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A MICRO ECONOMIC-DEMOGRAPHIC MODEL OF THE AGRICULTURAL HOUSEHOLD IN THE PHILIPPINES†

Economic-demographic modeling proposes to identify and measure the relationships that link economics to population growth. Such relationships extend beyond the narrow confines of either demography or economics. Chart 1 illustrates the point by suggesting relationships between health, nutrition, and fertility; the impact that social factors and institutions might have upon the benefits and costs derived from children; and the net effect of such factors on birthrates. These relations can be classified as determinants of population growth if the causality goes from economics to demography (from left to right in the figure) or as consequences of population growth when the causality is reversed.
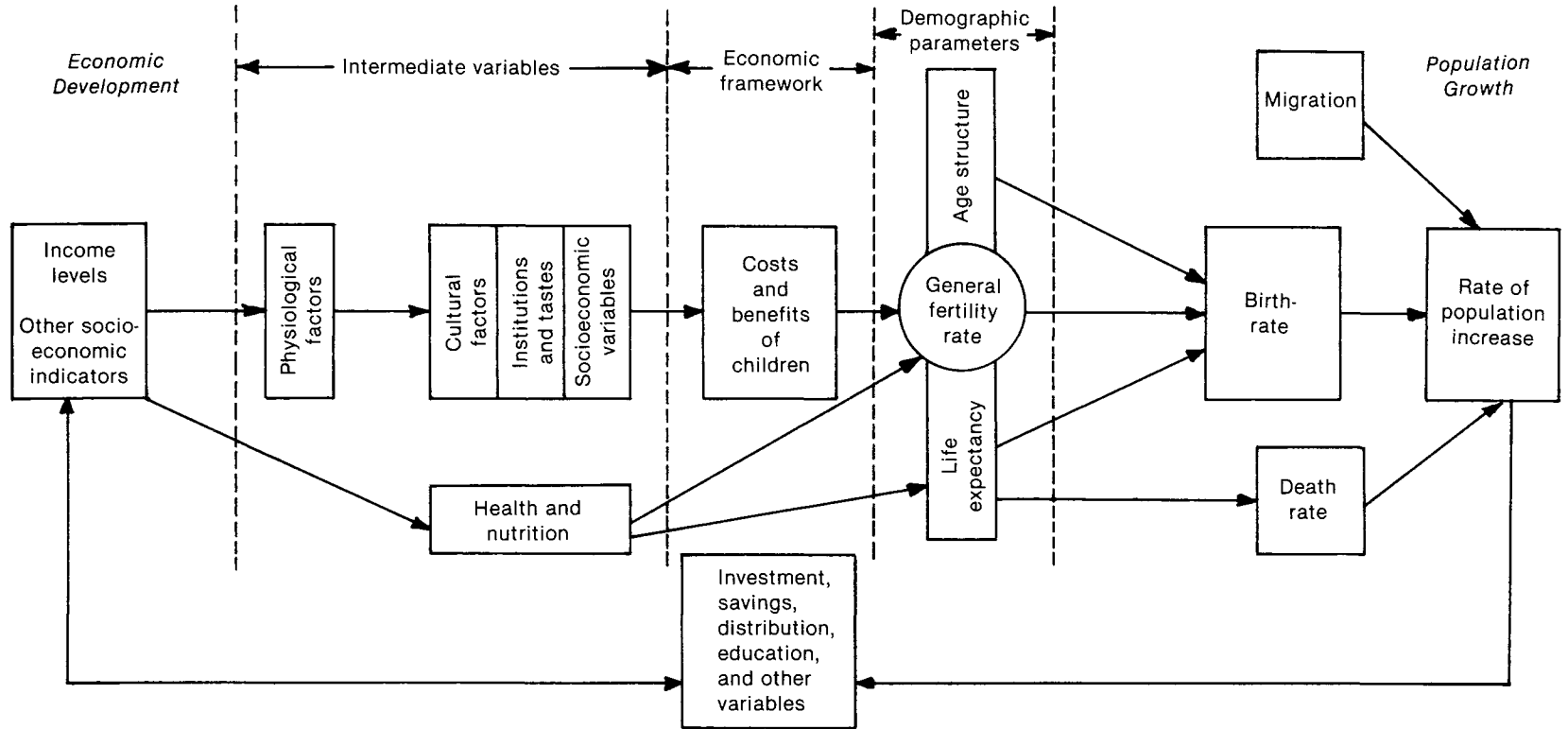
The approach of studying subsets of these relations by following either direction of causality has been employed at times with considerable success. A Solow-type model of economic-demographic interactions follows the causality from demography to economics and describes the consequences of population

CHART 1—A SCHEME FOR ECONOMIC-DEMOGRAPHIC INTERACTIONS

growth as bleak due to the process of capital widening (Solow, 1956).[1] A Samuelson-type model follows the same direction of causality but most often describes the consequences of population growth as advantageous (Samuelson, 1975).[2] On the other hand, the theory of demographic transition describes the determinants of population growth by following the interactions that go from economics to population (Yotopoulos, 1977).

Models that follow only one direction of causality do not close the feedback loop of determinants and consequences. This is unfortunate since the best probable reason for building a model (as opposed to studying a multiple relation) is precisely to close loops by endogenizing in the process variables that would otherwise have been treated as exogenous. Only in this way could one capture the second- and higher-order effects — what in economics is called spillovers and what Theodore White called the law of unintended consequences (White, 1982).

Malthus was the first modeler of economic-demographic interactions who was concerned with closing the loop between determinants and consequences of population growth. It is unfortunate that the most common knowledge of Malthus rests with the first edition of the *Essay on Population* (written in 1798), which in fact is "the vulgarized Malthus."[3] Although in that version both determinants and consequences of population growth are pursued, the emphasis is definitely on the latter since population pressure on limited land results in lower labor productivity forcing consumption below the subsistence point. The main checks to population are "positive," including war, diseases, hunger, and ". . . the vices of mankind [which] are active and able ministers of depopulation." The main determinant of population growth, on the other hand, is the "fixity of passion," which is largely exogenous to the system, since the "preventive" check, which is abstinence from sexual relations accomplished either by delay of marriage or by continence within marriage, receives notice only in passing (Malthus, 1926).

