World Bank Reprint Series: Number 160

Nancy Birdsall

A Cost of Siblings: Child Schooling in Urban Colombia

Reprinted with permission from *Research in Population Economics*, vol. 2 (1980), pp. 115–50.

A COST OF SIBLINGS:

CHILD SCHOOLING IN URBAN COLOMBIA

Nancy Birdsall, THE WORLD BANK

I. INTRODUCTION

Does the number of siblings amongst whom we grow up matter to our later fortunes in life? Do children who are raised in large families undergo some "cost of siblings" in terms of fewer parental resources received during childhood and a resultant loss of income-earning potential as adults?[1] And does such a process imply the perpetuation of poverty from one generation to the next among low-wage high-fertility groups?

The following analysis adds to other evidence indicating that there is some such cost of siblings, i.e., that on average, children from large families receive less schooling, do less well on tests of intelligence, and using indicators such as height, weight, and age at menarche, appear less well-nourished than children from small families, even controlling for socio-economic class.[2] But my purpose in this analysis is to go beyond the simple negative correlation now increasingly confirmed between family size and

Research in Population Economics, Vol. 2, pages 115-150

ISBN: 0-89232-125-3

various measures of child welfare, to consideration of the underlying causes of that negative correlation. My objective is to illuminate more precisely what factors ultimately determine the persistent and negative relation between numbers of children and allocation of resources to investment in those children.

Data used for the analysis are from a 1967–68 family budget study in the four major cities of Colombia[3]; they include information on expenditures by the household on a wide variety of categories, as well as information on income of each person in the household, age and educational attainment of the husband, wife, and all children present, and the number of wife's children-ever-born and children living.

In the following discussion, "investment in children" will refer to current expenditures of parents' time and money on children which are likely to contribute to the children's future earning power. The measures of parental investment in children used here are education-related, including both current household expenditures on education, and the educational attainment of children present in the household relative to that of other children in their age-sex group. Education is a particularly good commodity for analysis of this type, since it is clearly child-specific, and market expenditures on it are much less affected by the problem of economies of scale than are expenditures on such commodities as clothing and housing.

My analysis is based on a specific view of the household decision-making process underlying the simple negative correlation between family size and investment per child. Consider that the negative correlation could result for three conceptually distinct reasons.

First: large numbers of children impose additional burdens on parents, directly causing a reduction in the amount of resources they allocate to each child. This is the reasoning implicit in most standard analyses of family budgets.[4] The initial appeal of this explanation—that parents' time and money cannot be stretched proportionately to accommodate a growing household—provides little insight into why parents, who as a group have access to the same intuition and can foresee the constraining effect of many children on per-child expenditures, differ in their apparent choices regarding number of children and per-child expenditures.[5]

Second: an explanation often raised in the literature on fertility and its determinants: parents who wish to invest much of their time and money income in their children will restrict family size.[6] This is the first explanation turned on its head, and also to some extent begs the question as to why parents differ in their apparent desires regarding allocation of resources to children.

Third: the possibility that the direction of causality between family size and child welfare is not unique, that for parents neither the decision (or lack thereof) regarding family size nor that regarding investment per child precedes the other. In this view, the two sets of choices are interdependent and jointly determined by characteristics of the parents and of the economic and social environment in which they live. (Such a view does not preclude the possibility that parents neither "plan" consciously for number of children nor investment per child; the issue in this case is what determines such joint nondecisions.)

It is the third view which is the basis for the following analysis; it begins with the assumption that the behavior of parents regarding per-child investment cannot be viewed as independent from their apparent choices regarding the number of children to have. The joint persistence of the contradictory explanations one and two, alternatively offered by different analysts depending on their initial set of interests (i.e., the causes of differences in child welfare, or the causes of fertility differences) in itself lends credence to the third which, since it subsumes and reconciles the first two, is theoretically more appealing. The findings reported in this paper are largely consistent with this third view of the underlying process. General conclusions include the following:

1. In the simple correlative sense (based on ordinary least squares estimation), there is a clear "cost of siblings," which persists, even controlling for household income and other characteristics. The relationship of additional children to per-child investment is negative and nonlinear. Per-child investment declines monotonically as family size increases, but once the dependent variable is standardized for age, a particular and different pattern emerges: up to three or four children, families maintain steady investment per child; with five and more children, investment per child is distinctly lower.

2. Using a model in which number of children and investment per child are jointly determined (two-stage least squares estimation), we find that large family size has an important effect in the *causal* sense on per-child investment. In this sample, as much as a 30 percent increase in the income of the head of household would be required to offset the negative effect of one additional child on a household's per-child educational expenditures. From a policy point of view, the implication is clear: reductions in fertility will increase parents' investments in children's education. This is true partly because parents who seek to invest more restrict their fertility; but it is also true that an increase in parents' educational investment per child would follow even from a decrease in family fertility brought about solely by lower contraceptive costs.

3. This negative effect of fertility on investment in children could be interpreted as inevitably causing the perpetuation of poverty across generations among high-fertility groups, short of very substantial increases in

income for already-large families. Would such a conclusion be correct? Probably not: though family size matters, the vicious cycle is not inevitable. The analysis suggests one way such a cycle can be interrupted. Although rural-urban migrants have larger families than otherwise comparable long-term urban residents (probably reflecting the different economic environment in which the originally-rural families made their fertility decisions—such families face different relative prices for children and inputs to children; an example is different availability of contraceptives), and apparently spent less on education of their children while in the rural area (children of comparable urban families have higher educational attainment), their current educational spending is similar to that of long-term urban residents. Current spending is apparently not so greatly influenced by the migrant families' prior economic and social environment. Thus there operates some kind of a catch-up mechanism; despite higher fertility, larger average families, and lower average educational attainment of children (age and sex-standardized), migrant families adopt the educational spending habits of their urban counterparts; they do not spend less per child than those of comparable income and education.

