

Population Growth and Economic Development: Issues and Evidence

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National Saving Rates and Population Growth: A New Model and New Evidence

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INTRODUCTION

In many assessments of the macroeconomic consequences of population growth, the link between demographic factors and saving or investment plays a key role. In their 1958 study of India, Coale and Hoover argue that lower population growth will encourage saving. Likewise, Mason and Suits' 1981 estimates of economic gains from fertility reduction derive from a model in which national saving is reduced by population growth. By contrast, the long-run economic benefits generated by Simon's 1976 model accrue, in part, because population growth is postulated to lead to higher rates of saving.

This chapter presents new analysis and evidence on the link between population growth and national saving. The analysis is based on the variable rate-of-growth effect model (Mason, 1981; Fry and Mason, 1982), which distinguishes two population growth effects: the rate of growth effect and the dependency effect. As in the traditional life-cycle model, an increase in the growth rate of aggregate income, given life-cycle patterns of household saving, leads to higher aggregate saving. To the extent, then, that population growth leads to higher growth of aggregate income, saving increases with population growth. An increase in child dependency operates in the opposite direction. By shifting consumption from nonchildrearing to childrearing stages of the

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household's life cycle, an increase in childrearing affects the timing of life-cycle saving. The impact on aggregate saving depends on the rate of growth of national income: a rise in the dependency ratio, given a higher rate of economic growth, leads to a greater decline in the saving ratio.

Crude support for this view is apparent in Table 1, which compares net national saving rates, averaged over the 1960 and 1980 period, for 79 countries. The highest saving ratios are observed among countries with both a low dependency ratio and a high rate of economic growth. Such countries average a saving ratio roughly twice that averaged by countries with high dependency ratios and low rates of economic growth.

The next section of this chapter reviews previous research on the saving-population growth link. Included are applications of the variable rate-of-growth effect model.

The third section presents an extension of the variable rate-of-growth effect model by linking factors that determine the number of children reared to the budget shares devoted to childrearing and, in turn, to the national saving rate. If a decline in childrearing results in a decline in the childrearing budget share, aggregate saving increases. Such a result will occur in two circumstances: (1) childrearing declines because of change in nonprice factors; and (2) childrearing declines elastically in response to increases in the relative price of children. If, however, the demand for children were inelastic, a price-induced decline in the number of children would result in an increase in the childrearing budget share and a decline in the national saving rate.

The fourth section presents estimates from international cross-section data covering the 1960 to 1980 period. The econometric evidence shows that countries, particularly those with moderate to high rates of economic growth, have achieved higher national saving via lower dependency ratios. In addition, estimates of childrearing budget shares varying from a high of 30 percent for high-fertility countries to a low of 15 percent for low-fertility countries are obtained. Budget share differences are primarily attributable to nonprice factors. By contrast,

TABLE 1 Average Net National Saving Ratio for 79 Countries, 1960-80

Dependency Rate	Growth Rate of National Income		
	Less than 0.5	Greater than 0.05	Combined
Greater than 0.6	0.089	0.146	0.124
Less than 0.6	0.152	0.177	0.160

Note: See Appendix for definitions of variables.

the relative price of children is shown to be roughly similar in high- and low-income countries.

In the fifth section, the neoclassical growth model is employed to show circumstances under which the rate-of-growth effect dominates the dependency effect, reversing the relationship between population growth and saving. In addition, the long-run relationship between population growth, saving, and capital and output per worker is analyzed.

The final section of the chapter reviews the evidence and presents conclusions. The Appendix defines the variables used in the model and details of the theoretical model.

PREVIOUS RESEARCH

That demographic factors have an important bearing on national saving rates is far from universally accepted. The evidence for such a relationship comes from two sources. First, simulation models, such as those of Tobin (1967) and Mueller (1976), have been used to analyze the complex relationship between saving and demographic factors. The conclusions reached, however, are quite sensitive to the relationship between household saving and age of head, and to the impact of the number of children on household consumption. Unfortunately, there is very little concrete evidence on these issues, particularly for developing countries. Thus, simulation models illustrate, but do not establish, the saving-population growth link. The second source of evidence comes from econometric studies of aggregate savings, based primarily on international cross-national data. A number of these studies, reviewed below, have concluded that high population growth depresses national saving rates, although the validity of this conclusion has been challenged on numerous grounds.

Simulation Studies

Tobin's 1967 article is the first of a number of studies to employ a simulation approach for assessing the impact of population on saving. Tobin describes a steady-state economy in which household consumption and earning, and hence saving, vary by age. With age profiles following the Modigliani-Brumberg path, that is, dominated by the pension motive, young households save and older households dissave. A high population growth rate generates an age distribution tilted toward young, saving households. Consequently, in contrast to empirical work cited below, aggregate saving is higher. By way of illustration, Table 2 presents from Tobin's study the ratio of wealth to labor income (W/L), wealth to total income (W/Y), and saving ratios (S/Y), given an interest rate of 0.05, a growth rate of worker productivity of 0.03, and several rates of population growth (n).

Tobin offers a refined model using more realistic consumption and earning profiles. The earning profiles are based on survey data for the United States. The consumption profiles are con-

TABLE 2 Tobin's Results Using a Simple Life-Cycle Model

n	W/L	W/Y	S/Y
0.0	9.1	6.2	.19
0.01	8.4	5.9	.24
0.02	7.6	5.6	.28
0.03	7.0	5.2	.31

structured using synthetic households with varying numbers of equivalent adults: a husband, a wife, and children under 18 weighted by equivalent adult consumer units that vary from 0.1 to 1.0. This obviously complicates the role of population in an interesting way. Changes in population growth affect both the consumption profile and the age distribution of households. The net effect on saving of a change in population growth is no longer clear. Unfortunately, Tobin whets but fails to satisfy our appetite; he provides refined estimates for only one rate of population growth.

Several similar studies have been conducted (see, for example, Kelley's 1968 analysis of economic growth in Australia from 1861 to 1911, or Conroy's 1979 application of Tobin's model to data from Peru). Of particular interest are studies by Mueller (1976) and Lewis (1983).

Mueller uses an extensive amount of data to construct earnings and consumption profiles appropriate to the developing country context. In doing so, she establishes the importance of child earning, not just consumption.¹ She concludes, in general, that higher population growth results in a lower "potential" saving rate. For example, if one set of assumptions is used, an increase in the gross rate of reproduction from 2 to 3 results in a decline in the "potential" saving rate from 11.9 to 4.8 percent.

Lewis examines the extent to which fertility decline explains historical patterns in U.S. saving rates. Using the household as the unit of analysis, he examines the effect of declining child-bearing on the consumption profile of households, and hence on the aggregate saving rate.² He concludes that fertility decline contributed about one-quarter of the increase in saving rates observed from 1830 to 1900.

Household-Level Studies

All of the studies cited above suffer from a common problem: the limited data on earning and, particularly, consumption age

profiles. Even where data are relatively ample, as in the industrialized countries, differing conclusions are reached about the importance of life-cycle saving. (For two recent views, see Kotlikoff and Summers, 1981, and King and Dicks-Mireaux, 1982). Little concrete evidence is available on the effect of children on household consumption and earning patterns among developing countries.

Both macrosimulation models and estimates from international cross-section data reviewed below are based on the presumption that the typical household's current consumption, income, and hence saving are influenced by the number and demographic characteristics of its members. A number of studies of household consumption in industrialized countries provide support for this view. Eizenga's 1961 analysis of the 1950 U.S. Survey of Consumer Expenditures is one of the first efforts to estimate the relationship of family size to saving. Controlling for household income and age and occupation of head, Eizenga finds that saving declines very substantially as family size increases from one to three members, but declines much more gradually thereafter. A number of other studies show that in industrialized countries, consumption is affected by the number of children or household size (see, for example, Somermeyer and Bannink, 1973; Espenshade, 1975; and Mason, 1975).

Unfortunately, there is very little reliable evidence on the relationship between the number of children and household saving based on survey data for developing countries. Kwang Suk Kim's 1974 study of Korea is fairly typical. His analysis of 1964-72 Korean farm household saving data classified by farm size provides no evidence that household saving is depressed by the dependency ratio (ratio of employed members to total family size). His analysis of per capita saving by urban households during 1965 to 1972 shows that the average and marginal propensities to save are inversely related to household size. Kim's study, like most of the others discussed below, is limited by a lack of data (45 observations for the rural survey, for example); it is also limited by the fact that many of the variables of potential interest are not available, and that he had to rely on published data tabulated in a way that restricts the analysis.

Peter Peek (1974) analyzes 1961, 1965, and 1971 data for the Philippines classified by region (rural, Manila, and other urban) and by income. He finds that, given household income, an increase in household size reduces household saving, but that the number of children under age 18 has no significant effect on saving.