Malthus, a good modeler, was aware of the First Principle of the Art: "Forecast Early and Often" — otherwise known as "Forecast and Run." As a result, in the second edition of the *Essay* (written in 1803), he made a complete reverse and shifted emphasis on the preventive checks, more specifically the "moral restraint" that determines the "prolificness of marriages" and the "earliness of marriages" (Malthus, 1914, pp. 6, 12):

[1] For a given quantity of capital, population growth implies a reduction of capital per head of population, or capital widening. In a Solow-type model, output, which depends on the quantity of capital per head, declines as a result of population growth. The process can be reversed only if resources are diverted from consumption to investment, that is, if capital deepening takes place.

[2] Samuelson introduced a model of two overlapping generations with transfers from the young to the old. By combining such "consumption loans" with the neoclassical growth model, he concludes that the positive intergenerational transfer effect upon economic welfare would offset the negative capital-widening effect of faster population growth. More recently, W. Brian Arthur and G. McNicoll (1978) introduced a continuous-time model of overlapping generations that undermines Samuelson's conclusion while upholding the negative effect of capital widening.

[3] These points are developed further in Yotopoulos (1982).

The effects of this check on man are more complicated. Impelled to the increase of his species by an equally powerful instinct, reason interrupts his career, and asks him whether he may not bring beings into the world for whom he cannot provide the means of support.

. . . The preventive check, as far as it is voluntary, is peculiar to man, and arises from the distinctive superiority in his reasoning faculties which enables him to calculate distant consequences.

This may sound like "reason" overriding the "passion between the sexes" postulated earlier, which would jettison the natural law of increase in population. Its replacement by the "tendency of the *lower classes* to reproduce too much" saves the day. The preventive check is considered more important for the "cultured classes" as opposed to the "laboring classes," for "civilized life" as opposed to "savage life," for "Modern Europe" as opposed to "the ancient times and the uncultivated parts of the world." The theory of the demographic transition is thus anticipated. The literature on the socioeconomic determinants of population growth is launched, complete with the importance of education, the status of women, and the "social capillarity thesis" and replete with policy measures for curbing the reproductive tendency.

The later Malthus accomplished two things at least. First, he closed the loop of determinants and consequences of population growth by jettisoning the "fixity of passion" and making the determinants also endogenous. Second, he looked at social institutions and the way they operate on the family in order to provide the motivation for the determinants and the implication of the consequences. In the theory of economic transition, for example, modernization can be rationalized as affecting fertility only to the extent that it is channeled through the family, since the fertility decision is made at the household level. If, however, modernization at the macroeconomic level is described through per capita income and numbers of telephones or hospital beds, this implies some very strict conditions under which modernization is transmitted to the family level and thus affects fertility. Such conditions may be right or wrong.

THE FAMILY IN ECONOMIC-DEMOGRAPHIC MODELING

Following Malthus, the family can be recognized as the nexus of three important decisions, demographic, production, and consumption, which constitute the three components of behavioral analysis. The family is the locus of the major demographic decisions—to marry, to have another child, to migrate, to take in a relative, to encourage the aged kin to remain, and to provide education. These decisions are reflected in the age structure of the family, its size, and its type, such as nuclear, consanguineous, stem, or joint. The family's institutional specification has important economic connotations.

In a market economy most production decisions take place in business firms, outside the household, except for a good portion of agricultural production decisions, which take place within the family farm-firm. The conventional economic accounting system has focused on market production and has over-

looked the important component of production, carried on within the household, which includes subsistence production activities and maintenance services such as cooking, cleaning, fuel gathering, medical care, care of the elderly, and child care.

Finally, the family is the unit where the household budget is administered and consumption decisions are made. The family is responsible for distribution of leisure among family members, for distribution of food, and for the composition of family expenditure.

A convenient way to place the family within a full modeling framework is shown in Chart 2. It represents the integrated production-consumption system of a household. In a partial model one can study the effect on production of an exogenous variable, say an increase in the price of output, in terms of supply response. The same exogenous variable also affects consumption by changing the mix of the commodities consumed. This is captured through the familiar

CHART 2 — THE FULLY INTEGRATED ECONOMIC-DEMOGRAPHIC
SYSTEM OF THE HOUSEHOLD
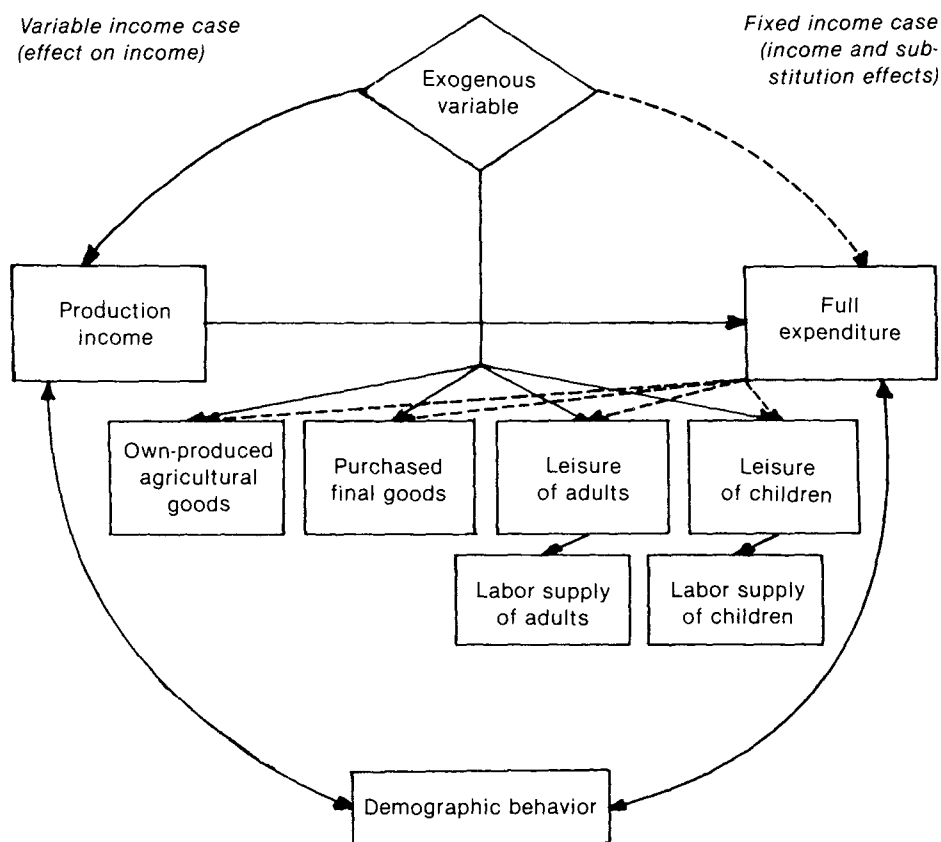
income and substitution effects. By integrating production and consumption within a modeling framework one can also capture the second-round effects of the same variable that go directly from the production to the consumption side, the so-called effects on income. These effects are external in the partial system but may well tip the balance of the effects measured directly. This is what Theodore White called the law of unintended consequences (White, 1982).