Thus we know that certain economic conditions (associated in this case with a move to an urban area, but other routes to changing prices are imaginable[7]) cause a decline in fertility; from conclusion 2 above, we know this lower fertility has a direct positive effect on per-child educational investment. Furthermore, in the case of recent migrants, even given already-large family size, a change in economic environment shifts investment upward. This increased educational spending by migrant parents will lower their children's fertility in the next generation, since education of parents itself has an independent negative effect on fertility. Even a modest increase in investment for one generation will lead to decreases in the fertility of the next; and modest decreases in the fertility of current parents have an immediate effect on their children's schooling.

Section II of this paper is a short discussion of the model on which the analysis is based; in Section III, empirical findings are presented and discussed.

II. ANALYTICAL FRAMEWORK

A link between family size and child welfare (or child quality) is built into a model of fertility proffered by Willis, as well as Becker and Lewis,[8] in which the household is viewed as maximizing a utility function of the form:

$$U = U(N,Q,Z)$$

where N is the number of children, Q is their quality or the household investment in them, and Z represents the rate of consumption of all other commodities. N and Q enter as separate arguments in the utility function, but child services, C, is set equal to NQ, and it is C which is produced (along with Z) according to the linearly homogeneous production function:

$$C = NQ = f(t_c, x_c)$$

where t_c and x_c are vectors of the total amount of time and goods parents devote to children during the parents' lifetime.

The fact that, in cross-section studies and over time, higher-income families tend to have fewer children is explained in two ways. First is a price effect. The principal "cost" of children is an opportunity cost, the time parents and especially mothers devote to childbearing and childrearing. Higher-wage parents experience greater opportunity costs in rearing children.[9] This price effect apparently swamps any positive effect of income on the demand for children.

Second is an explanation that bears more directly on the issue of child welfare and its relation to family size, namely the observation that parents may wish to substitute quality for quantity in the production (rearing) and consumption (enjoyment) of children, i.e., with greater income, parents may spend more time and monetary resources on fewer children as an alternative to having more children. A critical feature of the model is that even without any special assumption about the substitution between quantity and quality in the parents' utility function or in household production, it will be true that for a smaller number of children, the true shadow price parents face for quality in those children is lower; and that similarly for a greater number of children, the true shadow price of quality is higher. This follows because of the multiplicative relationship between N and Q in the production of child services; parents cannot "produce" children without producing in them some degree of "quality," nor can they produce "quality" without children.[10] (This, in fact, would be true for any commodity with both a quality and a quantity component.)

The model not only explains the empirical finding that as wage income of households increases, parents have fewer children; it also implies that high-wage parents will invest more in each of the fewer children they have, if only because the price of a given level of quality per child is lowered with fewer children. In addition, of course, higher-wage parents may have higher quality *goals* for their children, but such shifts in taste for quality with increases in wage income are not actually necessary for the quality-quantity substitution effect predicted by the model to occur.

The interaction between quality and quantity also causes a downward bias in the observed income elasticities for both N and Q: the direct or true effect of an increase in money income is to increase demand for both N and Q, but those increases in N and Q cause their shadow prices to rise, offsetting the pure income effect and reducing the observed income effect.

Some critical features of the model, relevant to the following empirical work, should be pointed out:

1. The model is static. Family size and parental investment in children are the result of jointly determined utility-maximizing decisions of parents made presumably at the beginning of their childrearing years. As children arrive, parents cannot change or adjust plans based on new information regarding their taste for children; as children grow, parents cannot alter investment strategies based on the ability or willingness of their children to participate in the investment process. Further, parents are assumed to foresee perfectly their future stream of income.

There is a seven to eight year lag between the time when parents conceive a child and begin spending on that child's education. To the extent that expansion of educational facilities in Colombia was greater in the 1960s than parents having children in the 1950s might have expected, the negative effect of number of children on per-child investment would be attenuated, and we have a strong test of the principal hypothesis. In fact, the rate of increase in the proportions of children enrolled did accelerate in the mid-Sixties.[11]

2. An assumption of the model is that there is no joint production nor are there economies of scale in producing, or raising, children. This is highly questionable where parents' time is concerned (few mothers increase time spent in child care proportionately as additional children are born), and even for purchased inputs to children such as clothing or housing. However, it is not unreasonable to assume there are few economies of scale in the purchase of schooling, which is the measure of investment used here.

3. A simplifying but not necessary assumption is that parents produce for each child the same quality level, i.e., there are neither favorites nor Cinderellas. Findings from this sample not reported in this paper indicate that there are systematic differences in parental investment within families, represented by birth order. These findings, however, do not alter the conclusions which follow from the analysis in this paper, as long as size effects dominate birth-order effects sufficiently so that, for example, even in cases where early children receive greater resources than middle children, they still receive less than they would have, on average, in the absence of other children.[12] Birth-order differences can be shown to be consistent with the quality-quantity model as long as parental time is a binding constraint within periods of childrearing.[13]

III. EMPIRICAL FRAMEWORK AND RESULTS

Results below are based on households in which both husband and wife are present. Estimates of educational investment are further confined either to households with at least one child between the ages of 6 and 18 or households with at least one child between the ages of 6 and 22—between 1200 and 1500 households.[14] Following a description of variables, results are presented and discussed in the following order:

A. Ordinary least squares regressions in which the dependent variable is one of several measures of parental investment in child schooling, conditioned on the number of children present in the household along with other household characteristics.