Kelley and Williamson (1968) assess the saving behavior of 490 Indonesian households surveyed during 1958 and 1959. Although the data will not support a direct analysis of the relationship of saving to the number of children or family size, Kelley and Williamson compare the average saving of households classified into broad age categories to that predicted by simple models in which saving varies with the number of "equivalent" adults. The age variation "predicted" by the model is roughly similar to that observed for rural households headed by persons

aged 30 or older. The observed variation among urban households, however, bears no relationship to variation in equivalent household size.

Kelley (1980) analyzes the saving behavior of 400 Kenyan nuclear households during 1968 and 1969. In this study, he finds no evidence that the number of children affects household saving.

Also of some relevance to understanding the saving-population link in the developing context is an analysis of saving by households headed by employees of the U.S. iron, coal, or steel industry in 1889. Analysis by Kelley (1973) shows that saving rates decline as family size increases above two members (see also Espenshade, 1975). However, Kelley's 1976 reanalysis of the data fails to find any significant relationship between family size and saving.

Cross-National Studies

Two approaches have been taken to estimating the impact of population growth on aggregate saving. Leff (1969) and related studies have analyzed international cross-section data using a specification in which the demographic effects are captured by including dependency ratios as regressors in the aggregate saving function. The second approach employs the variable rate-of-growth effect model discussed briefly above.

Leff and Related Studies

Leff (1969) analyzes gross national saving by 74 countries in 1964, and presents evidence that the saving rate is depressed by an increase in either the youth dependency ratio, DR1 (population younger than 15/population 15 to 64), or the old age dependency ratio, DR2 (population older than 64/population 15 to 64). Leff estimates the elasticity of saving with respect to the youth dependency ratio to be -1.35 , and with respect to the old age dependency ratio to be $-.40$. Calculated and presented in Table 3 are saving ratios predicted, holding all other variables constant, using dependency ratios typical of low- and high-income countries.

Leff's results have been subject to considerable scrutiny. Adams (1971), Bilsborrow (1979, 1980), Goldberger (1973), and Gupta (1971) have raised a number of issues. First, the theoretical basis of Leff's specifications has been questioned. The use of the natural log of the saving ratio and of the rate of growth of per capita income, variables that are not always defined, is one manifestation of the specification problem. Second, it is argued that a more appropriate dependent variable is household saving, while government and business saving should not be included. Third, some critics suggest additional variables that should be included in the saving function; others question the inclusion of per capita income. Fourth, simul-

TABLE 3 Calculated Saving Ratios Employing
Leff's Estimates

Variable	Low Income	High Income
DR1	.43	.27
DR2	.04	.10
S/Y	.17	.22

Note: Y/N set to \$1,000 and g set to .03.

taneity issues have been raised. Finally, a number of questions have been raised about the use of international cross-section data, particularly the presence of sample heterogeneity. Perhaps the most damaging evidence presented to this point is Ram (1982, 1984), who presents reestimates of Leff-like saving functions based on 1970-77 cross-section data. These results provide very little support for the existence of a significant dependency ratio effect in the form specified by Leff. An extensive review of the exchanges will not be undertaken here, but the interested reader is referred also to Leff (1971, 1973, 1980, 1984).

Two other studies based on cross-national data also differ in their conclusions about the importance of population growth. Simon (1975) provides evidence that population growth has led to additional investment in irrigation systems. On the other hand, Gupta (1975) employs World Bank data for the 1960s to estimate a simultaneous equations model with a saving function that includes the dependency ratio as an independent variable. He concludes that by using a single equation approach, Leff actually underestimates the impact of the dependency ratio.

The Variable Rate-of-Growth Effect Model

Empirical results from four applications of the variable rate-of-growth effect model are summarized in Table 4. Mason (1981) analyzes international cross-section data for 1960-70, while the present study extends the analysis to the 1960-80 period. Fry and Mason (1982) analyze 1962-72 time series data for seven Asian countries, and Fry (1984) extends the analysis to include fourteen Asian countries over the 1961-81 period. In each study, the dependency ratio is found to have a significant adverse impact on saving: a decline in the dependency ratio from 0.8 to 0.4 increases the saving ratio from 3.4 to 12.2 percentage points, depending on the sample and type of data employed.

TABLE 4 A Comparison of Calculated Gross Saving Ratios from Four Applications of the Variable Rate-of-Growth Model

Source	Dependency Ratio $[N(0-14)/N(15+)]$		
	0.4	0.611	0.8
Mason (1981)	0.239	0.203	0.170
Fry and Mason (1982)	0.245	0.203	0.165
Fry (1984)	0.265	0.203	0.143
Mason (this chapter)	0.224	0.203	0.190

Notes: DR = 0.611 and S/Y = 0.203 are sample means from Mason (this chapter); intercepts for Mason (1981), Fry and Mason (1982), and Fry (1984) were adjusted to facilitate comparison. All calculated values assume a rate of growth of national income equal to the sample mean from Mason (this chapter) of 0.051.

Other Cross-National Research

The "consumer durable" role of children is the focus of most research on the fertility-saving link. With the exception of Neher (1971), Lewis (1983), and Hammer (1984), the "provider of old age security" role of children has been overlooked. Children and saving are substitutes or alternative ways that households provide for their retirement. Thus, a decline in "the rate of return" to children vis-a-vis the rate of return to financial assets should lead households to substitute financial assets for children.

Hammer develops such an approach and postulates that the improvement of financial markets in developing countries has led households to reduce their fertility while compensating with increased saving. In analyzing an international cross-section, Hammer finds that the degree of monetization does lead to lower fertility. On the other hand, his model fails to explain variation in personal saving rates. Nonetheless, his approach may be a promising way of incorporating the role of children more fully into models of saving.

LIFE-CYCLE SAVING AND THE VARIABLE RATE-OF-GROWTH EFFECT

The basic idea behind the life-cycle saving model popularized by Modigliani and his colleagues (see Modigliani, 1965, 1966; Modigliani and Ando, 1957; and Modigliani and Brumberg, 1954) is illustrated by Panel A in Figure 1, which represents the life-

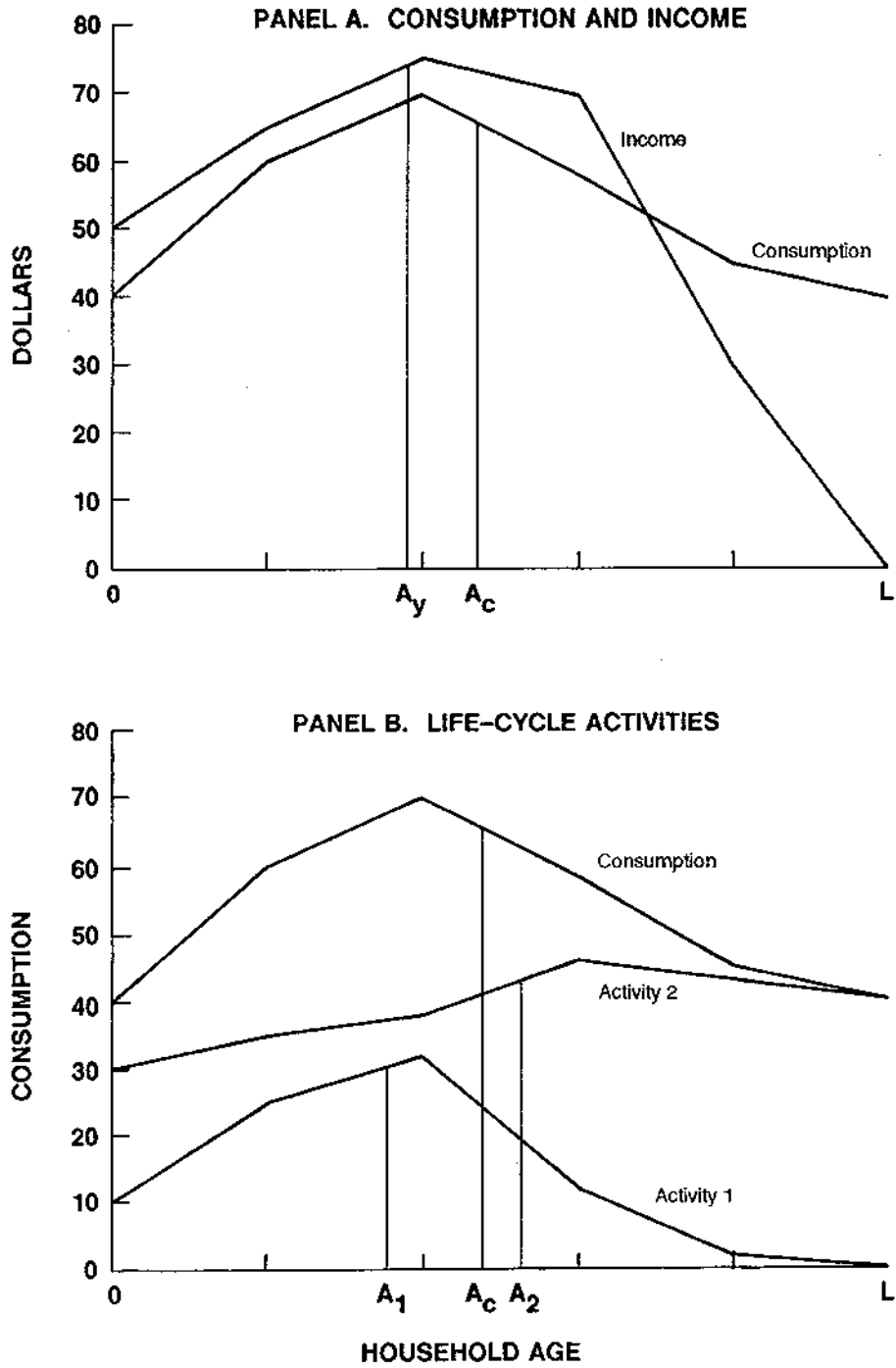


FIGURE 1 Life-Cycle Household

cycle patterns of consumption and earning of a "typical" household. Over the household's lifetime (OL measured on the horizontal axis), consumption is spread evenly, whereas earning is concentrated at preretirement years. The household saves

during periods of relatively high earning in order to maintain its consumption during periods of relatively low earning.