The family's demographic decision making can also be added in the chart. An increase in the number of children, or higher fertility, would affect both production and consumption, and they in turn would influence the fertility behavior of the household. In such a manner the fertility decision becomes endogenous to the model. But current fertility decisions affect consumption almost immediately, whereas their effect on production appears with perhaps a 15-year lag. Longitudinal data covering at least 15 years would be needed to make the system empirical. The reason this approach to the economic-demographic equilibrium of the household has not been attempted becomes evident.

AN APPROACH WITH SOCIOECONOMIC GROUPS AS CATEGORICAL VARIABLES

A less ambitious approach is followed here in introducing the family's fertility behavior into a demographic-economic model. First, a "richer" economic model is constructed by including a greater array of demographic characteristics such as family size, age and sex composition, and education. The number of children of working age in the household is introduced, and their contribution to production is quantified and entered as a parametric variable in the exogenous box.

The next question to be asked if the fertility decision is to be endogenized is what determines the size of the family. This explores the motivation for fertility behavior and can be tackled by analyzing households categorized in appropriate socioeconomic groups. To the extent that differences in fertility behavior can be identified, the socioeconomic characterization of the household belongs among the determinants of population growth. From the point of view of integrating demographic with economic analysis, of special interest are the socioeconomic groups that have obvious economic-empirical counterparts. In an agricultural context, for example, these may be groups distinguished according to the size of farm holding and according to the mode of tenancy. These are of special interest since they can lead to specific economic hypotheses linking determinants and consequences of fertility.

An interesting question is whether observed differences in fertility behavior carry over to the economic model. For example, to what extent is a group's measured fertility behavior consistent with the contribution of children quantified in the analysis of the group's economic behavior? Or, to put it another way, to what extent can its measured economic behavior be explained? Unless

there is a red thread of causation between economic and demographic behavior, the observed economic and demographic phenomena might as well be only happenstance.

The purpose of this research is to provide a more direct link between the demographic and economic behavior of the household. The demographic analysis focuses on discovering the regularities in fertility behavior of households grouped in different socioeconomic categories, particularly those with empirical counterparts in the production and consumption function of the household. The objective of the economic model is to identify factors that explain the specific values that the fertility statistics assume, as well as the deviation from these values. Furthermore, given the specific fertility behavior of the group, the question arises whether its production and consumption also vary in a systematic fashion from those of other groups.

THE DATA AND THE ECONOMETRIC PROBLEM

It was intimated earlier that the reason for the scarcity of this type of modeling is lack of data. In order to analyze demographic, production, and consumption behavior jointly, at least three sets of data are necessary: a fertility retrospective survey of eligible women in the household, a farm management survey of the agricultural production operations, and a family income and expenditures survey. Moreover, a full set of panel data running for at least 15 years is necessary to fully endogenize the demographic behavior.

To collect the three sets of data, a special survey, the Mindanao Survey, was organized by the author and funded by the Food and Agriculture Organization/United Nations Fund for Population Activities (FAO/UNFPA). It was conducted in the Philippines in late 1978 and early 1979 under the direction of Professor Alejandro Herrin. The Mindanao Survey yielded fertility, production, and consumption information from about 600 agricultural households. The purposive sample of households was drawn from the province of Misamis Oriental, located along the North Coast of Mindanao Island, the second largest island in the Philippine archipelago.[4]

The survey information contains data on household composition, marriage histories, birth histories, and work histories for all ever-married women aged 15 to 54 years. Members of 590 agricultural households, including 839 women aged 15 to 54 years, were interviewed, and detailed data for 484 ever-married women were collected. The standard quality cross-checks of the demographic information were performed and reported by Ellen Eliason (1982).

The sample provides data needed for specification of the production and consumption behavior of the household. On the production side, indirect estimation through the profit function requires that only households with nonnegative profits in their agricultural operations be included in the analysis.

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[4] For more detailed information on the survey see Herrin (1982).

Moreover, since child labor has been specified as a separate factor of production, households that do not employ children are excluded from the analysis. This leaves a sample size of 123 for the production analysis.

The production analysis is carried out separately for socioeconomic groups that have measurable differences in their fertility behavior, such as the owner-tenant and large-small size groups. Households that cultivate both owned and rented land are classified as owners; tenant households own none of the land they farm. There are 80 owner and 43 tenant households. Households farming less than two hectares are classified as small, two hectares or more are large. There are 52 large and 71 small farms.

The analysis of consumption is carried out with a sample of 94 households. The 29 households in the production sample that hired child labor (ages 6 to 15) but did not employ their own children in production were excluded from the analysis because no child-leisure expenditure equation could be estimated.

Linking fertility behavior of households categorized according to socioeconomic groups with their economic behavior actually uses economic behavior observed in 1979 to explain the fertility of households in the past. In this sense a one-period comparative statics economic model is used to analyze a multistage family decision about fertility behavior. The approach introduces some biases, but, lacking panel data, this is the best set of estimates that can be made. Lack of multiperiod data implies that the benefits and costs of children as durable goods and investments for the future have been overlooked. As a result, one would expect the net benefits measured from the one-period production contribution of children to be the lower bound of their economic worth.

Temporal transposition of the present valuation of children into future prices does not necessarily imply that future prices depend on present prices. Instead, application of the model of rational expectations of the future implies that although current prices may not provide information about future prices, future prices still determine current bids and thus existing market prices. As it refers to the demographic-economic decision making of agricultural households, the model implies that a family making a demographic decision in one period adopts as a guide the experience of other families under similar circumstances. In this sense, the question for a small farmer becomes whether children of other small farmers, for example, pay their way under the present circumstances. If so, rational imitative behavior would induce small farmers to have an additional child. In this sense, the model is one of temporal partial equilibrium.

