rate of return on assets in general, and financial assets in particular, could not be identified in statistical terms. Attempts to compute an implicit rate of return from a ratio like income to value of assets or from stated lending rates did not yield meaningful results. Financial assets did not account for any variation in income, as was anticipated from their composition.

<sup>2</sup>Debt was not subtracted because of the very partial information regarding its structure. The data suggest that the borrowers themselves were unclear about their indebtedness, particularly about the rates of interest and form of repayment.

Table 6  
 Regression Coefficients with Value of Financial Assets  
 and Total Value of Assets as Dependent Variables

Equation	Village	Dependent Variable	Constant	Income	Father's Age	(Father's Age) <sup>2</sup>	Number of Children Home by Age Group				R <sup>2</sup>	F (degree of freedom)
							0-10	11-15	16-25	26+		
1	Ankodia	Financial Assets	4460.230	1.243 (12.646)	-405.997 (-1.842)	6.164 (2.405)	- 101.797 (-0.084)	-996.847 (-1.626)	-1279.407 (-2.118)	-6653.849 (-3.298)	.50	29.7 (7,208)
2	N.D.	Financial Assets	3585.247	0.292 (4.004)	- 42.023 (-1.594)	-----	- 579.705 (-2.905)	192.610 (0.572)	335.199 (0.881)	2596.210 (1.518)	.13	6.0 (6,222)
3	Ankodia	Total Assets	-16048.357	8.320 (19.795)	251.093 ( 0.995)	-----	-2522.814 (-1.404)	1412.589 (0.535)	-967.003 (-0.356)	-23618.632 (-2.650)	.73	85.7 (6,187)
4	N.D.	Total Assets	-16469.501	10.427 (13.275)	341.0005 (1.202)	-----	- 357.322 (-0.167)	-758.677 (-0.210)	-3126.629 (-0.764)	-18260.581 (-0.992)	.49	35.47 (6,222)

### Holding of Financial Assets

The estimated coefficients of "financial assets" in the fertility equations (table 3) are negative but statistically insignificant. From equation 5, it is apparent that the statistical significance increases when the number of boys born is used as a dependent variable. The same seems to hold in N.D., especially for the more traditional asset-land holdings. These findings are consistent with regular savings behavior, and with the hypothesis that parents with more children, particularly sons, staying home tend to dispose of their assets.

The estimates in table 6 attempt to account for lifetime variation in asset holdings. The coefficients in the first equation suggest that the more older children in the house, the lower the accumulated stock of financial assets, *ceteris paribus*. However, it is conceivable that consumption levels increase as children--sons--grow up and get married and bring their wives into the household.<sup>1</sup> The second equation, based on data from N.D., provides poor estimates with limited statistical significance; it suggests the opposite pattern. It indicates that small children tend to cause a reduction in savings. However, given the interrelationships among the variables, it is possible that older children in this particular equation (2) account for part of the income effect on assets. It may also account for an apparent cohort or life-cycle phenomenon. The coefficients

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<sup>1</sup> These equations are misspecified in the sense that current income accounts for a stock of assets, which is a function of past income flows. This problem is apparently not serious on the assumption that most of the variations in income are explained by such rather "permanent" factors as land and education. More problematic may be the correlation between income and children, especially older ones. The equations in table 6 have been estimated without income. The estimated coefficients are similar, as expected, to the ones estimated for the income generating function (table 5), for the corresponding variables.

of father's age in the first equation in table 6 indicate a U-shaped pattern of holdings over the life cycle (or across cohorts). The second equation, based on the data from N.D., indicates a decrease in holdings as a function of father's age. But the positive effect of older children in this equation may account for the reversal. By the same token, it is conceivable that the father's age variable in the first equation may cause an upturn in holdings because of a possible positive effect on savings by older children. This particular explanation implies a reduction in accumulation of financial assets as children grow up, and an upturn after a certain stage. The upturn may imply a process of accumulation for and by children around their ages of marriage. This assertion is also based on the common Indian custom of the parents transferring assets to young married couples.<sup>1</sup>

Equations 3 and 4 estimate the above functional relationship using as a dependent variable the total value of land, financial assets, and livestock. The introduction of the latter two in this variable makes income account for more variation of the dependent variable. But this actually stands for the effect of land and livestock on current income. The effects of the other independent variables, however, are diminishing. The relationship of substitution between value of assets and children is maintained with limited or no statistical significance. The coefficients of father's age reverse their signs but are statistically insignificant.

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<sup>1</sup>The underlying economic reasons for this transfer may be of interest. One hypothesis is that this is a way the parents form the children's commitment. This may be a more efficient way to gain economic support than selling these assets in the market. This explanation implies a net inflow of assets like gold and jewelry into the traditional sector.

These particular results may be a result of the reality of very few land transactions among families.<sup>1</sup>

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<sup>1</sup>This appears when land is used as a dependent variable. The simple correlation between the age of the head of the household and the value of land owned is 0.095 for N.D., and .204 for Ankodia, which is the more developed village.

## XII. INVESTMENT IN CHILDREN'S HUMAN CAPITAL AND THE DEMAND FOR CHILD SERVICES

The theoretical discussion assumed that the education and health of a child are vehicles for the parents to increase the expected return from him. It also assumed that the investment in his education is determined by the technology the parents employ to produce it, and the risk of loss that is associated with mortality rates, which can be modified by investment in health. It is impossible to define an "educational production function" with the data. Instead, the discussion concentrates on explaining the variations in children's education relative to their environment. An inference about the investment in children's health is made from information about child mortality; this also provides estimates of the demand elasticities for surviving children.