The household pictured accumulates no wealth over its lifetime, with dissaving during later years just matching saving undertaken during earlier years. Even so, aggregate saving will occur in an economy composed entirely of such households if that economy is growing. The reason is simple: households at each point of the life cycle are not equally represented. If the population is a growing one, the young, saving households outnumber the old, dissaving households; if per capita income is growing, young households have greater lifetime income than do their elders. Hence, the absolute amount saved by the average young household will exceed the absolute amount dissaved by the average old household at any point in time. Effects of both population and per capita income growth can be captured by the growth rate of total income because, in equilibrium, the latter measures the differences, across successive cohorts, of total cohort lifetime earning.

The magnitude of the rate-of-growth effect, that is, the effect on saving of a change in the rate of growth in national income, depends on the extent to which household consumption lags household earning. The consumption lag is measured by the difference between the average age of consumption, A_C , and the average age of earning, A_Y , both of which are identified in Figure 1. The aggregate consumption ratio is given by

$$\ln c = a_0 + (A_Y - A_C)g, \quad (1)$$

where g is the rate of growth of national income and c , of course, is one minus the national saving ratio.³

Although the consumption lag has traditionally been treated as constant,⁴ recent research recognizes that the lag and hence the rate-of-growth effect are variable--responding to changes in childbearing (Mason, 1981; Fry and Mason, 1982), interest rates (Fry and Mason, 1982), retirement programs (Modigliani and Sterling, 1983), and other factors that affect the life-cycle pattern of consumption or earning and their mean ages, A_C and A_Y .

This chapter introduces a formal treatment of life-cycle consumption and the determinants of variation in the consumption lag. The essence of the model is captured by Panel B of Figure 1. The household participates in two activities--childrearing and all other activities. The age patterns of the activities (and their average ages, A_1 and A_2) are given, determined by technological considerations rather than by prices or household income. Expenditures on each activity and total expenditures are plotted against household age. The average age of consumption, A_C , varies depending on the household's allocation of its budget between the two activities: the greater the budget share of activity 1 (childrearing), the younger the average age of consumption; the greater the share of activity 2, the older the average age of consumption. As is shown in the Appendix, the average age of consumption can be calculated by

$$A_C = s_1A_1 + s_2A_2 . \quad (2)$$

A_C is a weighted average of activity ages where the weights are the budget shares s_1 and s_2 . Substituting $1-s_1$ for s_2 ,

$$A_C = s_1(A_1 - A_2) + A_2 . \quad (3)$$

The average age of consumption is determined by the share devoted to childbearing and the number of years, on average, by which expenditures on childrearing precede expenditures on other household activities.

In an algebraic sense, the budget share is determined by the price of children relative to adults (P_1/P_2) and the quantity of children relative to the quantity of adults (Q_1/Q_2). The childrearing share is calculated as

$$s_1 = \frac{P_1Q_1}{P_1Q_1 + P_2Q_2} = \frac{pq}{1 + pq} , \quad (4)$$

where p is the relative price of children and q is the relative quantity of children. In a behavioral sense, however, the relationship between share and quantity may be more complex because q and p need not be independent. The analysis carried out below distinguishes two cases.

Case I. Constant price (the equivalent adult consumer unit case). The simplest and most common approach to modeling the relationship of children to household consumption uses the equivalent adult consumer unit. Expenditures per child are held to be a constant fraction of expenditure per adult, with values used ranging from 0.1 upward. In terms of the model employed here, the relative price of children, p , is identical to the equivalent adult consumer unit. In this case, equation (4) describes the relationship of share to quantity. An increase in q unambiguously increases the share devoted to childrearing, with the magnitude depending on the value of the relative price.

Case II. Changing price and the demand for children. A more general representation of the relationship between share and quantity recognizes that the relative price of children may change and with it the number of children reared. The impact of price changes on the childrearing budget share will depend on the elasticity of demand. Figure 2 illustrates two possibilities. If demand is elastic, as is the case for the demand curve labeled DA, a relatively small price increase elicits a large decline in q and a decline in the share devoted to childrearing (judged by comparing the demand curve to the iso-share line). If, on the other hand, demand is inelastic, the case for DB, the price increase necessary to induce the observed decline in quantity is so large that the childrearing budget share actually increases.

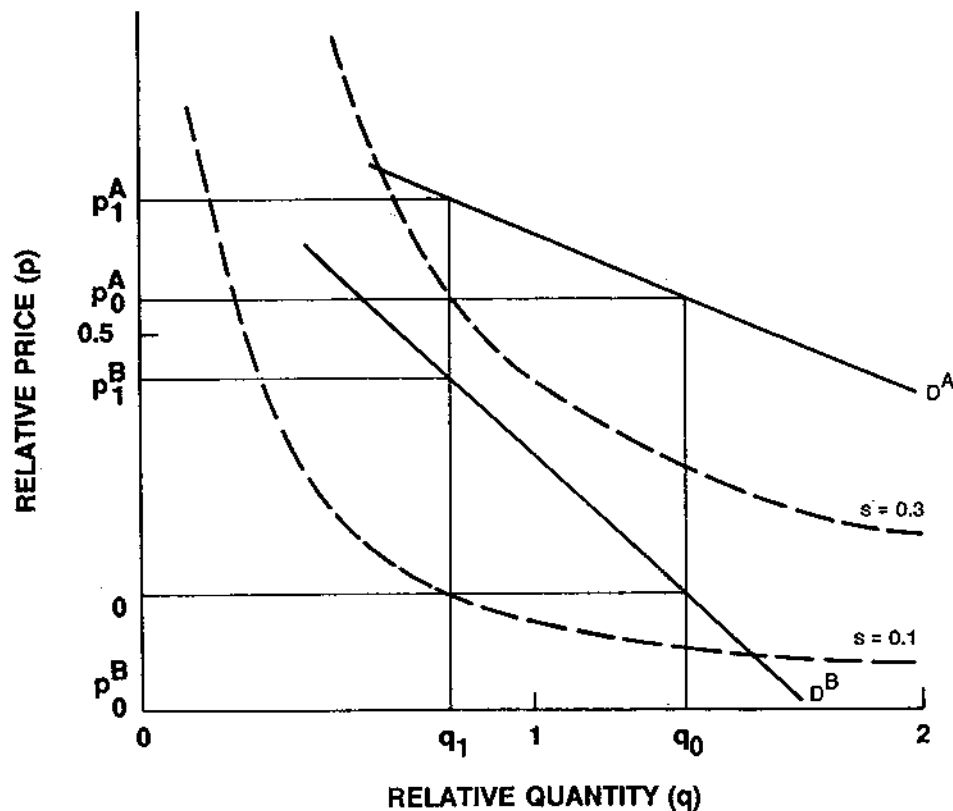


FIGURE 2 Relationship Between Budget Share, Elasticity of Demand, and Demand Price

In practice, the quantity of children will change in response to both shifts in the demand for children and relative price changes. Shifts in the demand curve will unambiguously affect the budget share, while movements along the demand curve will affect the budget share in keeping with the elasticity of demand. Thus, the relationship of the budget share to the relative quantity of children rests on two issues: (1) the extent to which fertility has declined as a consequence of changes in relative price as opposed to other factors, such as improved mortality conditions, family planning programs, and higher female education; and (2) to the extent the price changes are important, the elasticity of demand for children. On these issues also rests the extent to which a decline in the number of children reared increases the aggregate saving rate.