FERTILITY BEHAVIOR

To measure fertility differentials that may exist among distinct socioeconomic groups, it is convenient to reduce fertility behavior to as few descriptive parameters as possible. Comparing cohort fertility of two groups, for example, is likely to lead to contradictory conclusions in a typical, nonorderly situation in which one group does not dominate the other across all cohorts.

Similarly, using completed family size is likely to bias the comparisons since it excludes information from women who have not completed their childbearing cycle.

In dealing with fertility, demographers have a much stronger empirical grounding than economists. While economists deal mostly with "soft phenomena" and formulate "social laws," demographers deal with a combination of social and physiological-biological phenomena. Ansley Coale has utilized such regularities to construct the model marital fertility function employed in this section (Coale, 1972; Coale and Trussell, 1974). In determining marital fertility, Coale starts with some known parameters. First, biology sets the limits of the reproductive age of women between about 15 and 45. Second, L. Henry (1961) has established the "natural fertility," which is defined as the maximum fertility obtainable if no family limitation is practiced. The shape of the natural fertility function is determined by physiological factors that set the dates of menarche and menopause and yield fertility first increasing to a maximum and subsequently declining because of subfecundity. Based on these regularities, the marital fertility function is specified since:

"Marital fertility either follows natural fertility (if deliberate control is not practiced) or departs from natural fertility in a way that increases with age according to a typical pattern" (Coale and Trussell, 1974, p. 187).

In a population where natural fertility is voluntarily controlled, the ratio of marital fertility to natural fertility is given by

$$r(a)/n(a) = M\, e^{m \cdot v(a)} \qquad \text{or} \qquad r(a) = M\, n(a)\, e^{m \cdot v(a)} \tag{1}$$

Estimation of the marital fertility equation in (1) involves obtaining estimates of two parameters, M and m. Marital fertility at age a, r(a), is defined as the total number of births given by married women of age a, divided by the number of currently-married women of age a. Natural fertility, n(a), is defined as fertility under conditions of complete absence of voluntary control (Henry, 1961), implying that the behavior of a couple is not related to the number of children already born. The set of age-specific constants used to replicate the typical effects of family-limiting behavior on the structure of age-specific marital fertility rates is defined as v(a). Finally, M is a shift constant, expressing the ratio r(a)/n(a) at some arbitrarily chosen age. It can be interpreted as the effect that nutrition or other environmental factors could have on marital fertility.

The parameter of interest in the estimation of the marital fertility function is m, which represents the degree of family-limiting behavior. As such, m can be viewed as a systematic component of behavior, the "rational" tendency of having fertility different from Coale's 43 schedules of women that were used to construct the v(a) schedule. In principle voluntary family-limiting behavior could reduce fertility at any age. In practice, however, voluntary fertility control always seems to cause a greater proportionate reduction of fertility among older women (Coale, 1972, p. 5) thus causing marital fertility to further depart from natural fertility with age. Values of m less than one indicate a level of

conscious fertility control that is lower than the average of Coale's schedules, and vice versa for values greater than one. A value of m approaching zero may be evidence that children are considered as exogenous variables, beyond the couple's behavioral control.

Marital fertility expressed as in equation 1 involves m as the only behavioral parameter. Since the other variables represent physiological-biological factors, the degree of family-limiting behavior measured by m becomes the only behavioral component that is subject to policy control. It becomes therefore a crucial variable in a study of the determinants of fertility that aims at formulating policy implications. This is the justification for working with Coale's marital fertility schedules.

The results of the fertility analysis appear in Table 1. Except for household expenditure, all other groupings described marked differences in fertility behavior.

Electrification was provided for part of the study area in 1971. Eight of the villages were in the electrified parts of the province and ten were not. The value of the m parameter indicated a greater degree of family-limiting behavior in the sample of electrified households. A similar conclusion was reached in an earlier survey of the region by A.N. Herrin and F.C. Madigan (1977).

The relation between education and fertility is among the best documented in the literature. At the conceptual level, and once other variables have been controlled, one would expect an inverse relationship. Empirical cross-individual studies in developing countries, however, have not offered strong support to the inverse hypothesis. Susan Cochrane, after surveying the literature, concluded that the inverse relationship is less likely to hold in rural than urban areas and in less literate than in more literate regions of developing countries (1979, p. 143). The strong evidence of an inverse relationship in a rural and least-developed region of the Philippines shown in Table 1 is especially important, given the state of current research.

The status variables that are crucial for our study are ownership and land use. The distinction between owners and tenants and large and small farms is likely to have immediate implications for the production and hence the consumption of the household, and as a result it may provide a direct link between demographic and economic behavior. Table 1 indicates that owner households and households with large farms display a higher degree of family-limiting behavior than tenant households and small farms.

A strong theoretical and empirical link between fertility and land ownership and farm size has yet to be established in the literature. Findings of positive relationships between fertility control and farm size and tenure seem to contradict prevalent a priori theorizing and some of the empirical work. An interpretation of the benefits-and-costs-of-children hypothesis predicts a high fertility regime for families with access to more land since they can use additional family labor profitably (Rosenzweig and Evenson, 1977). Another interpretation of the same hypothesis suggests that farm size should be negatively related to fertility due to the downward shift in the marginal productivity of child labor

TABLE 1 — PARAMETERS OF THE COALE MARITAL FERTILITY FUNCTION BY
SOCIOECONOMIC GROUP, WOMEN BORN 1935 AND LATER[a]

	N	Cumulative fertility	M	m	Mean square error	Percentage error	t-statistic $H_0: m_i = m_j$[b]
All women	346	9.44	1.02	.307	.0006	1.89	
Ownership							
Tenants	200	9.45	0.91	.105	.0047	3.63	2.57
Owners	146	9.32	0.84	.279	.0318	16.23	
Land use							
Size <2 ha	247	9.53	1.01	.272	.0007	2.57	1.62
Size ≥2 ha	99	9.19	1.03	.390	.0001	3.35	
Electrification							
Nonelectrified	121	9.39	0.98	.134	.0004	2.15	2.53
Electrified	225	9.50	1.04	.406	.0024	4.26	
Household expenditure							
<6000P	229	9.11	1.01	.311	.0012	3.51	.04
≥6000P	117	10.03	1.03	.317	.0052	7.53	
Woman's education							
Grade school	254	9.34	1.00	.265	.0000	0.51	.97
High school or above	92	10.04	1.09	.499	.0122	7.05	

[a]Estimated from the equation $r(a) = Mn(a)e^{m \cdot v(a)}$.