The data provide the educational status of children in terms of years of schooling. Schooling in both villages is irregular, as implied by table 1. The reported grades for the children attending school do not necessarily correspond to the children's particular ages. This presents a problem of estimating the relative investment of parents who have an eight-year-old child in the first grade versus the investment of parents who have a six-year-old child in that same grade.<sup>1</sup> Therefore, investment in formal education has been defined in terms of the family's deviation

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<sup>1</sup>Informal means of acquiring education, primarily reading and writing in addition to "on-the-job training", are likely to be significant in this environment.

from the "expected" years of schooling the children are supposed to have given their age and sex distributions, based on a regression estimate.

Only the data from Ankodia provide information regarding child mortality, though without the ages and the sequence of the children's deaths. As already indicated, an attempt to explain the variation in the ratio of surviving children to children born (TCA/TCB) did not produce statistically significant results. Hence, child health is apparently an exogenous variable to the household.<sup>1</sup>

#### Definition of Investment in Schooling

The expected investment in schooling is based on the following equation that utilizes, as observations, the group of children aged 5 to 15:

$$\begin{aligned} (\text{yrs. of sch})_{ij} = & \alpha_0 + \beta_1(\text{AGE})_{ij} + \beta_2(\text{Sex})_{ij} \\ & + \beta_3(\text{Sex} \times \text{Age})_{ij} + U_{ij} \end{aligned}$$

$$E(U_{ij}) = 0, (i = \text{child}, j = \text{household}),$$

where sex=1 for a boy. This equation tests the difference in the level and marginal propensity to send girls (G) to school as opposed to boys (B).<sup>2</sup>

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<sup>1</sup>This argument is apparently common. See: S.P. Jain, "Some Aspects of Mortality" in Population in India's Development 1947-2000, Ashis Bose et.al. (ed.), (Vikas Publishing House, New Delhi, 1974), pp. 319-333.

<sup>2</sup>This procedure is equivalent to a "chow test." See: Damodar Gujarati, "The Use of Dummy Variables in Testing Equality Between Sets of Coefficients in Two Linear Regressions: A Note," The American Statistics, February 1970, pp. 50-52.

Using the estimated coefficients (table 7), the expected years of schooling (SCH) of each child in each village can be written

$$SCH_{k(i)} = \hat{\alpha}_k + \hat{\beta}_k (AGE)_{k(i)} + E_i$$

(k = boy, girl),

and the household's total investment is

$$\sum_{i=1}^{NC} SCH_i = \sum_{L=1}^{NB} \hat{\alpha}_B + \sum_{M=1}^{NG} \hat{\alpha}_G + \hat{\beta}_B \sum_{L=1}^{NB} AGE_L + \hat{\beta}_G \sum_{M=1}^{NG} AGE_M$$

The investment per child is

$$MEC = \frac{\sum SCH_i}{NC}$$

The difference between the actual average years of schooling for children 5-15 and MEC is defined as investment in education.<sup>1</sup>

The estimates in table 7 indicate that schooling in N.D. is very irregular, particularly for girls. Even for boys the marginal propensity to go to school, on the average, is only .295. The difference of this figure from unity is due to cases of no schooling at all and of drop-outs. Schooling in Ankedia is more regular, with marginal propensities to go to school for girls and boys .506 and .712, respectively. These findings

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<sup>1</sup>This is the average of the residuals for a particular household.

Table 7  
 Regression Coefficients with Years of Schooling  
 of Children 5-15 as a Dependent Variable

Village	Dependent Variable	Constant	Age	Sex (Boy=1)	Interaction (Age x Sex)	R <sup>2</sup>	F (degrees of Freedom)
Ankodia	Years of schooling	-2.4711	0.5062 (10.245)	-1.3038 (-1.711)	0.2060 (2.836)	.442	101.70 (3,386)
N.D.	Years of schooling	-0.1973	0.0449 (1.369)	-0.9934 (-2.319)	0.2008 (4.616)	.186	40.41 (3,529)

are consistent with the differential between the villages in children's contribution to income as previously discussed.

The discrimination between boys and girls in schooling is interesting. It can be related to the lower rate of return on investment in daughters as a source of future income. First, their market opportunities are relatively limited, and second, they leave their parents upon marriage.

The coefficients in table 8 explain some of the variation in investment in schooling, as defined above. The results are consistent for the two villages, although more variation is explained in the case of Ankodia. Income, parents' education, and being service workers have positive effects on investment per child. The positive income effect on education per child, in addition to the previously stated positive income effect on fertility, indicates that parents increase the demand for children and children's education as a means to increase the expected return from children. It is hard to establish whether parents decide a priori how much to invest per child and make contingent fertility decisions, or whether they decide ex post on education, based on their fertility experience. However, an effective compulsory schooling system can make primary schooling exogenous (pre-determined) to the parents' decisions. This is likely to be the case for service workers and educated people. As a result, they may lower the demand for children, as indicated previously, to comply with the legal requirement of schooling. It is apparent that in developing areas parents consider the cost of compulsory schooling to be an economic burden.<sup>1</sup>

The estimated coefficient on child mortality rates (number of children born/number of children died) is negative. Hence, these rates have an adverse effect on investment in children's education, ceteris paribus.

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<sup>1</sup>Heisel, "Fertility Limitation," and Caldwell, "Fertility Attitudes."

Table 8  
Regression Coefficients with "Investment in Schooling"  
as a Dependent Variable

Dependent Variable	Constant	Income	Father Literate (=1)	Mother Literate (=1)	$\left(\frac{\text{No. Children Died}}{\text{No. Ever Born}}\right)$	Occupation Services (=1)	R <sup>2</sup>	F (degrees of freedom)
Deviation from expected value	-0.91220	0.00008 (4.363)	0.53785 (2.340)	0.94605 (4.602)	-0.75146 (-1.745)	0.44902 (1.691)	.313	17.2 (5,188)
Deviation from expected value	-0.30588	0.00002 (1.276)	0.27727 (2.048)	0.76464 (2.923)		0.41928 (1.637)	.116	7.0 (4.224)

This effect is consistent with the model's prediction that an increase in children's health status--probability to survive--will induce parents to invest more in the children's education.