AN APPLICATION TO INTERNATIONAL CROSS-SECTION DATA

Equations (1) and (3) are readily combined to yield a consumption function amenable to estimation. Substituting for the mean age of consumption in equation (1) and rearranging terms, the consumption function is

$$\ln c = a_0 + s_1(A_2 - A_1)g + (A_y - A_2)g . \quad (5)$$

The difference between the average age of childrearing and other activities, $A_2 - A_1$, is represented by dA ; the difference between the average age of household earning and other activities, $A_y - A_2$, is estimated as a parameter of the model and is represented by b_2 . The childrearing budget share is approximated⁵ by

$$s_1 = a_1 + b_1 \ln q . \quad (6)$$

Substituting into equation (5), the aggregate consumption function is

$$\ln c = a_0 + [a_1 + b_1 \ln q] dA g + b_2 g . \quad (7)$$

The constant term a_0 , as explained in the Appendix, contains two additive components: approximation error plus a behavioral component. If the error component is relatively small, a_0 will approximate the natural log of the average household's lifetime consumption ratio; in this case, a_0 will take a small negative value (the $\ln 0.9 = -0.105$, for example). The relationship between the childrearing budget share and the relative quantity of childrearing is discussed above. In either the equivalent adult consumer unit case or the elastic demand case, $b_1 > 0$. As measured here, q essentially has an upper limit of 1 and $\ln q$ of 0, so that a_1 is an estimate of the maximum share devoted to childrearing if $b_1 > 0$. In the inelastic demand case, $b_1 < 0$, and a_1 is an estimate of the minimum share devoted to childrearing. In the unitary elasticity of demand case, $b_1 = 0$, and a_1 is an estimate of the constant share devoted to childrearing. In accordance with the life-cycle model, the average age of earning should be exceeded by the average age of adult consumption; thus the coefficient of g , b_2 , is expected to be negative.

No direct statistical test is used to determine whether the equivalent adult consumer model is consistent with the data. However, calculated values for p are easily obtained given values of q and calculated shares. Rearranging equation (4),

$$p = s_1 / (q - s_1 q) . \quad (8)$$

The calculated price is an estimate of the equivalent adult consumer unit; the discussion below assesses the extent to which it varies with number of children reared.

Variables and Data

The quantity of childrearing activities, Q_1 , is measured by the number of children (under age 15) per household. The quantity of other activities, Q_2 , is measured by the number of adults (15 years and older) per household. Thus, the ratio of

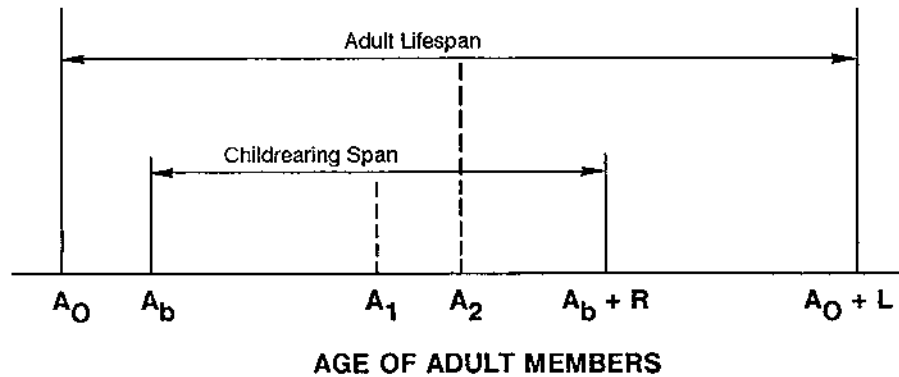


FIGURE 3 The Timing of Household Activities

the two quantities, q , is equal to the dependency ratio, the number of children per adult.

The approach taken to measuring dA is explained with the aid of Figure 3, which shows the timing of adult and childrearing activities. Households are formed by a group of adults, aged A_0 with a given lifespan of L . If adult consumption is distributed symmetrically with respect to age, then

$$A_2 = A_0 + L/2 . \quad (9)$$

A_0 is set to 20, and L is set to the average life-expectancy at 20 for the countries included in the sample.⁶

Children are born to adults aged A_b . The childrearing span is equal to R , and if child consumption is distributed symmetrically with respect to age, then

$$A_1 = A_b + R/2 . \quad (10)$$

A_b is measured by an estimate of the mean age at childbearing (see the Appendix for details), and R is determined by the level of enrollment observed in each country. Specifically,

$$R = 12 + 6*ENR2 + 4*ENR3 , \quad (11)$$

where $ENR2$ and $ENR3$ are the second- and third-level enrollment ratios; 12 years is the assumed minimum childrearing span; and 6 and 4 years are the durations of secondary school and college, respectively.

Analyses employing two measures of the consumption ratio are reported below. Because other cross-national studies use gross national saving as the dependent variable, the present study uses the "gross" consumption ratio equal to consumption (both private and government) divided by gross national income. The discussion focuses, however, on results obtained using consumption as a fraction of net national income, 1 minus the net national saving ratio, as the dependent variable.⁷

TABLE 5 Calculated Shares and Prices of Children

Dependency Ratio	Gross Estimates		Net Estimates	
	Share	Price	Share	Price
0.3	.18	.71	.15	.59
0.5	.29	.80	.21	.55
0.7	.36	.80	.26	.49
0.9	.41	.78	.29	.45

Estimates based on gross national saving rates imply a very stable relative price of children quite in keeping with the equivalent adult consumer unit model. However, the estimated value of the equivalent adult consumer unit of close to 0.8 is somewhat higher than the values typically employed by other researchers. The estimated value of EACU (0.45 to 0.6) obtained from analyzing net national saving is more in keeping with other research. However, the variation in relative price suggests that changes in childrearing are, in part, a consequence of changes in relative price. There is nevertheless no way to judge on the basis of this analysis the extent to which fertility change is a consequence of relative price changes versus changes in exogenous factors. This is an issue to which we will return below.

The impact on saving of changes in the dependency ratio and the rate of growth of national income are assessed using Table 6, which reports calculated values of the saving ratio. The rate-of-growth effect, with the dependency ratio and dA set to their sample means, is close to one; an additional percentage point in growth yields roughly one additional percentage point of saving. Given a very high dependency ratio, say of 0.9, saving is much less influenced by growth: an additional percentage point in growth yields only one-half a percentage point in additional saving. By contrast, a very low dependency ratio of 0.3 yields a rate-of-growth effect in excess of one and one-half additional percentage points in saving for each percentage point in growth. These results are similar to those reviewed by Mikesell and Zinser (1973), but somewhat below estimates from previous applications of the variable rate-of-growth effect model (Mason, 1981; Fry and Mason, 1982).

The impact of a decline on childrearing depends on the rate of growth of income. Given no growth, rates of saving are independent of the dependency ratio. By contrast, given a 10 percent rate of growth per year, a decline in the dependency ratio from 0.9 to 0.3 generates an additional eleven percentage points of

TABLE 6 Calculated Saving Ratios

Dependency Ratio	Rate of Growth of GNP					
	0.00	0.02	0.04	0.06	0.08	0.10
Gross Saving Ratios						
0.3	0.155	0.198	0.239	0.278	0.314	0.349
0.5	0.155	0.180	0.206	0.230	0.253	0.276
0.7	0.155	0.169	0.183	0.197	0.210	0.223
0.9	0.155	0.160	0.166	0.171	0.176	0.182
Net Saving Ratios						
0.3	0.086	0.122	0.156	0.189	0.221	0.252
0.5	0.086	0.111	0.135	0.159	0.182	0.204
0.7	0.086	0.103	0.121	0.138	0.155	0.171
0.9	0.086	0.098	0.110	0.122	0.134	0.145

saving. Given the average rate of growth for the sample of about 5 percent per year, a decline from a high-childrearing to a low-childrearing regime produces an increase in the net saving ratio of about five percentage points--roughly a 50 percent increase. Thus, the population dependency ratio has a substantial impact on saving given a moderate to high rate of economic growth.

The Source of Fertility Change and the Saving Ratio

The estimates reported above are based on a model in which the share of the household budget devoted to childrearing is determined solely by the number of children reared relative to the number of adults. Such an approach is convenient in that it provides a straightforward summary of the statistical relationship between aggregate consumption and the dependency ratio--one that can be compared to estimates from previous studies. For several reasons, however, the approach is not entirely satisfactory.

First, the results have a clear theoretical basis only if tastes and other exogenous factors affecting the demand for children are constant. In this case only, the specification of the share equation employed above can be obtained from a utility function consistent with the basic tenets of consumer theory. International differences in childrearing may be attributed, in part, to differences in the price of children. However, a variety of nonprice factors undoubtedly play a key role.

Second, by failing to model explicitly the "instruments" by which fertility and, hence, the dependency ratio change, the model estimated above has limited policy applications. On

theoretical grounds, the effect of reduced fertility on the aggregate saving ratio should vary depending on the means by which a fertility reduction is achieved: fertility decline accomplished via nonprice policies unambiguously reduces the share devoted to childrearing and increases aggregate saving; fertility decline induced via price changes has an ambiguous impact on saving that depends on the elasticity of demand.