[b]$H_0: m_i = m_j$ $T = m_i - m_j / (\sqrt{MSE_i} / \sqrt{var[v(a)]})$ for a = 22, . . ., 40. At the confidence level of 90%, the value of t = 1.74. At the level of 95%, t = 2.11.

associated with increased complexity of tasks and the use of nonfamily labor and labor-saving machinery (de Janvry, 1976).

The empirical literature, with few exceptions, supports the hypothesis of a direct relationship between fertility and size of cultivated area. Mark Rosenzweig and R. Evenson (1977) assumed noncomplementarity between child labor and farm size and found the latter positively related to fertility in a 1961 sample of 189 districts in India. D.S. Kleinman (1973) found that for 315 districts in India in 1961 cultivated acreage per household was positively related to fertility in a 15-variable regression model. J. Stoeckel and M.A. Chaudhury (1973) found that size of landholding and fertility were positively related in Bangladesh, and W. Stys (1957) found a similar relationship in southern Poland.

While the studies on farm size and fertility seem to support a direct relationship, the few available studies of ownership status and fertility present mixed results. A.H. Hawley found farm tenants in the Philippines to have higher fertility in all age groups of women except those 35 to 44 years of age (1955). V.A. Hiday, who studied two Mindanao communities, reported a negative relationship between land tenure and fertility of farm families (1978). W.C. Schutjer, C.S. Stokes, and G. Cornwall, using a village-level sample of Luzon, Philippines, found a positive effect of land ownership on fertility (1980). This direct effect was reversed, however, when indirect effects operating through female education and village-level traditionalism were considered. Where W.C. Schutjer, C.S. Stokes, and J.R. Poindexter (1982) used a multiple regression to relate fertility to size of farm and land tenure as shown by an Egyptian survey in 1978, they found a positive relationship of fertility with farm size and a negative relationship with land tenure. In another context, Paul David and David Weir found that among American native white farm women married between 1865 and 1885, owners controlled fertility more than tenant farmers. They explain this on the grounds that owners were concerned that the estate not be subdivided among several surviving male heirs, whereas tenants commonly sold the services of their children (David and Weir, 1981).

The empirical analysis of fertility suggests that the distinctions between owner and tenant households and between large and small farms have broad implications for the demographic behavior of the household. The remainder of this study reports a search for regularities in production and consumption behavior of the four socioeconomic groups, which may be corroborative of their respective fertility behavior.

PRODUCTION BEHAVIOR

The relationship between labor use and certain socioeconomic characteristics, such as farm size and tenure, has been a traditional concern of production analysis, dating at least as far back as A.V. Chayanov (1925). This relation can be made explicit by using socioeconomic characteristics as categorical variables to group the farm households in the production analysis. Group-specific differential fertility behavior can be reflected in Chart 2 by parametrically changing the number of children, treated as exogenous variables. Since the labor of children ages 6 to 15 enters the production function as a separate input, family size and fertility are viewed as determinants of labor use and correlates of farm size. The benefits of children, as a result, are directly captured in the production analysis. The consumption side, again from Chart 2, reflects the size of the family directly (and thus the number of children) and also indirectly through the feedback from the production side. Thus the second-order and spillover effects of the general equilibrium system are measured. Finally, to the extent that differences in fertility behavior are measured among socioeconomic groups that have a priori economic counterparts, or distinct production behavior, a link is provided between fertility behavior and observed

economic behavior. It is not necessary to resort to ratiocinating about fertility motivations.

The production function of the household is specified:

$$Q = F(X_1, X_2, X_i; K_j), \quad i = 3, \ldots, m; j = 1, 2, \ldots, n \quad\quad (2)$$

where

  Q = total amount of agricultural output
  X_1 = adult labor time
  X_2 = child labor time, ages 6 to 15
  X_i = variable input other than labor, such as fertilizers and
       agri-chemicals, $i = 3, \ldots, m$
  K_j = fixed input such as capital and land, $j = 1, 2, \ldots, n$.

It is assumed that competitive markets exist for adult and child labor as well as for the other variable inputs and agricultural output. This assumption was validated by the survey. Substitution between adult and child labor is assumed to be imperfect, but family and hired labor are assumed to be perfectly substitutable within each category.

The dual of the production function is the profit function that makes the "surplus" of output (over and above the total cost of the variable factors of production) a function of the prices each household pays for its variable inputs and receives for its output. It is written

$$\Pi^* = \Pi^*(P_A, q_1, q_2, q_i, K_j), \quad\quad i = 3, \ldots, m; j = 1, \ldots, n \quad\quad (3)$$

  Π^* = profit, i.e., total value of output minus total cost of the variable
       factors of production, normalized by the price of output
  P_A = agricultural output price
  q_1 = wage rate for adult labor, normalized by the price of output
  q_2 = wage rate for child labor, normalized by the price of output

Similarly the variable factor demand functions can be written:

$$X_i^* = X_i^*(P_A, q_1, q_2, q_i, K_j), \quad i = 1, 2 \text{ for labor}; i = 3, \ldots, m \quad\quad (4)$$

for other factors.

Simultaneous estimation of the reduced-form equations 3 and 4 yields the reduced-form elasticities for profit, demand for adult labor, demand for child labor, and demand for other variable inputs. These equations are specified empirically within a Cobb-Douglas framework and estimated using A. Zellner's efficient estimation procedure that allows testing of the nested null hypotheses of profit maximization and constant return to scale (Zellner, 1962). Where these hypotheses pass, we impose them as constraints to obtain the final restricted efficient estimates of the parameters of the profit and factor demand functions.[5]

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[5] For more complete discussion of the empirical implementation see Lau and Yotopoulos (1972) and Yotopoulos and Lau (1973).