### The Demand Elasticity for Child Services

The data on child mortality permit the computation of the demand elasticity for child services, with some qualifications. The model predicts that an exogenous increase in child mortality increases the relative price of services from children and produces a negative price and wealth effect on these services. The two cause a reduction in the demand for these services, i.e., for survivors.

The fertility equation that utilizes the Ankodia data is

$$\begin{aligned} \text{NCB}_j &= \alpha_0 + \beta_1 \text{LN (Duration of Marriage)}_j \\ &+ \beta_2(\text{NCD})_j + \sum_{i=3}^M \beta_i X_{ij} + U_j. \end{aligned}$$

Since  $\text{NCB}_j \equiv \text{NCA}_j + \text{NCD}_j,$

$$\begin{aligned} \text{NCA}_j &= \alpha_0 + \beta_1 \text{LN (Duration of Marriage)}_j \\ &+ (\beta_2 - 1)(\text{NCD})_j + \sum_{i=3}^M \beta_i X_{ij} + U_j.^1 \end{aligned}$$

$(\beta_2 - 1)$  stands for the effect of child mortality on the number of surviving children that, according to the model, is monotonically transformed into anticipated or expected services from children. Hence, if  $(\beta_2 - 1)$  is significantly different from zero ( $\beta_2$  differs from unity), its sign as well as its absolute value will indicate the demand elasticity for surviving children. Based on the estimated coefficients in table 3, equation 1,

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<sup>1</sup>Running the regression directly in this form reduces the  $R^2$  and the F values, but does not affect the levels and statistical significance of other coefficients.

$B_1$  is less than unity and differs at a .99 level of significance from this value, if  $B_1$  is normally distributed. This result suggests that the demand for survivors is negatively related to child mortality and the demand is relatively inelastic.<sup>1</sup> The same holds for the demand for child services.

The model and the empirical findings suggest that the parents will invest less in children's education in an environment of higher risk resulting from higher child mortality rates. However, a posteriori, parents may have more resources per survivor as a result of child mortality. Therefore, the model may predict a higher (negative) elasticity for child services by less investment in children than the elasticity measured a posteriori.

Of some interest may be the differential effect of the "number of girls died" on the number of girls born (equation 3, table 3) vis-a-vis the effect in the case of boys (equation 2). The two coefficients (.97505 and .90168) do not differ in statistical terms.<sup>2</sup> However, the one for boys differs from unity at a .61 level of significance while the one for girls differs from 1 at a .87 level. These coefficients indicate that the demand for services (survivors) from boys is less elastic than that from girls, i.e., daughters are less likely to be replaced than sons. This conclusion is subject to the statistical qualifications mentioned above. Yet it points toward a discrimination that is consistent with the relative importance of a son's economic role versus a daughter's in supporting their parents.

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<sup>1</sup>The elasticity around the mean is -0.0875. For similar findings, see: Donald W. Snyder, "Economic Determinants of Family Size in West Africa," *Demography* 11 (November 1974): 613-627.

<sup>2</sup>It is likely that the coefficient for "number of girls died" is biased upward relative to the one for boys, since the former variable is likely to be relatively underreported by the parents.

### XIII. CONCLUSIONS

This thesis explored one aspect of the economics of fertility behavior in developing economies; namely, children are a means of old age security for their parents.

The data source for the empirical analysis supports the basic hypothesis that in traditionally agricultural communities the capital market does not facilitate low cost temporal transfers of consumption. As an alternative, the extended household is one common institution in which intergenerational support manifests itself.

The empirical analysis, although subject to biases because of data limitations and specifications of the estimation procedure, is consistent with some of the basic assumptions postulated and the derived hypotheses.

The income elasticity of children and their education, derived from the demand for their services, is positive. The relationship is, however, complicated to establish from cross-section data in an environment where children make a positive contribution to household income at relatively young ages.

The evidence supports the hypothesis that parents whose old age income is likely to be more secure tend to have fewer children, or at least fewer adult children, living with them. The data suggest a negative relationship between accumulation of financial assets (savings) and children, who are regarded as a form of savings. It is impossible, however, to establish unambiguously that parents trade off assets as more children are born, or stay home because children are a form of savings.

This requires more of a qualitative response by parents at the time of each birth, based on the motive of disposing of their assets.

The demand elasticity for surviving children appears to be inelastic, and implies that parents replace children who have died. This may be an indication of a low demand elasticity for children's future services.

On the production side, it appears that older females in the extended household have a positive effect on fertility. The effect of mother's education, in an environment where labor force participation rates of females are inversely related to their level of education below the matriculation stage, is similar. These findings suggest that children are intensive in mother's time. The apparent negative effect of land holding on fertility may also imply a higher shadow price for children due to higher marginal productivity of mother's time.

Some of these conclusions are supported by similar findings of others, but such evidence is scattered. The introduction to the second part indicates that longitudinal household data pertaining to populations at different levels of economic development are needed to estimate stable coefficients, which will shed light on the parameters which were discussed. However, both in the theoretical as well as in the empirical analysis, the problem of simultaneous relationships among variables remains to be solved.

The basic empirical issue that remains to be studied in detail is the relationship between savings and fertility, and the relative rate of return on children. The complementary theoretical issue that requires further investigation is the determination of children's economic commitment to their old parents.