A further difficulty with the simpler model is that the statistical relationship between the dependency ratio and aggregate saving will vary depending on the source of the observed variation in the dependency ratio. If the model employed fails to distinguish price and nonprice determinants of fertility, empirical results can vary substantially depending on the nature of the sample at hand.

A more complete analysis is possible if the demand for children is explicitly introduced. The demand schedule uniquely identifies combinations of p and q given exogenous determinants, while changes in the exogenous determinants shift the demand curve for children. The demand price for children is given by

$$p = f(q, x) , \quad (13)$$

where x is a vector of exogenous determinants. Substituting for price in equation (4), the budget share is a function of q and x , that is,

$$s = \frac{f(q, x)q}{1 + f(q, x)q} . \quad (14)$$

Complete specification of the share equation can proceed only if the form of the demand function is known. Analysis here is based on the share equation associated with the direct homogeneous translog utility function (Christensen et al., 1975). The budget share is given by

$$s = b_0 + b_1 \ln q + b_2 x_1 + \dots$$

The impact on share of a change in quantity, given exogenous factors, is determined by the elasticity of demand. If demand is inelastic, $b_1 < 0$; if demand is elastic, $b_1 > 0$; and if demand has unitary elasticity, the null case, $b_1 = 0$. The partial effect of any exogenous factor, x , on share depends on the change in the demand price for specified quantities that results from shifts in the demand schedule. If demand shifts to the right in response to a change in x , a higher demand price and a higher budget share will prevail at each quantity. Thus, the coefficient of factors that increase the demand for children will be greater than zero; for factors that reduce the demand for children, the coefficient will be less than zero.

Four factors that affect fertility are included: the proportion of the adult population that is literate (LIT); the proportion of the labor force employed in agriculture (LFAG); a dummy variable equal to one for countries in which the dominant culture

and/or religion (Islamic or Catholic) is pronatalist (REL); and a time variable (YEAR, equal to 0 for 1960-70 observations). (For more information on these variables, see the Appendix.) The equation estimated is

$$\ln c = a_0 + [b_0 = b_1 \ln DR + b_2 LIT + b_3 LFAG + b_4 REL \quad b_5 YEAR] * dA * g + a_1 g . \quad (15)$$

The interpretation of a_0 and a_1 is unaffected by the inclusion of additional determinants of the budget share. The term b_0 , however, no longer has a useful interpretation. An increase in education or a decline in the labor force in agriculture should lead to a downward shift in the demand for children. Pronatalist countries should have a higher demand for children. The secular trend in the demand for children should be downward, capturing Caldwell's "westernization" process and/or the impact of family planning programs. Thus, the coefficients of LIT and YEAR should be negative, while the coefficients of LFAG and REL should be positive. For a detailed discussion of the relationship of these factors to fertility and, hence, the dependency ratio, the interested reader is referred to the vast literature. Estimated coefficients and standard errors are as follows:

$$\begin{aligned} \ln c_1 = & -0.171 + [0.024 + 0.089 \ln DR + 0.133 LIT + 0.391 LFAG \\ & (0.010) \quad (0.165) \quad (0.046) \quad (0.053) \quad (0.077) \\ & + 0.051 REL - 0.0076 YEAR] * dA * g - 3.294 g . \quad (16) \\ & (0.021) \quad (0.0022) \quad (1.389) \end{aligned}$$

$$R^2 = .431 \quad N = 154$$

$$\begin{aligned} \ln c_2 = & -0.093 + [0.021 + 0.053 \ln DR + 0.120 LIT + 0.263 LFAG \\ & (0.009) \quad (0.153) \quad (0.042) \quad (0.050) \quad (0.073) \\ & + 0.040 REL - 0.0058 YEAR] * dA * g - 2.849 g . \quad (17) \\ & (0.020) \quad (0.0022) \quad (1.300) \end{aligned}$$

$$R^2 = .337 \quad N = 157$$

Empirical results are generally consistent with the model proposed. Of the exogenous determinants of the dependency ratio, the effects of LFAG, REL, and YEAR are in the expected direction and significantly different than zero. The coefficient of g is significantly less than zero, as expected. The coefficient of the dependency ratio is small, positive, and not significantly different from zero, consistent with an elasticity of demand near unity.

LIT, contrary to our expectations, is significantly greater than zero. There are a number of plausible explanations for this positive effect. First, the measure does not distinguish female from male education, which may have a positive effect on fertility. Second, the relationship may be spurious, picking up the effect of excluded variables. Child mortality is an obvious

example of such a variable.⁸ Of course, even direct estimates of the determinants of fertility, based on international cross-sections, generally fail to untangle the various effects of education, urbanization, religion, etc. (see Hazeldine and Moreland, 1977, for example). It is hardly surprising, then, that an indirect approach is not entirely successful. In any case, the results will not support an analysis of the effect on saving of any particular antinatalist policy.

A somewhat less demanding issue can be addressed: the effect of price- versus nonprice-induced changes in the dependency ratio. Figure 4 presents calculated demand curves obtained by varying dependency ratios, holding other determinates of the budget share constant. The budget share devoted to childrearing is obtained and the relative price of children calculated using equation (4). Two demand curves are shown: the demand curve labeled "nonindustrialized" is calculated using sample means for countries with a GNP per capita in 1973 under \$1,000; the other demand curve, "industrialized," is calculated using sample means for countries with an income exceeding \$1,000. Also shown in the figure are the average dependency ratios of the two subsamples and the implied prices. This figure illustrates several key points. It is quite clear that the difference in fertility observed between the industrialized and nonindustrialized countries is not the consequence of a difference in the price of children. The price of children evaluated at the means for both samples is about one-third. Differences in the quantity of

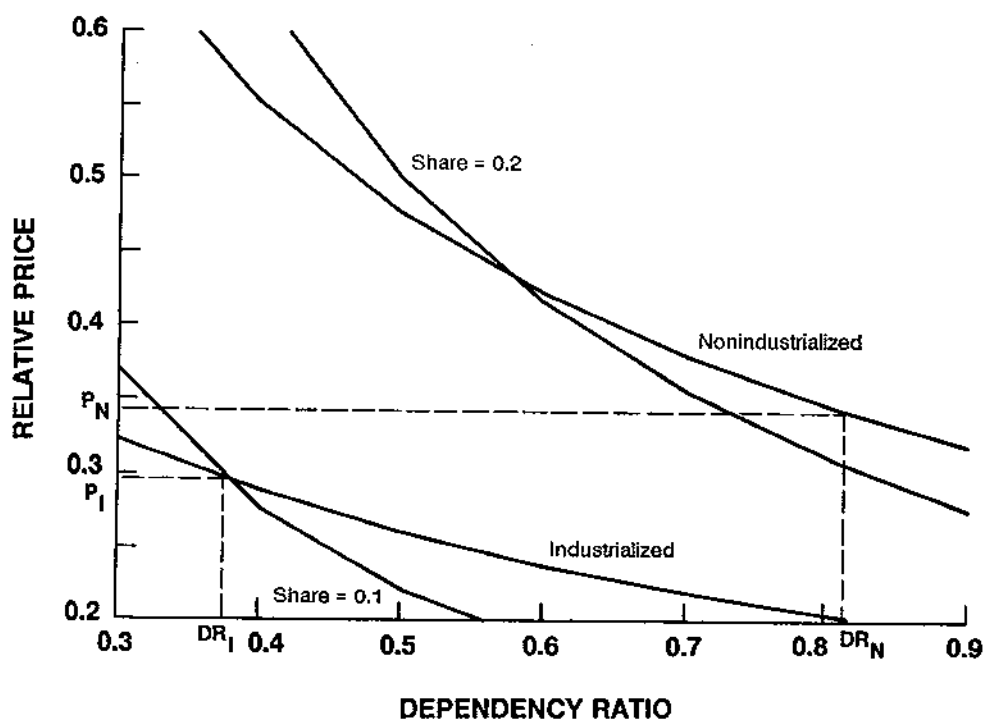


FIGURE 4 Demand for Children

TABLE 7 Calculated Net National Saving Ratios
for Industrialized and Nonindustrialized Countries

Rate of Growth	Industrialized (low fertility)	Nonindustrialized (high fertility)
.02	.124	.106
.04	.158	.122
.06	.190	.139
.08	.221	.155
.10	.251	.170

childrearing are dominated by shifts in the demand for children. This "finding" will come as no surprise to students of fertility change. Nonetheless, it is critical to our finding that a decline in fertility is accompanied by a decline in the budget share devoted to childrearing.