The results of the estimation are presented in Table 2 for the four socioeconomic groups that displayed differences in fertility behavior: large-farm, small-farm, owner, and tenant households. Within each group, both the profit-maximization and the constant-returns-to-scale hypotheses are accepted. Therefore only the restricted estimation is reported. The results yield

TABLE 2 — COEFFICIENTS OF RESTRICTED ESTIMATION OF
COBB-DOUGLAS PROFIT AND FACTOR SHARE FUNCTIONS

	Parameter	Large farms (N = 52)	Small farms (N = 71)	Owners (N = 80)	Tenants (N = 43)
Constant	$\ln A^*$	4.377* (6.685)	4.173* (12.220)	4.426* (9.889)	4.077* (7.879)
$\ln$ adult wage	α_1^*	− 0.424* (− 3.147)	− 0.486* (− 6.354)	− 0.469* (− 4.842)	− 0.475* (− 4.759)
$\ln$ child wage	α_2^*	− 0.072* (− 3.181)	− 0.157* (− 2.266)	− 0.094* (− 1.808)	− 0.181* (− 2.533)
$\ln$ animal-machinery	β_1^*	0.137** (1.728)	0.130* (3.152)	0.135* (2.768)	0.146* (2.057)
$\ln$ land	β_2^*	0.863* (10.860)	0.870* (21.120)	0.865* (17.800)	0.854* (11.990)
Adult labor demand function	α_1^*	− 0.424* (− 3.147)	− 0.486* (− 6.354)	− 0.469* (− 4.842)	− 0.475* (− 4.759)
Child labor demand function	α_2^*	− 0.072* (− 3.181)	− 0.157* (− 2.266)	− 0.094* (1.808)	− 0.181* (− 2.533)

The estimating equations are

$$\Pi^* = A^* q_1^{\alpha_1} q_2^{\alpha_2} K_1^{\beta_1} K_2^{\beta_2} e^{\delta_i D_i} \quad \text{and} \quad -\frac{q_1 X_i}{\Pi^*} = \alpha_1^* \quad \text{and} \quad -\frac{q_2 X_2}{\Pi^*} = \alpha_2^*$$

where Π^* and q are profit and wage rates of adult and child labor respectively, all normalized by the price of output; K_1 is animal-machinery input and K_2 is cultivated area; D_i is a dummy variable (representing categorical variables such as land ownership, number of coconut trees, fertilizer use, electrification, head of household's educational level, and the share of livestock output in total production); and the other variables are as defined earlier. The coefficients α_i^* and β_i^* are the parameters of the profit function to be evaluated. Their transforms α_i and β_i, the parameters of the production function, are estimated indirectly.

The hypotheses of profit maximization and constant returns to scale were accepted, and the coefficients estimated with these restrictions are reported.

Figures in parentheses are computed asymptotic t-ratios.

Coefficients with * and ** are statistically significant at the 5 and 10 percent levels, respectively.

Estimates of dummies are not reported.

coefficients that are statistically significant and with the expected signs, nega-
tive for the prices of the variable factors and positive for the quantities of the
fixed factors of production. Indirect estimates of the production elasticities of
the four factors are presented also by socioeconomic group in Table 3, along
with the computed (at the mean level of input utilization) elasticities of the
factors of production.

TABLE 3—INDIRECT ESTIMATES OF PRODUCTION ELASTICITIES
AND MARGINAL PRODUCTS BY SOCIOECONOMIC GROUPS

	Parameter	Marginal product	Large farms	Small farms	Owners	Tenants
Adult labor	1		0.2833	0.2958	0.3000	0.2868
		pesos / day	28.33	11.13	27.49	11.61
Child labor	2		0.0480	0.0957	0.0601	0.1092
		pesos / day	27.89	13.08	29.07	11.81
Animal-machinery	1		0.918	0.0790	0.0861	0.0884
		pesos / peso	2.04	1.13	1.82	1.39
Land	2		0.5769	0.5295	0.5538	0.5156
		pesos / hectare	3,921	2,894	4,108	2,144

The coefficients with restrictions of equalities and constant returns to scale given in Table 2 were
used for the computation of the elasticities. The relations between α and β and α^* and β^* are
given by $\alpha_i^* = -\alpha_i^* (1=\mu)^{-1}$ and $\beta_j^* = \beta_j (1=\mu)^{-1}$ where $\mu = \alpha_1 + \alpha_2$ and $i=j=1, 2$.

Examination of Tables 2 and 3 yields some important insights regarding
child labor. Comparing the estimates across the two socioeconomic groups in
Table 2, we observe a striking similarity in the coefficients of three of the four
production-operational variables, those of adult wage rate, animal-machinery
input, and land cultivated. The coefficient of child wage rate, on the other
hand, is about twice as great for small farms and tenants as it is for large farms
and owners. Except for child labor, all factors seem to be perfect substitutes
between the respective groups of farms and as a result would have required no
separate treatment in the productions analysis. Given the separate treatment of
the two groups, however, the marginal products of all factors reflect the differ-
ences in the coefficients of child labor between farm size and tenure. Marginal
productivity of adult and child labor is roughly equal within small farms and
within large farms. This is not surprising since it constitutes evidence of suc-
cessful profit maximization, a hypothesis tested and accepted. The marginal

productivity of child labor, however, is markedly smaller for the small farms
and tenant farms, roughly 13 pesos a day versus 28 pesos a day for large farms
and owner-operated farms. The same relationship exists for the marginal
products of the other factors compared across groups; small farms and tenant
farms have roughly one-half the marginal products of the large farms and
owner-operated farms.

The conclusion from Tables 2 and 3 is striking. Labor utilization is much
more intensive on the small farms and tenant farms, and the marginal product
of labor is depressed relative to the large farms and owner-operated farms.
This imbalance most likely reflects the preexisting differences in initial endow-
ments. Large farms and owner-operated farms are better endowed with factors
of production and are able to employ more animals, machinery, and land in-
puts. Given the complementarity of all factors of production, the higher utili-
zation of fixed factors for this group is reflected in higher labor productivities.
The less-privileged, small, and tenant farmers, on the other hand, can only
increase total output by increasing the quantities of the factors they already
control, adult and child labor, thus driving their marginal products down.
These results reject de Janvry's hypothesis of the downward shift in the mar-
ginal products of child labor in the large and owner-operated farms as a result
of the increased complexity of tasks and the substitution by labor-saving
machinery (1976). This is not surprising, since all sampled households seem to
operate within the same narrow technological frontier.

The surprising result that requires explanation is the association of the
privileged groups (large and owner farmers) with family-limiting behavior. At
first blush the explanation may appear simple, since it is the less-privileged and
high-fertility groups (small and tenant farmers) that use labor more intensively.
This does not account for the basic disequilibrium in the labor market, how-
ever, nor does it explain why the privileged groups do not breed more children
or hire more labor to bring their marginal products in line with those of the
less-privileged groups. Some tentative hypotheses can be advanced to explain
this inverse fertility implication of the endowments hypothesis.