Appendix A  
The Demand Function

The demand function for children is derived by maximizing the utility function,

$$U(C_1, C_2), \quad (1)$$

subject to the full wealth constraint,

$$C_1 + C_2 \pi_2^* - I_2 = 0. \quad (2)$$

The first order conditions for a maximum are obtained by maximizing the Lagrangian

$$L = U(C_1, C_2) + \lambda(C_1 + \pi_2^* C_2 - I_2), \quad (3)$$

where  $\lambda < 0$  is the Lagrange multiplier; and these are:

$$\frac{\partial L}{\partial C_1} = U_1 + \lambda = 0, \quad (4)$$

$$\frac{\partial L}{\partial C_2} = U_2 + \lambda \pi_2^* = 0, \quad (5)$$

$$\frac{\partial L}{\partial \lambda} = C_1 + \pi_2^* C_2 - I_2 = 0, \quad (6)$$

where  $U_j = \frac{\partial U}{\partial C_j} \quad (j=1, 2).$

The marginal rate of substitution in consumption at the optimum is

$$\frac{U_1}{U_2} = \Pi_2^*, \quad (7)$$

which can be substituted by

$$\frac{U_1}{U_2} = (1 + r^*), \quad (8)$$

where  $r^* > 0$  is a market rate of return on assets.

By substituting in the first order conditions

$$\Pi_2^* = T_N^{-1} \Pi_N^*, \quad (9)$$

and

$$C_2 = T(N, P, W) + Y_2, \quad (10)$$

and by totally differentiating these conditions we obtain the following system of simultaneous equations in a matrix form:

$$\begin{bmatrix} U_{11} & U_{12}T_N & 1 \\ U_{12} & (U_{22}T_N - \lambda \Pi_N^T T_{NN} T_N^{-2}) & \Pi_N^T T_N^{-1} \\ 1 & \Pi_N(1 - T_N^{-2} T_{NN} C_2) & 0 \end{bmatrix} \begin{bmatrix} dC_1 \\ dN \\ d\lambda \end{bmatrix} =$$

$$\begin{bmatrix} 0 & -U_{12}T_{\beta} & -U_{12} & 0 \\ -\lambda T_N^{-1} & -(U_{22}T_{\beta} - \lambda \Pi_N T_{N\beta} T^{-2}) & -U_{22} & 0 \\ -T_N^{-1}C_2 & \Pi_2(T_{N\beta}T_N^{-1}C_2 - T_{\beta}) & -\Pi_2 & 1 \end{bmatrix} \begin{bmatrix} d\pi_N^* \\ d\beta \\ dY_2 \\ dI_2 \end{bmatrix} \quad (11)$$

where  $\beta = P, W$ .

The exogenous variables are on the right hand side of the above set of equations.

Two of the second order conditions for a maximum are a positive determinant of the bordered Hessian matrix,  $D$ , on the left, and a positive third column - third row cofactor,  $D_{33}$ , i.e.,

$$D_{33} = U_{11}(U_{22}T_N - \lambda \Pi_N T_{NN} T_N^{-2}) - U_{12}^2 T_N > 0,$$

which by reorganizing is

$$D_{33} = (U_{11}U_{22} - U_{12}^2) T_N - U_{11} \lambda \Pi_N T_{NN} T_N^{-2} > 0. \quad (12)$$

$D > 0$  and  $D_{33} > 0$  when

$$(U_{11}U_{22} - U_{12}^2) > 0 \quad (13)$$

$(U_{11}, U_{22} < 0)$  and

$$T_{NN} < 0. \quad (14)$$

(13) indicates that  $C_1$  and  $C_2$  are normal goods and (14) indicates that the intertemporal transformation function  $T$  is concave to the origin. When either (13) or (14) holds, the other becomes only a sufficient condition. The two conditions (13) and (14) are assumed to hold. Hence  $D_{33} > 0$ , which implies  $D > 0$ .

The second column cofactors of the left hand matrix are:

$$D_{12} = (-1)^3 (-\pi_N^* T_N^{-1}) > 0, \quad (15)$$

$$D_{22} = (-1)^4 (-1) < 0, \quad (16)$$

and

$$D_{32} = (-1)^5 (U_{11} \pi_N^* T_N^{-1} - U_{12}) > 0. \quad (17)$$

These are employed to derive the changes in the demand for children ( $N$ ).

The effect of a change in any of the exogenous variables on the demand for children is given by:

$$\frac{dN}{d\pi_N^*} = U_1 T_N^{-1} \frac{D_{22}}{D} - T_N^{-1} C_2 \frac{D_{32}}{D} < 0 \quad (18)$$

$$\frac{dN}{dT_2} = \frac{D_{32}}{D} > 0 \quad (19)$$

$$\frac{dN}{dY_2} = -U_{12} \frac{D_{12}}{D} - U_{22} \frac{D_{22}}{D} - \pi_2 \frac{D_{32}}{D} < 0 \quad (20)$$

$$\frac{dN}{d\beta} = -U_{12} T_{\beta} \frac{D_{12}}{D} - (U_{22} T_{\beta} + U_1 \pi_N T_{N\beta} T_N^{-2}) \frac{D_{22}}{D} \\ + \pi_2 (T_{N\beta} T_N^{-1} C_2 - T_{\beta}) \frac{D_{32}}{D} \begin{matrix} \geq \\ < \end{matrix} 0 \quad (21)$$

(18) is the Slutsky equation, where  $\frac{D_{22}}{D}$  ( $<0$ ) displays the substitution effect and  $\frac{D_{32}}{D}$  ( $>0$ ) the income effect, which is given by (19)--holding  $Y_2$  constant.

**Appendix B**  
**The Supply Function**

The supply function for children is derived by minimizing the total cost (income),

$$C_1 + \pi_N N = I_1, \quad (1)$$

subject to the two production relationships

$$N = G(\ell, S) \quad (2)$$

and

$$C_1 = F(L, \ell, K) - S, \quad (3)$$

which contain the endowments constraints.