B. Estimates, using ordinary least squares, of demand equations for investment in children and for number of children as a function of parents' characteristics (hereafter the "reduced-form estimates").

C. Estimation by two-stage least squares of a demand equation for investment in children, conditioned on number of children, in which fertility is entered as an endogenous variable on the right-hand side (hereafter the "structural equation").

Description of Variables

Table 1 lists variables used in regressions, with means and standard deviations for the sample of households with at least one child aged 6 to 18. Several measures of parental investment in the schooling of children are used. The simplest is the total amount of spending reported on education (TOTED). Similar is the share of the household's total budget going to education (BUDSHED). A serious shortcoming of these variables as measures of parental investment is that educational costs parents face may differ by age and sex of children; declining expenditure with increasing family size could thus overestimate or underestimate the effect of siblings on per-child investment, depending on whether larger families tend to have more or fewer older children (assuming older children cost more to keep in school, which is generally the case in Colombia, where most primary schools are public, but most secondary schools private and tuition-charging).[15] Household expenditures on education should thus be standardized for age and sex of children present. Moreover, for a measure of average costs by age and sex, household expenditures on education should be estimated for *enrolled* children only, since dropout rates increase with age.

Unfortunately, interviewees were not asked whether children were currently enrolled, but only what amount of school children had completed. I therefore compared age and educational attainment to designate children as currently enrolled or not. Predicted expenditures by age-sex category were then estimated as a function of a regression of household educational expenditures on children "enrolled." (The various age standards tried and sets of predicted expenditures are shown in the Appendix. By any of these standards, enrollment probabilities decline monotonically from above 90 percent at age 9 to about 35 percent at age 17. Since parameter estimates using four different resulting "scores" for each household do not differ

Table 1. Variable Definitions and Descriptive Statistics (for sample of households with at least one child aged 6 to 18, n = 1433)

		Mean	Standard Deviation
TOTED	Total household spending on education (1968 pesos, quarterly)	64.8	107.8
BUDSHED	Share of household budget spent on education	.05	.05
SC	Family score (relative to other households) using current expenditures on education	.40	.73
EDI	Family educational index (relative to other households) using children's educational attainment	1.05	.945
CHL	Number of children of wife currently alive	4.77	3.05
ARAT	Fertility measure, based on children-ever-born, standardized for the age-fecundity relationship using a natural fertility schedule	.59	.29
LYH	Natural log of husband's income (1968 pesos, quarterly)	6.3	.92
SCH	Husband's number of years of schooling completed	7.2	4.6
SCW	Wife's number of years of schooling completed	6.3	4.2
MIGD	Migrant dummy. Equals one if household members arrived from anywhere in Colombia other than Bogota, Medellin, Cali, or Barranquilla within the last 5 years	.10	.31
YSBC	Number of years household members have resided in current city. Equals 1 to 5, or 8 for more than 5	7.5	1.7
BOGD	Bogota dummy. Equals one if current city of residence is Bogota	.29	.45
CALD	Cali dummy	.21	.41
MEDD	Medellin dummy	.25	.43
AGW	Age of wife	36.4	8.4
AGSW	Age of wife-schooling of wife interaction term	208.	185.

markedly, only the results using one of the computed scores are reported.) The resulting predicted expenditure for each household, depending on the age and sex of its children, is then the denominator in the dependent variable:

$$SC_i = \frac{EXED_i}{PRED_i} = \frac{\text{actual total expenditures}_i}{\sum_{i=1}^{n_j} \text{expenditure}_{ixs}}$$

in which j denotes the household, i the children in the household, x the ages 6, 7 . . . 18, and s male or female. Each household's score is thus the ratio of its actual educational expenditure on education to its predicted expenditure. This score is calculated only for families with at least one child between ages 6 and 18 and no older children at home; this is because older children might affect the numerator but are not taken into account in the denominator. The same procedure is then followed for all families with children between ages 6 and 22.[16]

An alternative method of measuring a family's investment in education is to compare households according to their children's educational attainment alone,[17] without consideration of actual direct money expenditures, using as the dependent variable an index of the household's educational achievement relative to others in the sample with children in the same age-sex categories:[18]

$$\mathrm{EDI}_j = \sum_{i=1}^{n_j} \frac{\mathrm{education}_{ixsj}}{\overline{\mathrm{education}}_{ixs}} .$$

In the denominator is the mean educational attainment of children in the sample, by age and sex (shown in Table 2), and in the numerator household j's children's attainment. The index may be overstated for families with children in younger age groups (some of whom will drop out); still, in an ordinary least squares regression on this dependent variable in which mother's age was included, the coefficient of age was not statistically significant, and the coefficient was not negative, as we might expect, but positive. On the one hand, the index understates the efforts of families

Table 2. Mean Educational Attainment in Years of School Completed by Age and Sex*

Age	Boys	Girls
6	.18	.25
7	.60	.68
8	1.20	1.23
9	1.78	1.74
10	2.40	2.60
11	3.16	3.38
12	4.02	4.32
13	5.17	5.10
14	5.87	6.01
15	6.74	7.18
16	7.53	7.94
17	7.71	8.01
18	8.08	9.61

*The sample includes more than 100 persons in each age-sex category.

whose children repeat years of school, and thus for their age have completed fewer years; children who start late also depress the index for their household. On the other hand, late starters and repeaters could well reflect differences in preschool and during-school investments by parents of time and other inputs.