A market-failure hypothesis can be formulated regarding access to frag-
mented labor markets. The labor bottleneck in agricultural work occurs at
peak season when the wage rates are high. Suppose the privileged group of
farms has better access to peak-season labor because of higher initial endow-
ments. In the maximizing framework that is tested and accepted in this study,
the privileged group would also be expected to have year-round marginal
productivities that are high and close to the peak-season wage rate. The less-
privileged group, on the other hand, is crowded out of the peak-season labor
market and can only rely on additional family labor for peak-season work.
Thus follows the higher fertility of the small and tenant farmers, and the lower
marginal product of labor that is, in a maximizing framework, equal to the
year-round opportunity cost of family labor. The testable implication of this
hypothesis is that the privileged group of farms hires more labor than the less-
privileged group.

Purely demographic hypotheses can also be suggested to explain the same phenomenon. Fertility control requires the conjunction of motivation and access to knowledge. It is conceivable that the better-endowed farms have better knowledge of, and more access to, birth control methods. On the other hand, family-limiting behavior is a negative function of infant mortality rates. To the extent that children in poorer, small-tenant households have lower life expectancy at birth, these households may be observed to have higher fertility. Finally, high school education was found earlier to have a negative and significant effect on fertility. Education of the wife is usually a correlate of initial endowments, and one would expect to find women in large and owner farms to have more education. All these demographic hypotheses are testable.

An economic-demographic hypothesis can also explain the higher fertility of the less-privileged group of farms. The preceding economic analysis deals with one year's benefits of children, mostly from agricultural work. The value of children as an investment, for portfolio diversification and for old-age security, cannot be inferred from analysis of one period. Poorer households may view a larger number of children as increasing their probability of producing a successful child, perhaps in the urban sector, who would provide greater security for their old age. This economic-demographic hypothesis is not testable with the data of the survey since it requires time-series observations of economic activities of children.

CONSUMPTION BEHAVIOR

Estimation of the consumption side of Chart 2 and its integration with the production behavior follows the work of Lau, Lin, and Yotopoulos (1978) and is based on the econometric application of the linear expenditure system (Lau and Mitchell, 1970).[6] The utility function implied by Chart 2 can be written as

$$U = U(Z_1, Z_2, Z_3, A, C; a_1, a_2, a_3) \tag{5}$$

where

Z_1 = leisure time of adult workers
Z_2 = leisure time of child workers
Z_3 = leisure time of dependents
A = amount of consumption of own-produced agricultural commodities
C = amount of consumption of purchased consumer final goods
a_1 = number of adult workers
a_2 = number of child workers between ages 6 and 15
a_3 = number of dependents including children younger than 6 years old and old and retired family members.

The utility function is assumed to be well behaved and to have the usual properties.

[6] For more complete discussion of the empirical implementation of the consumption side, see Kuroda and Yotopoulos (1982).

Through the duality theorem, the maximized value of utility becomes a function of the prices that are implicit in equation 5. The indirect utility function is thus defined as

$$V^* = V^*(q_1, q_2, P_A, P_C; a_1, a_2, a_3) \tag{6}$$

where

V^* = the indirect utility function
P_C = the price of the purchased consumer final good

and the other prices, q_1, q_2, and P_A, are as defined in equation 3.

By introducing the indirect utility function along with the profit function, the two sides in Chart 2, consumption and production, become dependent on the same set of exogenous variables—largely the prices of outputs and inputs and certain parametric variables such as fixed factors of production and the composition of the household. These common variables, then, become the handle for integrating the two sides of economic behavior. This becomes clear by writing also the full income and expenditure constraint:

$$\left(P_A Q - q_1 X_1 - q_2 X_2 - \sum_{i=3}^{m} q_i X_i\right) + q_1(a_1 \overline{Z}_1 - Z_1) + q_2(a_2 \overline{Z}_2 - Z_2) + I_A$$
$$= P_A A + P_C C \tag{7}$$

where

$\overline{Z}_1, \overline{Z}_2$ = the maximum quantity of leisure that can be taken by adults and working children, respectively
I_A = nonlabor asset income.

The first term in equation 7 represents the profit from agricultural operations as in equation 3, that is, the total value of output minus the cost of the variable factors of production. Along with profit from farm operations and other asset income (I_A), the full income of the household in G.S. Becker's sense includes also the evaluation of leisure of the household members (1965). This is represented by the second and third terms of equation 7, the maximum possible leisure minus the work expended by family members on farm activities.

Following Becker, we solve for maximization of the household utility function given in equation 5 subject to the income-expenditure constraint in equation 7, which includes also the production function constraint, and subject to the time constraints implicit in equation 7 through the leisure-labor allocation terms. A Langrangean multiplier method yields a set of simultaneous equations referring to marginal productivities (production side) and marginal utilities (consumption side) with supply of output, demands of the variable factors of production, and demands of consumption goods ($Q, X_1, X_2, X_i, Z_1, Z_2, Z_3$, A, and C) being the endogenous variables; and prices of the variable factors of production and output, quantities of the fixed factors of production, price of consumption goods, non-own-production income, and the demographic com-

position of the household (q_1, q_2, K_j, P_A, P_C, I_A, a_1, a_2, and a_3) being the exogenous variables.

The results of the estimation appear in Tables 4 and 5 as elasticities of the four consumption demands (adult leisure, child leisure, own-produced agricultural goods, and purchased final goods) that are estimated with respect to the exogenous variables (their respective prices; the composition of the household between adult workers, children of working age, and dependents; and the fixed factors of production of animal and machinery input and land). The elasticities of supply of family labor and of marketing of produce can also be derived from the system, but they are omitted here since they are the respective complements of demand for leisure and demand for own-produced goods.

Two cases are distinguished in Tables 4 and 5. In the full-income-fixed case all elasticities are computed under the assumption that total expenditure on own-produced goods, purchased goods, and leisure remains constant, and the estimated elasticities measure the combined impact of the income and substitution effect. In the full-income-variable case the total expenditure is made endogenous by feeding into the consumption side the results of the production operation of the household, and the effect on income is captured.

Results on the consumption side tend to highlight some differential characteristics of owner and tenant households that were identified in the production analysis.[7] More precisely, the production analysis suggested that the tenant households are characterized by: (1) lower initial endowments; (2) greater strain on labor resources partly to compensate for lower initial endowments; (3) more pronounced complementarity between family child and adult labor. With this distinction in mind between owner and tenant households, one can proceed to analyze the effects of changes in the exogenous variables.