The first order conditions for a minimum are obtained by minimizing the Lagrangian

$$M = C_1 + \pi_N N + \lambda_1 [G(\ell, S) - N] + \lambda_2 [F(L, \ell, K) - S - C_1] \quad (4)$$

where  $\lambda_1$  and  $\lambda_2$  are the Lagrange multipliers. These conditions are:

$$\frac{dM}{dC_1} = 1 - \lambda_2 = 0 \quad (5)$$

$$\frac{dM}{dN} = \pi_N - \lambda_1 = 0 \quad (6)$$

$$\frac{dM}{ds} = \lambda_1 G_s - \lambda_2 = 0 \quad (7)$$

$$\frac{dM}{d\ell} = \lambda_1 G_\ell + \lambda_2 F_\ell = 0 \quad (8)$$

$$\frac{dM}{d\lambda_2} = F(L, \ell, K) - S - C_1 = 0 \quad (9)$$

$$\frac{dM}{d\lambda_1} = G(\ell, s) - N = 0 \quad (10)$$

conditions (5) and (6) state the shadow prices in the system. The shadow price of children is:

$$\pi_N = - \frac{F_\ell}{G_s} = \frac{1}{G_s}, \quad (11)$$

obtained by substituting (5) and (6) into (7) and (8).

$$\text{Since } F[L, \ell, K] = X(L-\ell, K) - R(L, K), \quad (12)$$

$$F_\ell = -X_\ell, \quad (13)$$

which stands for the loss in production of income from increasing the allocation of female time into child production.

By substituting (5), (6) and (13) into (7)-(10), the system of first order conditions is reduced to:

$$\pi_N G_\ell - X_\ell = 0, \quad (14)$$

$$\pi_N G_s - 1 = 0, \quad (15)$$

$$G(\ell, s) - G = 0, \quad (16)$$

$$F(L, \ell, k) - S - C_1 = 0. \quad (17)$$

When the mother (females) is (are) participating in the labor force, the equation

$$\pi_N G_\ell - W_w^* = 0 \quad (18)$$

must be added.

By totally differentiating (14)-(17) we obtain the following system of simultaneous equations in a matrix form:

$$\begin{bmatrix} 0 & \pi_N G_{\ell\ell} + X_{\ell\ell} & \pi_N G_{s\ell} & G_1 \\ 0 & \pi_N G_{s\ell} & \pi_N G_{ss} & G_s \\ -1 & G_\ell & G_s & 0 \\ 0 & -X_\ell & -1 & 0 \end{bmatrix} \begin{bmatrix} dN \\ d\ell \\ ds \\ d\pi_N \end{bmatrix} = \begin{bmatrix} 0 & X_{\ell\ell} & X_{\ell k} \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ -1 & -F_L & -F_k \end{bmatrix} \begin{bmatrix} dC_1 \\ dL \\ dK \end{bmatrix} \quad (19)$$

The exogenous variables are on the right hand side of the above equations.

The determinant of the bordered Hessian matrix is obtained by expanding by the first column, i.e.,

$$\begin{aligned}
 D &= - \begin{vmatrix} \Pi_N G_{\ell\ell} + X_{\ell\ell} & \Pi_N G_{S\ell} & G_e \\ \Pi_N G_{S\ell} & \Pi_N G_{SS} & G_S \\ -X_\ell & -1 & 0 \end{vmatrix} \\
 &= X_\ell \begin{vmatrix} \Pi_N G_{S\ell} & G_\ell \\ \Pi_N G_{SS} & G_S \end{vmatrix} - \begin{vmatrix} (\Pi_N G_{\ell\ell} + X_{\ell\ell}) & G_e \\ \Pi_N G_{S\ell} & G_S \end{vmatrix} \\
 &= X_\ell A - B,
 \end{aligned} \tag{20}$$

where A and B stand for the corresponding determinants (above).

$A > 0$  if  $G_{SS} < 0$ , and  $B < 0$  if  $X_{\ell\ell} < 0$  in addition to  $G_{\ell\ell} < 0$ . These conditions

hold if the two production functions are linear and homogeneous.

By substituting (14) and (15) into (20), the latter is rewritten

$$\begin{aligned}
 D &= \Pi_N G_\ell A - \Pi_N G_S B \\
 &= \Pi_N (G_\ell A - G_S B) > 0.
 \end{aligned} \tag{21}$$

The inverse of the shadow price of children (the slope of the production possibility curve between  $C_1$  and  $N$ ) is given by:

$$\begin{aligned} \frac{dN}{dC_1} &= \frac{D_{41}}{D} \\ &= - \frac{(G_{\ell}A - G_S B)}{\pi_N (G_{\ell}A - G_S B)} = - \frac{1}{\pi_N} < 0, \end{aligned} \quad (22)$$

where  $D_{ij}$  is the cofactor of the  $A_{ij}$  element in the bordered Hessian matrix in (19).

The change in shadow price (the curvature of the production possibility curve) is given by:

$$\begin{aligned} \frac{d^2 N}{dC_1^2} &= \frac{1}{\pi_N^2} \frac{d\pi_N}{dC_1} \\ &= - \frac{1}{\pi_N^2} \frac{D_{44}}{D} \\ &= \frac{1}{\pi_N^2} \frac{1}{D} \left[ (\pi_N G_{\ell\ell} + X_{\ell\ell}) \pi_N G_{SS} - \pi_N^2 G_{S\ell}^2 \right] \\ &= \frac{1}{\pi_N^2} \frac{1}{D} \left[ \pi_N^2 (G_{\ell\ell} G_{SS} - G_{S\ell}^2) + \pi_N X_{\ell\ell} G_{SS} \right] > 0, \end{aligned} \quad (23)$$

since  $G_{\ell\ell} G_{SS} - G_{S\ell}^2 = 0$ ,  $X_{\ell\ell} < 0$ , and  $G_{SS} < 0$  under the assumption that the two production functions are linear and homogeneous.