Differences in regression results for the two dependent variables indicate whether parents respond to the financial pressures of schooling primarily by removing children from school or primarily by spending less on education of children while keeping them enrolled. The two variables differ in another respect as well. The first measures current spending on education: the second reflects to some extent a whole series of past spending decisions, which have produced a certain level of educational attainment for children. Thus differences in them may also provide some insight into how patterns of investment change as the economic situation of households changes, as will be seen below.

Two different measures of fertility are also used. In a standard budget analysis, the number of children currently being supported might be viewed as best capturing the constraint on educational spending children may present. However, from a lifetime planning point of view, children currently living at home is not the correct variable. On the one hand, older children who have left the household could be contributing to household income and thus influencing current expenditures on education of children still at home positively. On the other hand, they could affect negatively household expenditures on education of children still present, if they contributed to an earlier depletion of resources allocated by parents for children's education. Moreover, the age at which children leave home itself depends on parental investments in their education, and is thus endogenous. For these reasons, a measure of completed family size is preferable. Two are used. One is children currently alive; it is assumed to represent the best measure of household's desired number of children, as well as the best indicator of number of children in terms of the effect of family size on investments in children, assuming mortality does not vary systematically across households. Both these assumptions are based on the premise that most children who die do so in infancy, so that parents can replace them if they wish,[19] and so that their existence does not strongly affect investment-per-child. (Ideally children-ever-born would be used, and an additional equation representing child mortality would be entered into the structural system; however this would make the identification problem discussed below even more serious.)

The second measure of fertility, ARAT (age ratio), is standardized for mother's age using a natural fertility schedule.[20] Its principal effect is to purge the fertility variable of differences in fertility by age of mother due solely to biological effects. This variable is based on children-ever-born to the wife, not children alive.

The income variable used is the natural log of income of the husband. Income of the husband is preferred to total household income because hours and type of work of the husband (in cases where he heads the household) are less likely to be affected by the family's composition than those of the wife. In this way, any contribution children make to total income is also excluded.[21]

The relation of income to both household fertility and household educational investment is assumed to be nonlinear; for this reason the natural log of income is used in all regressions. The log form has the effect of imposing diminishing returns to higher income in terms of fertility and investment. In the investment regressions, the resulting semilog function implies that the income elasticity of educational spending declines toward zero, allowing for saturation. This is not a bad approximation over most levels of income, assuming parents perceive diminishing returns to educational expenditures per child. To produce human capital, education purchased in the market must be combined for each child with innate ability and child time, so that diminishing returns to market expenditures on per-child education are not unlikely.

Education of husband and wife are continuous variables, i.e., years of schooling completed. Differences in type of education (e.g., post-secondary vocational vs. university) are not distinguished.

The data include information on the number of years a family had resided in its city of residence at the time of the survey, up to five years, with families living in that city more than five years lumped together. For those who had arrived within the preceding five years, there is information on whether prior residence was one of the other of the four cities sampled, elsewhere in Colombia, or outside of Colombia. Families which had arrived in one of the four cities from elsewhere in Colombia within the five years preceding the survey are classified as migrants (MIGD). A second migrant variable, YSBC (years since in big city) is continuous, being between one and five, or for families in their current city more than five years, being valued as eight. Since the cities sampled are the four largest in the country, families coming from elsewhere in Colombia would have come from rural areas or smaller cities.

Dummies are used representing the household's current city of residence: Bogota, Cali, or Medellin, with Barranquilla the excluded city.

Age of wife and the age of wife-schooling of wife interaction term, and their expected signs, are discussed with the regression results below.

Unfortunately, there is no explicit information in this data set as to whether children in the households surveyed were actually enrolled in school at the time of the survey; what is known is the educational attainment of children. Thus it is impossible to do separate regressions predicting enrollment, and impossible to do regressions predicting educational spend-

Table 3. Simple Correlations of Fertility and Investment Variables

	LYH	CEB	CHL	ARAT	CH618	TOTED	SPENDPC	BUDSHED	EDI	SC	ENRSC
LYH	1	–.19	–.10	–.21	.003	.59	.59	.28	.37	.55	.43
CEB		1	.66	.84	.54	–.07	–.23	.009	–.16	–.23	–.27
CHL			1	.57	.50	–.02	–.16	.05	–.11	–.16	–.19
ARAT				1	.41	–.14	–.26	–.09	–.17	–.21	–.19
CH618					1	.16	–.13	.25	–.09	–.16	–.10
TOTED						1	.82	.65	.30	.70	.31
SPENDPC							1	.53	.41	.38	.39
BUDSHED								1	.26	.42	.21
EDI									1	.49	.48
SC										1	.33
ENRSC											1

N = 1433

For variable definitions, see Table 1 and p. 122.

ing conditional on enrollment. However, as mentioned above, a prediction of expenditures by age-sex groups was constructed; using four different sets of criteria for what level of education should have been reached by what age, four sets of calculated guesses as to whether children of specific ages were still enrolled were made (see Appendix). Using the least demanding criteria of the four, about 25 percent of families with children between the ages of 6 and 22 have no children enrolled—many of these families may only have older children. This figure corresponds roughly to that of 20 percent of all families with children aged 6 to 18 which reported zero spending on education.