Aside from their implication for aggregate saving, the estimate of the equivalent adult consumer unit and the finding that it does not vary substantially with economic development are interesting results in their own right. Although simulation studies cited earlier have used the equivalent adult consumer unit, no estimate based on aggregate consumption data has yet been available. Furthermore, no evidence has been presented that so simple an approach has any empirical validity in comparing countries at different stages of development. The evidence presented here indicates that the idea that adults and children share resources in fixed proportions has more than intuitive appeal. The equivalent adult consumer unit approach provides a fairly accurate description of differences between the industrialized and nonindustrialized countries.

The effect on saving of the shift in the demand for children shown in Figure 4 is substantial. The share of the budget devoted to children declines from over 20 percent to just at 10 percent for the industrialized countries. At the mean rate of growth of national income, the calculated net national ratio rises from 13.5 percent to 18.2 percent. The impact of the shift in the demand for children at other rates of growth is shown in Table 7. Again for moderate- and high-growth economies, a decline in the dependency ratio has a substantial effect on saving.

Robustness of Findings

Critics of cross-national studies of saving and population growth have focused, in particular, on two issues: (1) the inclusion of government saving or consumption in the dependent variable, and (2) the sensitivity of results to sample selection. These issues are addressed in this section.

Are Government and Private Saving Perfect Substitutes?⁹

Studies of aggregate saving or consumption are frequently criticized for their choice of dependent variable. Bilsborrow (1979, 1980), in his critiques of Leff's analysis, argues for a narrow concept--household saving. That such an approach is unattractive is evident when it is examined from the perspective employed here. Current consumption is "constrained" by lifetime resources, and whether those resources are paid in the current period as wages, distributed as profits, or retained by corporate (or unincorporated) enterprises is irrelevant. On a priori grounds, then, private consumption is preferable to household saving. On the other hand, it is arguable that government and private saving are perfect substitutes. The analysis that follows shows that, other things being equal, private saving (or its consumption counterpart) should be employed. However, there are costs to doing so, because data on private saving are not available for many low-income countries. Analysis shows that using national saving as a dependent variable may not result in substantially biased estimates.

The traditional application of the life-cycle model focuses on private consumption, C_p , as a fraction of disposable income, that is,

$$C_p = MPC [Y - T] , \quad (18)$$

where Y is national income, T is taxes net of transfers, and the marginal propensity to consume is MPC . This approach has recently been challenged by Barro, who argues that government deficits, D , are indistinguishable from taxes in their impact on private consumption, so that

$$C_p = MPC [Y - T - D] . \quad (19)$$

If Barro's model is employed, government saving ($-D$) and private saving are close substitutes depending on the MPC .

The model used above implies that government and private saving are perfect substitutes. The government acts as an agent of households, so that government and private consumption together are "constrained" by total national income, that is,

$$C_p + C_g = MPC[Y] . \quad (20)$$

Noting that C_g is equal to $T + D$, dividing both sides by Y , and using lower case letters to represent the resulting ratios, a general model of consumption is given by

$$C_p = MPC[1 + a_1t + a_2d] , \quad (21)$$

where the three models differ with respect to the values of a_1 and a_2 :

Model	a ₁	a ₂
Life-cycle	-1	0
Barro	-1	-1
Mason	-1/MPC	-1/MPC

It is not possible to test directly the validity of all three specifications from the general model. A second model will be estimated, however, to analyze the approach employed here:

$$C_p = MPC + a_1 t + a_2 d, \quad (22)$$

where the Mason specification is consistent with $a_1 = a_2 = -1$. A somewhat simpler specification of the marginal propensity to consume than that employed above is used:

$$\ln MPC = b_0 + b_1 g \ln DR + b_2 g. \quad (23)$$

This differs from the specification employed above in that the difference in the ages of consumption, dA , is subsumed in the coefficient $b_1 \approx s_1 dA$ and the intercept term, b_0 .

The alternative models are estimated applying nonlinear least squares to the 96 observations, out of the full sample, for which the required additional data are available. Equation (24) presents the LCH-Barro model:

$$C_p = \exp[-0.081 - 0.532g + 0.953 g \ln DR] [1 - 1.019t - 0.290d] \\ (0.031) \quad (0.299) \quad (0.306) \quad (0.101) \quad (0.181) \quad (24)$$

$$N = 96 \quad -2 \lambda = 167.59$$

The results are consistent with the "pure" LCH ($a_2 = 0$) or with substantial substitution between government and private saving. We can reject the "pure" Barro specification, however.

Equation (25) presents the Mason specification:

$$C_p = \exp[-0.086 - 0.503g + 0.714g \ln DR] - 0.909t - 0.273d \\ (0.028) \quad (0.226) \quad (0.240) \quad (0.106) \quad (0.160) \quad (25)$$

$$N = 96 \quad -2 \lambda = 167.90$$

Again the traditional LCH approach is clearly more consistent with the data than is the approach using national saving as the dependent variable. A deficit ratio coefficient of -1 is soundly rejected by the data. Thus, using national saving as a dependent variable gains efficiency, by enlarging the sample, at the expense of introducing specification error. How serious is the error? Equation (26), in which equation (25) is reestimated with a_2 and a_3 constrained to -1, provides some evidence on the issue:

$$c = c_g + c_p = \exp[-0.100 - 0.790g + 0.757g \ln DR] \quad (26)$$

(0.015) (0.251) (0.287) .

$$N = 96$$

$$-2 \lambda = 152.134$$

As compared with equation (24), employing the total consumption ratio as the dependent variable leads to an estimate of the impact of the dependency ratio and an estimate of the partial effect of g , evaluated for possible values of DR , that are closer to zero. Thus, available evidence suggests that the standard approach, using national saving, may underestimate the importance of demographic factors.

Sensitivity to Sample Selection

Previous studies of the dependency ratio-saving link have noted the sensitivity of the results to both sample selection and the inclusion of additional variables. The analysis carried out above provides one explanation of the sensitivity of previous results. Nonetheless, estimates of the model employed here are sensitive to sample selection. Table 8 reports estimates of the consumption function obtained by fitting equation (15) to the two subsamples--industrialized and nonindustrialized countries--referred to above. The effect of the dependency ratio in industrialized countries is quite similar to that found for the all-country sample; for nonindustrialized countries, however, the effect of the dependency ratio is significantly less than zero, consistent with an inelastic demand for children. Where significantly different than zero, the effects of other determinants of the budget share are in the expected direction. For the industrialized sample, literacy and the trend variable lead to a lower budget share; in the nonindustrialized countries, the labor force in agriculture, religion, and the trend variable are significant and have the expected impact on the share.

If the equations are evaluated at their respective sample means, the calculated childrearing share for nonindustrialized countries substantially exceeds that for industrialized countries. In general, this supports the conclusion reached above--that shifts in the demand curve reduce both fertility and budget share devoted to childrearing, and hence increase the aggregate saving ratio. However, the differences in the shares are implausibly large. The estimates based on the subsamples will not support the demand analysis carried out for the full sample. Calculated shares frequently exceed one for the nonindustrialized countries and are negative for the industrialized countries.

NEOCLASSICAL GROWTH AND SAVING

The analysis of the dependency ratio carried out above is a partial one. The effect of the dependency ratio is estimated given the rate of growth of national income. Changes in the

TABLE 8 Results from Extended Analysis; Coefficients and Standard Errors (in parentheses)

Dependent Variable	Industrialized		Nonindustrialized	
	Gross Consumption	Net Consumption	Gross Consumption	Net Consumption
a ₀	-0.168 (0.020)	-0.086 (0.017)	-0.167 (0.012)	-0.093 (0.011)
b ₀	0.384 (0.293)	0.160 (0.246)	0.368 (0.384)	0.669 (0.304)
ln DR	-0.062 (0.086)	-0.048 (0.072)	-0.239 (0.144)	-0.225 (0.097)
LIT	-0.719 (0.324)	-0.446 (0.272)	0.078 (0.066)	0.088 (0.060)
LFAG	0.101 (0.188)	-0.013 (0.158)	0.341 (0.110)	0.274 (0.100)
REL	-0.028 (0.047)	-0.041 (0.039)	0.079 (0.033)	0.088 (0.031)
YEAR	-0.0116 (0.0039)	-0.0078 (0.0032)	-0.0050 (0.0028)	-0.0050 (0.0024)
g	0.247 (1.426)	0.485 (1.194)	-7.048 (3.702)	-9.765 (2.974)
N	67	67	87	90
R ²	0.387	0.404	0.315	0.417

rate of growth of population may affect both the dependency ratio and the rate of growth of aggregate income. The discussion below employs the neoclassical growth model to broaden the analysis of saving and, at the same time, to examine the impact of population growth on capital output ratios and output per worker. Although the chief attraction of the analysis is its simplicity, the comparative static results presented below are primarily of academic interest because steady state results obtain over such extended periods that they are of little value in framing economic policy. Unfortunately, there are no widely accepted models that capture the short-run effects of population growth on growth of per capita income. Research conducted on this subject finds that growth in aggregate income does not generally decline point-for-point with population growth. Thus, the neoclassical model is a very conservative approach to the impact of population growth.