The change in the shadow price due to a change in  $J$  ( $J = K, L$ ) is given

by

$$\frac{d\pi_N}{dJ} = -F_J \frac{D_{44}}{D} + X_{\ell J} \frac{D_{14}}{D}. \quad (24)$$

Given that  $D_{44} < 0$  as indicated in (23), and  $D_{14} > 0$  as can be shown, each of the two terms on the right has the following effect on the price of children:

- A. when factor J increases the parent's net income ( $F_J > 0$ ), the relative intensity of S in G will increase ( $C_1 = C_1^0$ ), causing an increase in  $\pi_N$ , ceteris paribus. The opposite happens when ( $F_J < 0$ ).
- B. when  $\ell$  and J are gross substitutes ( $X_{\ell J} < 0$ ), an increase in J will cause a reduction in  $\pi_N$  because of the opposite effect on G to the one outlined in A, ceteris paribus. The opposite happens when  $\ell$  and J are complementary factors ( $X_{\ell J} > 0$ ).

Appendix C  
The Total Changes in Demand for Children

I. The total change in the demand for children, resulting from a change in any of the exogenous variables, is a combination of wealth and price effects and is summarized by:

$$\frac{dN}{dj} = \frac{dN}{dI_2} \frac{dI_2}{dj} + \frac{dN}{d\pi_N} \frac{d\pi_N}{dj},$$

$$(j = L, K, W, P, Y_2, W_L^*, W_K^*). \quad (1)$$

The first and second terms on the right hand stand for the two effects, respectively. In terms of elasticities, indicating the sensitivity of the changes, the price and wealth effects are:

$$E_{Nj} = E_{NI_2} \eta_{I_2j} + E_{N\pi_N} E_{\pi_Nj}, \quad (2)$$

where  $E_{ij}$  is the elasticity of variable  $i$  with respect to variable  $j$ , and  $\eta_{I_2j}$  is the share of the variable in full wealth.

II. The income elasticity for children ( $E_{NI_2}$ ) is derived from the income elasticity of consumption in  $T_2$ . A change in full wealth ( $I_2$ ) has the following total effect on the demand for children:

$$\frac{dN}{dI_2} = \frac{dC_2}{dI_2} \frac{dN}{dC_2} \quad (3)$$

$$= \frac{dC_2}{dI_2} \frac{1}{\frac{dN}{dC_2}}.$$

The terms of the right stand for the increase in the demand for  $C_2$  and the derived increase in  $N$ . In terms of elasticities the above is

$$E_{NI_2} = \frac{E_{C_2I_2}}{E_{C_2N}}, \quad (4)$$

where  $E_{C_2I_2}$  is the income (wealth) elasticity of  $C_2$  and  $E_{C_2N}$  is the elasticity of the transformation curve  $T$ .

III. The determination of  $E_{\Pi_N j}$  ( $j = K, L, W_k^*, W_L^*$ ) is based on the expression

$$\Pi_N = \frac{1}{G_S}. \quad (5)$$

Differentiating (5) with respect to  $j$ ,

$$\frac{d\Pi_N}{dj} = \frac{d}{dj} \left( \frac{1}{G_S} \right),$$

yields

$$= -\frac{1}{G_S^2} \left[ G_{SS} \frac{ds}{dj} + G_{S\ell} \frac{d\ell}{dj} \right]. \quad (6)$$

By substituting

$$\left. \begin{array}{l} ds = F_j dj \\ C_1 = C_1^o \end{array} \right\} \quad (7)$$

(6) becomes

$$\frac{d\pi_N}{dj} = - \frac{1}{G_s} \left[ \frac{G_{ss}}{G_s} F_j + \left( \frac{G_{s\ell}}{G_s} \frac{G}{G_\ell} \right) \frac{G_\ell}{G} \frac{d\ell}{dj} \right], \quad (8)$$

which is in terms of elasticities

$$\begin{aligned} E_{\pi_N j} &= \frac{d\pi_N}{dj} \frac{j}{\pi_N} = - \left[ \frac{G_{ss}}{G_s} \frac{F_j j}{F} + \frac{1}{\sigma_{s\ell}} \frac{G_\ell \ell}{G} \frac{d\ell}{\ell} \frac{j}{dj} \right], \\ &= - \left[ \frac{G_{ss}}{G_s} \eta_{Fj} F + \frac{1}{\sigma_{s\ell}} \eta_{G\ell} \frac{d\ell}{\ell} \frac{j}{dj} \right] \end{aligned} \quad (9)$$

where  $\sigma_{s\ell} = \frac{G_s G_\ell}{G_{s\ell} G}$  is the elasticity of substitution between S and  $\ell$  in G, and  $\eta_{Fj}$  is the share of j in  $F_s$  and  $\eta_{G\ell}$  is the share of  $\ell$  in G.

The total effect of a change in j is a combination in the price and income effects as given by (2) combining (4) and (9).

IV. The determination of  $E_{NY_2}$  is based on the expression

$$\frac{dC_1}{dY_2} = \frac{dC_1}{dI_2} \frac{dI_2}{dY_2}. \quad (10)$$

From relationships

$$I_2 = C_1 + \pi_2 C_2 \quad (11)$$

and

$$C_2 = Y_2 + T(W, N, P), \quad (12)$$

follows

$$dI_2 = \pi_2 dY_2; \quad (13)$$

when

$$d\pi_2 = 0.$$

The substitution of (10) in (13) yields

$$\frac{dC_1}{dY_2} = \frac{dC_1}{dI_2} \pi_2. \quad (14)$$

The substitution of

$$\left. \frac{dC_1}{dN} \right|_{I_1 = \text{const.}} = -\pi_N$$

in (10) yields

$$\frac{dN}{dY_2} = - \frac{dC_1}{dI_2} \frac{\pi_2}{\pi_N}.$$

By multiplying (15) by  $\left(\frac{Y_2}{N}\right)$  and  $\frac{I_2 C_1}{C_1 I_2}$  we get the elasticity of N with

respect to  $Y_2$ :

$$\begin{aligned}
\frac{dN}{dY_2} \frac{Y_2}{N} &= - \frac{dC_1}{dI_2} \left( \frac{I_2}{C_1} \frac{C_1}{I_2} \right) \frac{\pi_2}{\pi_N} \left( \frac{Y_2}{N} \right) \\
&= - E_{C_1 I_2} \frac{C_1}{\pi_N N} \frac{\pi_2 Y_2}{I_2} \\
&= - E_{C_1 I_2} \left( \frac{I_1}{\pi_N N} - 1 \right) \frac{\pi_2 Y_2}{I_2}
\end{aligned} \tag{16}$$