Table 3 is a matrix of simple correlations between the different educational investment variables and fertility-related variables, for families with at least one child aged six to eighteen. Several variables not described above (and not used in the regression analysis) are included. ENRSC is a household enrollment score; using the least demanding age-attainment standard, it is the ratio of apparently enrolled children to all children aged 6 to 22. CEB is children ever born. SPENDPC is spending per child age 6 to 18. CH618 is number of children aged 6 to 18.

Not surprisingly, total spending on education (TOTED) is positively correlated with the number of school-age children, those aged 6 to 18. It is very slightly negatively correlated with children ever born and children alive. Spending *per child* is negatively correlated with all family size variables, and the age-standardized indices of investment per child (SC, EDI, and ENRSC) are even more negatively correlated with these variables.

A. Ordinary Least Squares Analysis

Table 4 indicates the results of regressions of four different dependent variables, all indicators of parents' educational investments in children, on the income variable and a series of dummies representing families with from one to nine or more children, with four-child households the omitted variable. In column 1, the dependent variable is total educational spending. The signs of the coefficients on the dummies indicate that, holding husband's income constant, total expenditures on education increase steadily up through four-child households, and then remain relatively constant.

Our real interest, though, is the relationship between additional children and *per-child*, rather than total, spending. Table 5 shows the results of calculations of changes in per-child spending with additional children based on the column (1) regression, Table 4.[22] Figures 1 and 2 indicate the shape of the relationship between number of children and both total spending and per-child spending. Additional children are clearly associated with declining per-child expenditures.

The column (2), Table 4 regression has as the dependent variable the share of a household's total expenditures in the period going to education.

Table 4. OLS Regressions of Investment Variables on Children (n = 1447)

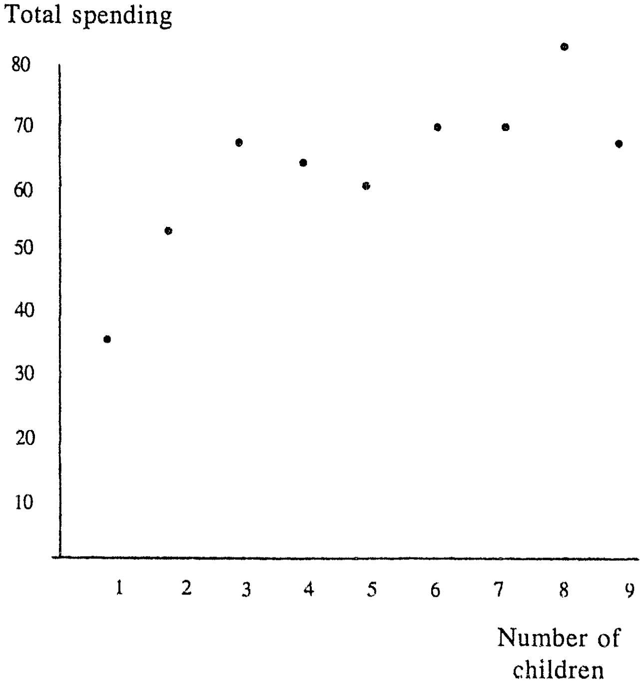
Dependent variable:	(1) Total educational spending TOTED		(2) Budget share to education BUDSHED		(3) Educational attainment index EDI		(4) Educational expenditure score SC	
constant	−364.		−.052		−1.13		−2.14	
Log of husband's	67.7		.0167		.360		.414	
income (LYH)	(27.7)		(11.3)		(14.3)		(23.7)	
CD1*	−28.5		−.0167		−.135		−.0623	
	(2.3)		(2.2)		(1.07)		(.72)	
CD2	−12.6		−.00856		.0173		.0928	
	(1.5)		(1.7)		(.20)		(1.54)	
CD3	.712		.00123		.0122		.0393	
	(.09)	F = 1.58	(.28)	F = 2.51	(.16)	F = 3.39	(.75)	F = 6.9
CD5	−2.17	8,1437	−.00770		−.255		−.182	
	(.30)		(1.8)		(3.43)		(3.56)	
CD6	2.94		.00202		−.0758		−.226	
	(.32)		(.36)		(.80)		(3.46)	
CD7	3.01		.00093		−.216		−.192	
	(.35)		(.18)		(2.43)		(3.13)	
CD8	17.4		.0130		−.317		−.208	
	(1.42)		(1.76)		(2.52)		(2.40)	
CD9 or more	.785		.00525		−.217		−.217	
	(.08)		(.90)		(2.18)		(3.17)	
	$R^2 = .36$		$R^2 = .09$		$R^2 = .15$		$R^2 = .32$	

*CD = dummy for number of children alive, 1 through 9 or more, with households with 4 children the excluded variable.
The t-statistic for each coefficient is in parentheses.