The analysis follows Solow (1956), with exogenous labor augmenting technological growth. Output is a linearly homogeneous function of capital and effective labor, E , so that output per effective worker, y , depends only on capital per effective worker, k ; that is,

$$y_t = f(k_t) , \quad (27)$$

where $f' > 0$ and $f'' \leq 0$. The effective labor force grows at rate $\lambda + n$, where λ is the growth in effective labor per worker and n is the growth of the labor force (and the population). Letting $\dot{}$ stand for the growth rate,

$$\dot{E}_t = \lambda + \dot{L}_t = \lambda + n . \quad (28)$$

The growth of the capital stock is determined by the saving ratio and the ratio of output to capital; that is,

$$\dot{K}_t = s_t Y_t / K_t = s_t y_t / k_t . \quad (29)$$

Equilibrium is attained with $\dot{k}_t = \dot{y}_t = 0$. Because \dot{k}_t is equal to

$$\dot{k}_t = \dot{K}_t - \dot{E}_t = s_t y_t / k_t , \quad (30)$$

the equilibrium capital-output ratio $(k/y)^*$ is equal to

$$(k/y)^* = s^* / (\lambda + N) . \quad (31)$$

The equilibrium saving ratio, s^* , is determined by $g = \lambda + n$ and the dependency ratio associated with n employing the consumption function estimated above.

TABLE 9 Equilibrium Saving and Capital-Output Ratios for Selected Values of λ and n

n	$A_y - A_c$	$\lambda = 0$		$\lambda = .02$		$\lambda = .04$	
		s^*	$(k/y)^*$	s^*	$(k/y)^*$	s^*	$(k/y)^*$
0.00	-2.0	0.085	--	0.121	6.0	0.155	3.9
0.01	-1.4	0.098	9.8	0.123	4.1	0.147	2.9
0.02	-1.0	0.103	5.2	0.121	3.0	0.138	2.3
0.03	-0.7	0.104	3.5	0.117	2.3	0.129	1.8

Note: Saving ratios are calculated using $\ln c = -0.089 + (A_c - A_y)$, where the relationship of the consumption lag to the dependency ratio is based on the net consumption variant of equation (27) with dA set at its sample mean. The values of DR used at the selected population growth rates are based on Mason (1981).

TABLE 10 Equilibrium Output Per Worker

n	$\lambda = .00$	$\lambda = .02$	$\lambda = .04$
0.00	--	167e.02t	149e.04t
0.01	174	137e.02t	129e.04t
0.02	124	115e.02t	113e.04t
0.03	100	100e.02t	100e.04t

Note: Cobb-Douglas production function with capital elasticity of 0.35 is used to calculate output per worker ratios.

Table 9 shows calculated saving ratios and capital-output ratios for selected values of n and λ . Table 10 provides an index of output per worker where the Y/L is set to 100 for $n = 0.03$.

Table 9 demonstrates that, given slow productivity growth, the rate-of-growth effect dominates the dependency effect; higher population growth leads to higher saving. In the extreme case, $g = 0$, a change in the dependency ratio has no impact on saving at all, and the rate-of-growth effect necessarily dominates. At higher values of g , the dependency effect is of greater importance and eventually dominates the rate-of-growth effect; thus, increased population growth leads to reduced saving.¹⁰

For all values of productivity growth, an increase in the population growth rate leads to a decline in equilibrium capital/output and output/worker ratios. On a percentage basis, the high-productivity-growth economies have the smallest differentials in output per worker. For $\lambda = 0.04$, output per worker for the ZPG case is 50 percent above that obtained when $n = .03$. In absolute terms, of course, differences in output per worker will be greater the higher the growth in productivity.

The association between the capital/output and output/worker ratios and the rate of population growth is a consequence of the capital-dilution effect. If higher population growth leads to higher saving, as is the case for low values of g , the capital-dilution effect is offset. If, on the other hand, higher population growth leads to higher saving, the capital-dilution effect is compounded. Were the saving ratio constant at 0.129 for $\lambda = 0.04$, for example, the capital/output ratio and index of output per worker, given ZPG, would be 3.2 and 137 versus the table values of 3.9 and 149.¹¹

CONCLUSIONS

Available evidence from the international cross-section supports the proposition that a higher dependency ratio leads to lower saving, particularly among countries with moderate to high rates

of income growth. At the mean rate of growth observed over the last two decades for the seventy countries analyzed here, a decline from a high- to a low-childbearing regime generates an increase in the net national saving rate of about five percentage points--nearly a 50 percent increase. In addition to this central finding, the results reported above also address the magnitude and validity of the equivalent adult consumer unit. Aggregate consumption data imply an equivalent adult consumer unit of about one-third, a value surprisingly constant across the stage of development. This analysis implies that simulation models based on the equivalent adult consumer unit can provide useful insights about the relationship between population growth and aggregate consumption and saving rates.

There are a number of important issues, however, that are not adequately addressed by the preceding analysis. For one, the analysis presented here does not fully resolve the issue of the relative importance of the rate-of-growth and dependency effects. The importance of the population rate-of-growth effect is determined in part by the impact of the rate of population growth on the rate of growth of national income. The analysis above is based on the neoclassical growth model, for which the equilibrium rate of growth of national income increases point-for-point with an increase in the rate-of-growth of population. If, however, the growth rate of per capita income is inversely related to the population growth rate, the population rate of growth effect is overstated by the above analysis. Given the long periods required to adjust from one equilibrium to another, the steady-state results of the neoclassical model may have limited relevance to the design and evaluation of development and population policy. Furthermore, there is no consensus that the neoclassical model accurately describes the relationship of population growth to national income, even in the long run.

Further, although the model proposed here clearly delineates the link between children, household saving, and national saving, the role ascribed to children is limited. The model acknowledges only that children require household resources for their support. A more complete analysis would focus, as well, on the varied institutions by which households provide for their old age security. The mechanism emphasized here is the accumulation of financial assets. No attention has been paid to old age support provided by children, or to investment in the human resources of children by parents as a substitute for the accumulation of financial assets. Furthermore, in many developed countries, governments play an increasingly pervasive role in the provision of old age security, further clouding the relationship between children and saving. A more comprehensive model of saving should acknowledge the joint determination of investment in human resources and the accumulation of financial resources and their dependence on publicly funded social insurance schemes.

Although this study relies entirely on aggregate-level data, the findings are verifiable, in principle, at the micro level as well. The critical relationship is that of the number of children to the average age of consumption. Unfortunately, few

studies of the impact of household composition on household consumption or saving have been conducted in developing countries. Furthermore, most studies tend to emphasize the impact of current composition on current consumption. Analysis of the timing of consumption requires estimates of the impact of children on the entire age-consumption profile, or alternatively, analysis of the impact of children on current assets. Until richer survey data are available and analyzed, the importance of demographic factors to national saving rates is likely to be the subject of continued debate.

NOTES

- 1 This is a point made by Kelley (1968, 1973, 1976, 1980), as well, in his analysis of micro data.
- 2 Lewis does not consider the impact of fertility on the subsequent age distribution of the adult population. Thus, his analysis does not admit the rate-of-growth effect.
- 3 See the Appendix for the derivation.
- 4 Empirical studies show that a one percentage point increase in growth generates between one and four percentage points worth of saving, consistent with a lag between earning and consumption averaging 1 to 4 years (Mikesell and Zinser, 1973).
- 5 The choice of this particular functional form is clarified below. It is based on the direct homogeneous translog utility function (Christensen et al., 1975).
- 6 L is not allowed to vary from observation to observation, because an adequate modeling of the role of mortality would recognize that all timing variables are affected by mortality change.
- 7 The use of gross national saving as a dependent variable has been criticized by Bilsborrow and others, who argue that either private saving or household saving would be more appropriate to the household model on which the empirical studies are based. Using household saving as the dependent variable would be appropriate if for some inexplicable reason, lifetime wealth, as perceived by households, were not affected by undistributed corporate profits. In the absence of evidence to support this view, most studies of life-cycle saving have not analyzed household saving. The choice between private and total net saving is a more ticklish affair, given the considerable interest in the impact of government deficits on private consumption. Barro (1974) provides the theoretical grounds for the argument that government and private saving may be close to perfect substitutes. Supporting empirical evidence is provided for the U.S. by Kormendi (1983) and for Turkey by Fry (1979). Recent analysis of cross-section data by Modigliani et al. (1984) also shows government and private saving to be partial substitutes. Of course, even were government and private saving totally independent, including government saving in

the dependent variable would not necessarily lead to biased estimates. On the other hand, private saving as distinct from total saving is available for a substantially reduced sample. Analysis presented below provides evidence that the dependency ratio depresses private as well as national saving.