The last expression is obtained by substituting

$$\frac{C_1}{\pi_N N} = \frac{I_1}{\pi_N N} - 1,$$

which follows from

$$I_1 = C_1 + \pi_N N$$

in (16). Hence, the relative change in the demand for children is

$$\frac{dN}{N} = E_{C_1 I_2} \left( 1 - \frac{I_1}{\pi_N N} \right) \frac{\pi_2 Y_2}{I_2} \frac{dY_2}{Y_2}. \tag{17}$$

V. The determination  $E_{NJ}$  ( $j = P, W$ ) is based on the expression

$$\frac{dC_1}{dJ} = \frac{dC_1}{dI_2} \frac{dI_2}{dJ}. \tag{18}$$

By substituting

$$\left. \frac{dC_1}{dN} \right|_{I_1 = \text{const.}} = -\pi_N \quad (19)$$

into (18) we obtain

$$\frac{dN}{dj} = - \frac{dC_1}{dI_2} \frac{dI_2}{dj} \frac{1}{\pi_N} \quad (20)$$

From the definition of  $I_2 (= \pi_2 C_2 + C_1)$  follows:

$$\begin{aligned} \frac{dI_2}{dj} &= \pi_2 \frac{dC_2}{dj} + C_2 \frac{d\pi_2}{dj} \\ &= \pi_2 \frac{dC_2}{d\pi_2} \frac{d\pi_2}{dj} + C_2 \frac{d\pi_2}{dj} \\ &= (\pi_2 \frac{dC_2}{d\pi_2} + C_2) \frac{d\pi_2}{dj} \\ &= (E_{C_2\pi_2} + 1) C_2 \frac{d\pi_2}{dj} \\ &= (1 - |E_{C_2\pi_2}|) C_2 \frac{d\pi_2}{dj} \quad (21) \end{aligned}$$

Since the elasticity of  $C_2$  with respect to the price  $\pi_2$  ( $E_{C_2\pi_2}$ ) is presumed negative.

Substituting (21) into (20) yields

$$\frac{dN}{dj} = - \frac{dC_1}{dI_2} (1 - |E_{C_2\pi_2}|) \frac{C_2}{\pi_N} \frac{d\pi_2}{dj} \quad (22)$$

which by multiplying  $\frac{j}{N}$  and  $\frac{\pi_N}{\pi_N}$  becomes

$$\frac{dN}{dJ} \frac{j}{N} = - \frac{dC_1}{dI_2} (1 - |E_{C_2 \pi_2}|) \frac{C_2}{\pi_N} \frac{d\pi_2}{dJ} \frac{j}{\pi_N} \frac{\pi_N}{N}. \quad (23)$$

(23) can be expressed by

$$\begin{aligned} E_{Nj} &= - \frac{dC_1}{dI_2} (1 - |E_{C_2 \pi_2}|) \frac{C_2}{\pi_N} \frac{d\pi_2}{dj} \frac{j}{\pi_2} \frac{\pi_N}{T_N N} \\ &= - \frac{dC_1}{dI_2} \frac{I_2}{C_1} \frac{C_1}{I_2} (1 - |E_{C_2 \pi_2}|) E_{\pi_2 j} \frac{C_2}{T_N N}, \end{aligned} \quad (24)$$

since  $\pi_N = \pi_2 T_N$ .

By reorganizing

$$\begin{aligned} \frac{C_2}{I_2} \frac{C_1}{T_N N} &= \frac{C_2}{I_2} \frac{C_1}{T_N N} \frac{\pi_N}{\pi_N} \\ &= \frac{C_2 \pi_2}{I_2} \frac{C_1}{\pi_N N} \quad (\text{Since } \pi_2 = \frac{\pi_N}{T_N}) \\ &= \frac{C_2 \pi_2}{I_2} \left( \frac{I_1}{\pi_N N} - 1 \right), \end{aligned} \quad (25)$$

and by substituting it in (24) we get:

$$\begin{aligned}
 \frac{dN}{N} &= -E_{C_1 I_2} (1 - |E_{C_2 \Pi_2}|) E_{\Pi_2 j} \frac{C_2 \Pi_2}{I_2} \left( \frac{I_1}{\Pi_N N} - 1 \right) \frac{dj}{j} \\
 &= E_{C_1 I_2} \left( 1 - \frac{I_1}{\Pi_N N} \right) (1 - |E_{C_2 \Pi_2}|) \frac{C_2 \Pi_2}{I_2} E_{\Pi_2 j} \frac{dj}{j},
 \end{aligned}
 \tag{26}$$

which is the relative change in the demand for children because of a relative change in either P or W.