Table 5. Per-Child Educational Expenditures by Size of Family

Number of Children	*Per-Child expenditures, based on regression in Table 4, Col. 1*
1	35.5
2	25.7
3	21.6
4	16.0
5	12.4
6	11.2
7	9.6
8	10.2
9 or more	≤ 7.2

Figure 1: Total Educational Spending and Number of Children



The mean share for the sample is slightly over five percent. It is somewhat lower for families with one or two children, and then remains the same, regardless of how large the family becomes. The results are similar if dummies for only those children currently living at home are used (not shown). Thus families retain a certain proportion of spending on education, even as increasing family size makes other demands on the budget; with a fixed proportion, per-child spending necessarily falls as family size increases.

In columns 3 and 4 of Table 4 are similar regressions, using the age-standardized dependent variables. A similar pattern is evident, as illustrated in Figures 3, 4, and 5. Parents are able to maintain per-child educational investment as family size increases up to three or four children; a significant drop in investment scores occurs with five or more children.

The F-tests shown in Table 4 indicate that as a group the child dummies are significant at the 1 percent level in columns 2, 3 and 4, but fall short of significance at 5 percent in column 1.

The results of these regressions, however, must be interpreted with caution as at most indicating how number of children and investment in children are correlated. On the one hand, we have not controlled for