Under the fixed-income case, the impact of an increase in the number of children, a_2, puts strain on labor resources in the tenant households (2) and decreases adult leisure and consumption of agricultural commodities. This is the effect of lower initial endowments of tenant households. The effect on adult leisure incorporates also the impact of greater complementarity between family child and adult labor (3). As a result, it is more pronounced. The results for small farms are even stronger, presumably because of lower initial endowments than in tenant households.

Again, in the fixed-income case an increase in the child wage rate, q_2, decreases the leisure of children. The decrease, however, is smaller in tenant households because greater strain is placed on their labor resources as a result of more pronounced complementarity between family child and adult labor (3).

The full-income-variable case amounts to evaluating the consumption side after the effects of the production activities of the household and thus the production contribution of children are taken into consideration. Under full-income variable an increase in the price of output, P_A, increases the leisure of

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[7] The results for the large and small farms are comparable and are omitted from the table.

TABLE 4—MATRIX OF ELASTICITIES OF THE CONSUMPTION SYSTEM
FULL INCOME FIXED AND VARIABLE, OWNERS

	Leisure of adults (Z_1)	Leisure of children (Z_2)	Own-produced agricultural goods (A)	Purchased final goods (C)
Full income fixed				
q_1	−.491	−.414	−.172	−.634
q_2	−.254	−.321	−.271	−.182
P_A	−.069	−.178	−.549	−.010
P_C	−.185	−.087	−.007	−.173
a_1	.537	−.525	−.125	−.165
a_2	−.285	.650	−.092	−.266
a_3	−.003	.027	−.001	−.025
Full income variable				
q_1	−.088	−.011	.230	−.231
q_2	.002	.185	−.014	.074
P_A	.293	−.087	−.186	.353
K_1	.031	.031	.031	.031
K_2	.201	.201	.201	.201

TABLE 5—MATRIX OF ELASTICITIES OF THE CONSUMPTION SYSTEM
FULL INCOME FIXED AND VARIABLE, TENANTS

	Leisure of adults (Z_1)	Leisure of children (Z_2)	Own-produced agricultural goods (A)	Purchased final goods (C)
Full income fixed				
q_1	−.303	−.469	−.031	−.465
q_2	−.576	−.271	−.274	−.584
P_A	.016	−.119	−.735	−.039
P_C	−.137	−.141	−.022	.088
a_1	.424	−.365	−.015	.109
a_2	−.426	.526	−.308	−.183
a_3	−.027	.021	.073	−.126
Full income variable				
q_1	.012	−.154	.346	−.150
q_2	−.200	.105	.102	−.209
P_A	.495	.353	−.257	.439
K_1	.042	.042	.042	.042
K_2	.247	.247	.247	.247

adults and children in tenant households, and the effect on income that comes from the production side relieves the strain on the labor resources of the tenant households (2).

The same pattern of more pronounced effects when the production contribution of children is considered appears with an increase in the wage of adult and child labor (q_1 and q_2). This affects own and cross elasticity. The own-elasticity effect increases leisure through its effect on income. The cross-elasticity effect decreases leisure more drastically in tenant households because of the greater strain on labor resources in those households and of the more pronounced complementarity between family child and adult labor (2 and 3).

The conclusion from the estimation of the consumption side is that the less-privileged households register a stronger impact from changes in exogenous variables that relate to the economic contribution of children. The results are especially pronounced and consistent with the effect on income in the full-income-variable case when the production activities of the household and therefore the production contribution of children are captured on the consumption side. Findings from the consumption analysis are consistent with results of the production side described earlier and with the inverse-fertility-endowments hypothesis that was formulated in this paper.

SUMMARY AND CONCLUSIONS

This paper has explored the links between demographic and economic (production and consumption) behavior in a sample of Philippine agricultural households. Distinct socioeconomic groups were analyzed to assess differential fertility behavior. The type of tenure and the size of farm operation were the two socioeconomic criteria that distinguished well between households with high and low fertility. The type of tenure and the size of farm also have economic attributes that pertain to production and consumption behavior. The literature treating the relationship between fertility and farm size and type of tenure is ambivalent as to the sign and direction of causality. In contrast, this study reveals that conscious fertility control is significantly less for tenant and small farm households than for owner and large farm households. The finding of an inverse relationship between the size of farm operation and fertility and the finding of lower fertility for landowner households as compared to tenant households became the link between the demographic and the economic analysis of the study.

The objective of the production analysis was to identify factors that might explain the specific values that the fertility statistics assumed in the two groups of households. The demographic characterization of the household, especially the number and the economic contribution of children, became the linchpin of the study of the economic-demographic interactions at the household level.

The production side of the economic model served to evaluate the contributions of children in each of the socioeconomic groups of households and to relate them to the findings of fertility differentials between groups with different initial endowments. It was found that, contrary to a priori theorizing,

the marginal productivity of child labor in agriculture is much greater (about double) in the well-endowed households (owners and large size) than it is in the less-privileged households (tenants and small size). The inverse-fertility-endowments hypothesis was based on a number of testable propositions involving demographic, economic, and economic-demographic behavior.

On the consumption side, the measured effects of changes in the exogenous variables were consistent with the different characteristics of tenant and small farm households that were identified in the production analysis. In general, a change that tends more to affect households with lower initial endowments becomes more visible on tenant and small households through, for example, a greater decrease in adult leisure, child leisure, or consumption of own-produced agricultural commodities. When, however, the effects of household production activities, and thus of the production contribution of children, are also included in the analysis of the full-income-variable case, the effect on income offsets many of the income and substitution effects that dominated the results of the less-privileged households. This constitutes further evidence that the production contribution of children is more valuable in the tenant and small farm households.

The linchpin of the economic explanation advanced for the inverse-fertility-endowments hypothesis is labor-market failure, which has special impact on the poorly endowed households of tenants and small farms. The policy conclusion follows that fertility could be reduced by measures that alleviate the labor shortage during peak-season activities. Machinery stations, for example, that provide rental services of harvesters and plowing equipment to small farmers and tenants could help in labor substitution during peak seasons and could therefore decrease the year-round benefits derived from an additional child.

While this paper cannot claim broader applicability of the inverse-fertility-endowments hypothesis beyond the sample of the Mindanao Survey, it can point to a fruitful methodological conclusion. It appears that the analysis based on a direct link between demographic and economic behavior can produce testable propositions and empirical findings on hypotheses that have so far rested mostly on a priori considerations.

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