## Appendix D

Changes in the Expected Value and Variance of  $C_2$ 

The expected value of  $C_2$  and its variance are given respectively by:

$$E(C_2) = WPN + Y_2 \quad (P=P_i=P_j, i \neq j) \quad (1)$$

and

$$\text{VAR}(C_2) = W^2NP(1-P). \quad (2)$$

1. The effect on (1) and (2) of a change in  $N$  is given by:

$$\frac{dE(C_2)}{dN} = WP > 0, \quad (3)$$

$$\frac{d\text{VAR}(C_2)}{dN} = W^2P(1-P) > 0. \quad (4)$$

II. The effect on (1) and (2) of a change in  $W$  is given by:

$$\frac{dE(C_2)}{dW} = PN > 0, \quad (5)$$

$$\frac{d\text{VAR}(C_2)}{dW} = 2WNP(1-P) > 0. \quad (6)$$

III. The effect on (1) and (2) of a change in P is given by:

$$\frac{dEC_2}{dP} = WN > 0, \quad (7)$$

$$\frac{dVARC_2}{dP} = W^2N(1-2P) \begin{cases} > 0 & P < 0.5 \\ = 0 & \text{if } P = 0.5 \\ < 0 & P > 0.5 \end{cases} \quad (8)$$

## Appendix E

Distribution of Households Excluded from the  
Analysis by Reason of Exclusion and Village

Reason	Village	
	N.D.	Ankodia
(a) No children are reported living in the household	16	*
(b) Gap between age of eldest child and duration of marriage exceed 15 _ _ _ _ _	13	*
(c) More than one family of the same age group share the same household _ _ _ _ _	15	34
(d) Widows and widowers _ _ _ _ _	9	25
(e) Singles (not married) _ _ _ _ _	3	5
(f) Missing and inconsistent data _ _ _ _ _	<u>6</u>	<u>10</u>
TOTAL	62	74

## Appendix F

## Included Variables: Means and Standard Deviations

Variable Name	NAURANGDESHAR		ANKODIA	
	Mean	Std. Dev.	Mean	Std. Dev.
Number of children home	3.8341	1.9327	2.9467	1.8363
Number of sons home	2.2096	1.4179	1.6844	1.2475
Number of girls home	1.6245	1.2699	1.2622	1.1981
Number of children born	*	*	5.1822	2.6756
Number of children died	*	*	1.6000	1.6664
Number of sons born	*	*	2.7022	1.6996
Number of sons died	*	*	0.7956	1.0786
Number of daughters born	*	*	2.4711	1.7754
Number of daughters died	*	*	0.8044	1.0844
Number of sons ages 0-10	1.3624	1.0449	0.7467	0.7751
Number of sons ages 11-15	0.4454	0.6707	0.4267	0.6305
Number of sons ages 16-25	0.3755	0.6999	0.4578	0.7788
Number of sons ages 26	0.0262	0.1601	0.0533	0.2442
Number of daughters ages 0-10	1.1703	1.0930	0.7378	0.9343
Number of daughters aged 11-15	0.3799	0.6419	0.3778	0.6711
Number of daughters ages 16-25	0.0742	0.2789	0.1378	0.4049
Number of daughters ages 26	0.0000	0.0000	0.0089	0.0941
Income (in rupees)	4,797.6157	4,042.1934	4,177.6222	5,509.1337
Income from agriculture	3,527.6725	4,266.3657	2,511.1200	5,017.7562
Income from skilled occupations	534.7336	1,424.6527	824.3422	2,262.7844
Income from unskilled occupations	569.8297	1,038.5329	588.3867	773.8887
Value of land (in rupees)	38,432.1000	56,028.0000	21,412.5022	46,394.8222
Financial assets (in rupees)	2,302.9083	4,236.9698	2,143.1111	9,338.1068
Other females in households	0.1659	0.3728	0.1467	0.3546
Other males in households	0.1266	0.3333	0.1111	0.3150
Age of other females	10.0218	22.9288	8.1422	20.6386
Age of other males	7.3668	20.4955	5.5156	17.5886
Occupation services	0.0611	0.2401	0.1546	.3615
Father literate	0.3450	0.4764	0.7244	0.4478
Father's years of schooling	1.6550	3.0635	7.6356	19.9616
Mother literate	0.0611	0.2401	0.4533	0.4989
Mother's years of schooling	0.2402	1.0169	1.7689	2.4238
LN (Duration of marriage)	2.7382	0.7041	2.9078	0.6929
Mother's age of marriage	14.7817	4.1544	13.1911	6.8975
+ Father's years of schooling	4.7975	3.4876	4.7580	5.9210
+ Mother's years of schooling	3.9286	1.5915	3.9020	2.1503
+ Age of other females	60.3949	10.7315	55.5152	16.4186
+ Age of other males	58.1724	18.9606	49.6400	24.6118

\* unavailable.

+ Mean and Standard Deviation of the group with positive values.

## Appendix G

The Income Variable and Sources of Income

## I. The Income Variable

The income variable that has been used in the statistical analysis measures the value of receipts, in money and kind, by the household--net of related expenditures (seeds, rentals, etc.)--during the year of the survey.

Two alternative measures to the above had been experimented:

A. Income, as defined, less the net value of sale of assets, livestock in particular.

B. Income, as in A, plus the value of production reported as retained for own consumption.

The changes in the results using A and B were negligible because of the high correlations among the three measures. The simple correlations between the variable used and alternative A and alternative B are .93 and .95. Thus, they were almost identical for statistical purposes.

The variable used has been preferred on a priori grounds. Sale of livestock is a common source of income in an agricultural economy, and the net gain should be viewed as part of income. Inclusion of retained production in the income variable must be accompanied by deducting the value of unpurchased inputs. Since measuring retained production and unpurchased inputs may have relatively large error components, it has been assumed that both cancel out. Omission of

retained output from the income variable may mean omitting a form of savings. But this form is, apparently, not related to long run accumulation of assets, but a form of turnover capital.

## II. Source of Income

### 1. Agriculture:

Cultivation of own land

Dairy

### 2. Unskilled Occupations:

Agricultural labor

Share cropping/rent of land

### 3. Skilled Occupations:

Pottery

Carpentry

Masonry

Watch making

Tailoring

Tanning

Flour mill

Barber

Sweepers

Drum beater

Cook

Merchants

School teacher )

Factory workers\* ) Service workers

Sweepers/Janitors )

Office clerks                    )  
Shop assistants                   )   Service workers

Other sources include income from rentals of land farm implements  
and Bullocks as well as sale of assets.

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\*Particular to Ankodia.

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