Figure 2

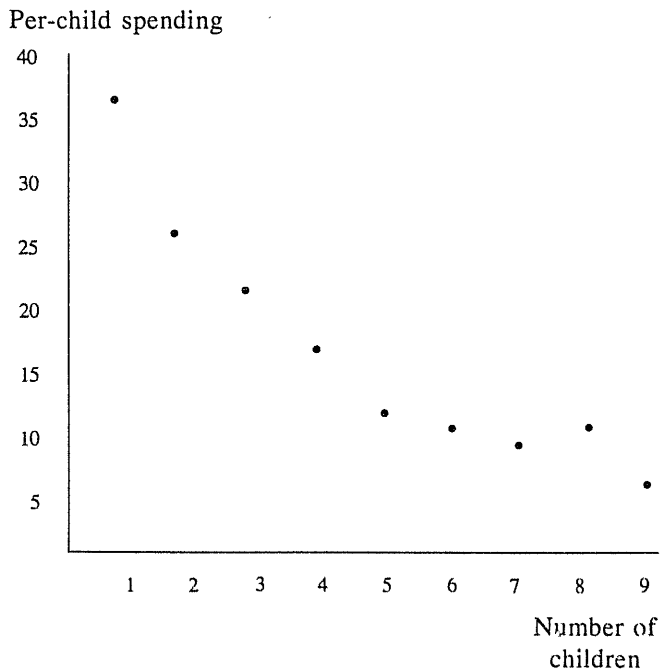


Figure 3

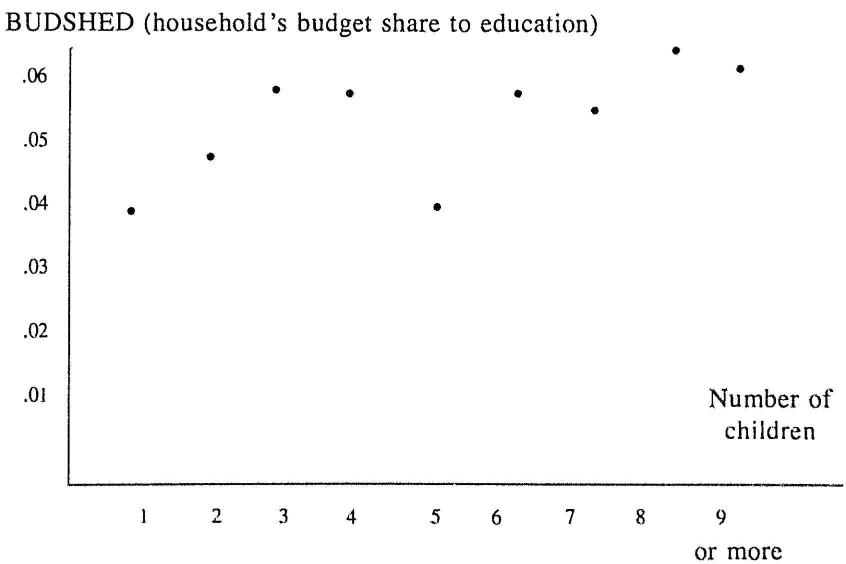


Figure 4

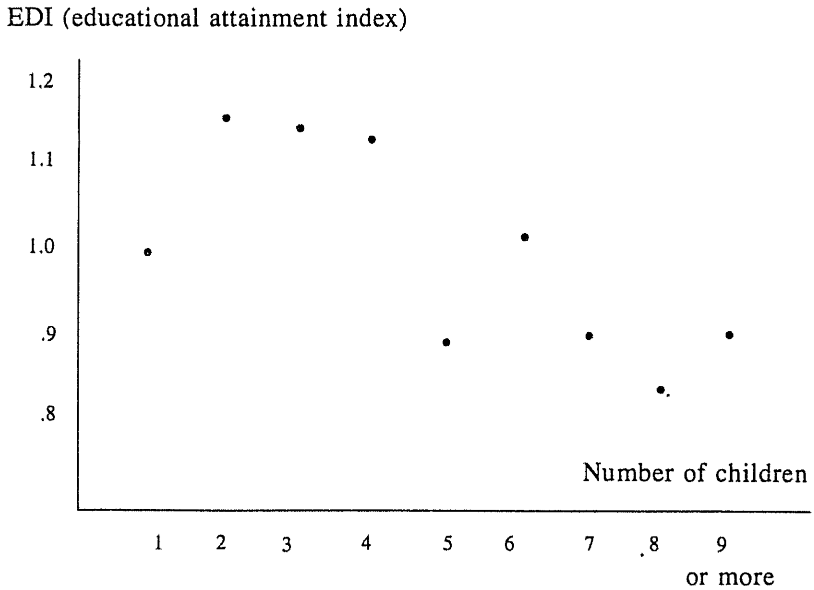
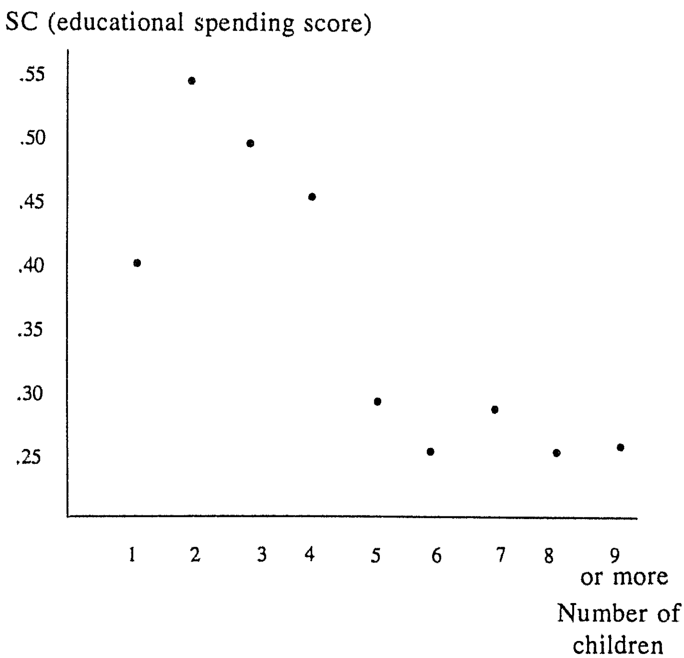


Figure 5



parents' education or migrant status. If less-educated or migrant parents have more children and spend less on education, the "cost of siblings" effect could be spurious. A more serious problem is the endogeneity of number of children. An investment equation is better estimated as part of a system representing the parents' simultaneous decisions regarding family size and investment, i.e., in linearized form:[23]

$$N = \alpha_0 + \alpha_1 Q + \alpha_2 SCW + \alpha_3 SCH + \alpha_4 LYH + \sum_i \alpha_i Z_i + \epsilon_1$$

$$Q = \beta_0 + \beta_1 N + \beta_2 SCW + \beta_3 SCH + \beta_4 LYH + \sum_j \beta_j W_j + \epsilon_2$$

where N is the fertility variable, Q is the variable representing investment in education per child, SCW, SCH, and LYH are the educational attainment of the wife, educational attainment of the husband, and log of income of the husband, the Z_i are variables which influence number of children but not investment per child, and W_j are variables which influence investment per child, but not the number of children. An OLS estimate of the Q equation will result in parameter estimates which are biased, for two possible reasons:

a. Assuming N and Q are substitutes, the coefficient on N will be negatively correlated with ϵ_2 and thus biased downward. The shadow price of investment per child is lower for parents with fewer children.

b. ϵ_1 and ϵ_2 may be correlated, though in what direction is not clear. We do not observe individual differences in fecundity nor in parental tastes. A preference for large numbers of children could be positively or negatively related to a preference for child-oriented patterns of expenditure. Positive correlation between ϵ_1 and ϵ_2 could offset the negative bias of the number of children coefficient in equation (2); negative correlation would increase further the bias.

For these reasons, we turn to reduced-form and two-stage least squares estimates.

B. Reduced-Form Estimates

The two structural equations above are estimated as reduced-forms:

$$N = \gamma_{10} + \gamma_{11} SCW + \gamma_{12} SCH + \gamma_{13} LYH + \gamma_{14} M + \gamma_{15} AGW + \gamma_{16} AGSW + \sum_{i=7}^{9} \gamma_{1i} U_i + \epsilon_{11}$$

$$Q = \gamma_{20} + \gamma_{21} SCW + \gamma_{22} SCH + \gamma_{23} LYH + \gamma_{24} M + \sum_{i=5}^{7} \gamma_{2i} U_i + \epsilon_{21}$$

where M is one of the two variables indicating the household's migration status, AGW and AGSW are age of wife and an age of wife-schooling of wife interaction term, and U_i are the city dummies (BOGD, CALD, MEDD).

In interpreting the signs and overall magnitudes of the reduced-form coefficients, it is important to take into account predictions from theory of their signs in the structural equations for N and Q. Even apart from direct estimation of the structural equations, we can use the theoretical predictions to improve interpretation of the reduced-form coefficients. For example, in terms of the structural parameters, γ_{21}, γ_{22} and γ_{23}, the reduced-form coefficients of mother's and father's education and father's income, are equal to:

$$\gamma_{21} = (\beta_1\alpha_2 + \beta_2) \,/\, (1 - \beta_1\alpha_1)$$
$$\gamma_{22} = (\beta_1\alpha_3 + \beta_3) \,/\, (1 - \beta_1\alpha_1)$$
$$\gamma_{23} = (\beta_1\alpha_4 + \beta_4) \,/\, (1 - \beta_1\alpha_1).$$

Looking, then, first at coefficient signs in the structural equations, the following comments can be made:

Given the assumption that parents treat N and Q as substitutes, we expect α_1 and β_1 to be negative. α_2 will be negative insofar as wife's education represents the value of her time and the wife bears sufficient responsibility for care of children. The signs of α_4 and β_4 are not known *a priori;* additional income could increase either N or Q or possibly both. A prevailing assumption is that the true income elasticity of Q is positive, so that the observed income elasticity, β_4, is likely to be positive, unless the true income elasticity of N is sufficiently greater than that of Q. Moreover, β_4 will be influenced positively if capital markets are imperfect, and parents with higher income are better able to finance investments in their children. The observed income elasticity of number of children (α_4) is generally less likely to be positive; even if the true elasticity is positive, the interaction between N and Q will cause a downward bias, and could make α_4 negative.