- 8 The model was also estimated using life expectancy at birth as a proxy for child mortality. The life expectancy variable was not significant, nor does it reverse the sign of the literacy variable.
- 9 This section draws heavily from a recently completed study by Modigliani, Mason, and Sterling (1984).
- 10 The first-order condition for a maximum saving ratio is that the percentage changes in the consumption lag and the percentage change in g with respect to n are of equal magnitude and of opposite sign. This result is easily obtained by equating to zero the partial derivative of $\ln c = a_0 + (A_y - A_c)g$. This result does not depend on use of a neoclassical growth model.
- 11 These conclusions bear on recent theoretical work by Arthur and McNicoll (1978), Lee (1982), and Willis (1983) on the relationship of population growth to the equilibrium capital labor ratio. Arthur and McNicoll elaborate on the neoclassical growth model to show that, in the presence of age-dependent consumption and earning, Solow's capital-dilution effect may be offset or complemented by what they term the "intergenerational transfer effect." The latter is just another manifestation of the rate-of-growth effect. Based on illustrative calculations, Arthur and McNicoll conclude that the rate-of-growth effect reinforces the capital-dilution effect. The analysis presented here supports a more complex view.

APPENDIX

This Appendix describes in detail the life-cycle model presented in this chapter.

The Life-Cycle Household

The household is assumed to have a known lifetime, commencing at age 0 and ending at age L . The household engages in two utility-yielding activities and chooses activity levels that maximize its utility function:

$$U = U(Q_1, Q_2) , \quad (A-1)$$

subject to

$$V > P_1Q_1 + P_2Q_2 , \quad (A-2)$$

where V is the household's lifetime resources. Given a well-behaved utility function, the demand prices for each activity level are given by

$$\begin{aligned} P_1 &= F_1(Q_1, Q_2, V) \\ P_2 &= F_2(Q_1, Q_2, V) . \end{aligned} \quad (A-3)$$

The budget share of each activity, s_i , is equal to

$$s_i = P_i Q_i / V = Q_i F_i(Q_1, Q_2, V) / V . \quad (A-4)$$

If the utility function is homothetic, as assumed below, s_1 is independent of lifetime resources and is uniquely determined by the quantity of childrearing relative to the quantity of other activities; that is,

$$s_1 = f(q) , \quad (A-5)$$

where $p = P_1/P_2$ and $q = Q_1/Q_2$. The share devoted to activity 2 is equal to $1-s_1$.

The Age Consumption Profile

Households engage in activities at one or more ages, and the proportion of Q_i "consumed" at each age is designated by $k_i(a)$, where $k_i(a) \geq 0$ and $\int k_i(a) da = 1$. The proportion is assumed to be independent of prices, income, and the total level of each activity. The amount "consumed" at age a is equal to $k_i(a)Q_i$, and the value of expenditures on activity i at age a is given by

$$C_i(a) = P_i Q_i k_i(a) . \quad (A-6)$$

The age distribution of activity i is summarized by its average age, A_i , where

$$A_i = \frac{\int_0^L a C_i(a) da}{\int_0^L C_i(a) da} = \frac{\int_0^L a k_i(a) da}{\int_0^L k_i(a) da} . \quad (A-7)$$

Expenditure on all activities at age a is equal to

$$C(a) = P_1 Q_1 k_1(a) + P_2 Q_2 k_2(a) . \quad (A-8)$$

The fraction of lifetime earnings expended at age a , $c(a)$, is equal to

$$c(a) = C(a)/V = s_1 k_1(a) + s_2 k_2(a) . \quad (A-9)$$

The timing of consumption is summarized by its average age, A_C , where

$$A_C = \int_0^L ac(a) da . \quad (A-10)$$

The average age of consumption is a weighted average of the average ages of each activity, where the weights are the activity budget shares. Substituting equation (A-9) into (A-10) and rearranging terms,

$$A_C = \sum_{i=1}^2 s_i \int_0^L a_{ki}(a) da = \sum_{i=1}^2 s_i A_i . \quad (A-11)$$

The Age Earning Profile

The household's age earning profile is described in similar fashion to the household's consumption profile. The fraction of lifetime earnings accruing at age a is given by

$$y(a) = Y(a)/V , \quad (A-12)$$

where $Y(a)$ is the age a earnings by the household.

The timing of earning is summarized by its average age, A_y , where

$$A_y = \int_0^L ay(a) da . \quad (A-13)$$

The Aggregate Consumption Rate

The aggregation of life-cycle households requires that consumption and earning profiles, $c(a)$ and $y(a)$, be independent of lifetime resources, V . This condition is fulfilled if life-cycle activities are homothetic. It is assumed, as well, that steady-state growth in both per capita income and population prevails, so that the lifetime resources of all members of the cohort currently aged are given by

$$H(a)V(a) = e^{-ga} H(0)V(0) , \quad (A-14)$$

where $H(a)$ is the number of households aged a , $V(a)$ is the lifetime resources per age a household, g is the rate of growth of national income, and $H(0)V(0)$ is the lifetime resources of all members of the cohort of newly formed households.

Current consumption by the age a cohort is equal to $c(a)H(a)V(a)$, and aggregate consumption, C , is obtained by summing across all household ages:

$$C = \int_0^L c(a)H(a)V(a) da = H(0)V(0) \int_0^L e^{-ga} c(a) da . \quad (A-15)$$

Likewise, current income of the age a cohort is equal to $y(a)H(a)V(a)$, and aggregate income, Y , is

$$Y = \int_0^L y(a)H(a)V(a) da = H(0)V(0) \int_0^L e^{-ga} y(a) da . \quad (A-16)$$

Taking the ratio of C to Y yields the aggregate rate of consumption, c :

$$c = \frac{\int_0^L e^{-ga} c(a) da}{\int_0^L e^{-ga} y(a) da} . \quad A-(17)$$

Finally, taking the logarithm of both sides and approximating the integral terms using a Taylor series expansion (see Mason, 1981),

$$\ln c = a_0 + (A_y - A_c)g , \quad (A-18)$$

where $a_0 = \ln \int_0^L c(a) da + e$, and e is an error term associated with the Taylor series approximation. $A_y - A_c$ is the average consumption lag.

This representation of the life-cycle model is quite similar to its extensively analyzed cousins. In the absence of growth, and the error term aside, the consumption rate for the economy as a whole is equal to the lifetime consumption rate of the average household, $\int_0^L c(a) da$. The rate-of-growth effect, the partial effect of change in the rate of growth of national income, is $A_y - A_c$. This term has a straightforward interpretation: it is the average lag between the point at which the household earns and the point at which it spends its income. If households, on average, earn before they spend, that is, they are net creditors over their lifetimes, an increase in the rate of growth of total income leads to a lower aggregate consumption rate, and, consequently, a higher saving ratio.

TABLE A.1 Description of Variables and Sources (mean values in brackets)

Gross Consumption Ratio (c1) [.797]	Ratio of total consumption to gross national income. Gross national income defined as net national income plus capital consumption. Sources: United Nations (1976b, 1981) and World Bank (1976; 1981).
Net Consumption Ratio (c2) [.862]	Ratio of total consumption to net national income. Net national income corresponds to U.N. classification "national disposable income"; excludes capital consumption and taxes paid to supranational organizations; includes net current transfers from abroad. Sources: United Nations (1976b, 1981).
Rate of Growth of Income (g) [.051]	Rate of growth of net national income. Calculated as the difference between the rate of growth of nominal income and the inflation rate as measured by the rate of growth of the consumer price index (CPI). Source for CPI: IMF (1981).
Dependency Ratio (DR) [.611]	Ratio of population under 15 years of age to population 15 years and older in 1970. Source: United Nations (various years).
Mean Age of Childbearing (MACB) [28.5]	The mean age of childbearing was not used directly in the measure of dA because a major source of variation in MACB is the age at marriage, which should not affect dA. However, variation in MACB due to fertility variation should affect dA. The MACB was regressed on the total fertility rate using a logistic functional form. Predicted values of MACB were used to construct dA. Source: United Nations (various years).
Labor Force in Agriculture (LFAG) [.412]	Ratio of labor force employed in agriculture to the total labor force. Source: United Nations (1976a).
Literacy Rate (LIT) [.674]	Ratio of literate population to population over age 14. Source: United Nations (1976a).
Religion (REL) [.357]	Dummy variable equal to one for countries that are predominantly Islamic or Catholic.
Time Variable (YEAR)	Year of observation of the dependent variable: for 1960-70 observation YEAR is 0; for 1965-75 observation YEAR is 5; for 1970-80 observation YEAR is 10.

Notes: All monetary variables were calculated using nominal values of a country's currency. Consumption ratios were calculated for three ten-year intervals: 1960-70, 1965-75, and 1970-80. For each interval, ratios were calculated using three values: the endpoints and the midpoint. Where all three values were not available, decadal estimates are the average of available data. Growth rates were calculated over the ten-year interval or the longest available subinterval using the inflation rate over the corresponding interval.

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