Insofar as we view Q, the dependent variable in the investment equation, as "quality" per child in the general sense of the word, and not specifically as investment in schooling per child, the signs of β_2 and β_3, the coefficients on the education of parents, are not theoretically obvious. On the one hand, parents with more education are likely to have greater access to information on the returns to investment in schooling, an allocative effect of the parents' education, as well as to have greater taste for education in their children. On the other hand, as parents' education increases, the value of their own time increases concomitantly, so that if we include in Q parents' own time spent with children, at least the parent-time component of investment might decrease with parents' education. Another twist, however, is that even as parent inputs measured in time-units might decrease with parents' education, if parents with more education are more efficient users of their own time with their children, parents' time measured in efficiency or value units might be constant or increase, even given a drop in actual time spent with children, as parents' education increases. Evidence from empirical studies indicates that parents with greater education do seem to invest more of their own time in their children. Interpretation of the evidence differs as to whether high-education parents manage this primarily by having smaller families (thus increasing per-child inputs of time even as total childrearing time is held constant or reduced), or by actually spending more hours *in toto* in childrearing.[24]

In this empirical analysis, the measure of investment per child is expenditures on schooling per child and children's schooling attainment. Since parents' time does not enter directly into schooling—in fact, schooling may be a substitute for parents' time—β_2 and β_3 will probably be positive, either because of the taste effect or allocative effect of parents' education, or because parents substitute purchase of schooling for their own time in providing education to children.

Turning then to expectations regarding the reduced-forms, note that with β_1 and α_1 both negative, it is clear that in the reduced-form investment equation, the coefficient of mother's education must be greater than the structural effect of mother's education on child investment. In contrast, if α_3 (the coefficient of father's education on N) is close to zero, as is a common assumption, i.e., that the price of father's time does not affect demand for children, then the reduced-form coefficient of father's education is, relative to that of mother's education, closer to representing the true structural effect of father's education on investment in children. Such a contrast may explain the not uncommon finding that mother's education affects child quality more than father's education, a result usually attributed to the presumed greater amount of time mothers spend with children. Similarly, if the structural effect of income is positive ($\alpha_4 > 0$) in the demand for children equation, it will bias downward the coefficient of income in the reduced-form investment equation.

1. *Fertility Results.* Table 6 shows the results of reduced-form estimation of the fertility equation, with the number of children alive the dependent variable in columns 1 and 2, and ARAT the dependent variable in columns 3 and 4.

The coefficient of age of wife in the children alive equation (columns 1 and 2) is positive as expected, reflecting the longer exposure to the risk of pregnancy, and possibly some cohort effect—that the older women have higher fertility even on an age-specific basis (which is likely, since the fertility rate in Colombia has been declining). In the ARAT regressions, where the biological factor of increased exposure to pregnancy is controlled for, any cohort effect is apparently swamped by a strong life-cycle effect, i.e., relative to the possibilities of childrearing, Colombian women restrict fertility significantly in the latter part of their childbearing years.

Education of the wife and husband both depress fertility. In all cases, the

Table 6. Reduced-Form Fertility Regressions (n=2346)

Explanatory variables:	(1) Dependent variable: children alive	(2)	(3) Dependent varaible: ARAT	(4)
Constant	2.42	1.23	0.816	0.669
	(3.85)	(2.27)	(12.7)	(11.5)
SCW	−0.176	−0.179	−0.0188	−0.0187
	(−3.74)	(−3.82)	(−3.90)	(−3.92)
SCH	−0.111	−0.109	−0.012	−0.0120
	(−5.81)	(−5.77)	(−6.25)	(−6.22)
LYH	0.338	0.335	0.0165	0.0162
	(3.83)	(3.81)	(1.83)	(1.82)
AGW	0.056	0.054	−0.00209	−0.00228
	(6.69)	(6.49)	(−2.46)	(−2.70)
AGSW	0.00258	0.00263	0.000192	0.00185
	(2.26)	(2.26)	(1.61)	(1.56)
YSBC	−0.132	—	−0.0195	—
	(−3.44)		(−4.99)	
MIGD	—	0.853	—	0.116
		(3.92)		(5.24)
BOGD	—	0.248	—	−0.0137
		(1.43)		(−0.78)
CALD	—	−0.340	—	−0.064
		(−1.84)		(−3.42)
MEDD	—	0.606	—	0.0615
		(3.40)		(3.40)
	$R^2 = .13$	$R^2 = .14$	$R^2 = .09$	$R^2 = .11$

The t-statistic for each coefficient is in parentheses.

magnitude of the coefficient of wife's education is greater; since the wife usually is the partner primarily responsible for childrearing in Colombia, this result is consistent with the theory that fertility is influenced by parents' price of time. Education may also represent a lower information cost of using contraceptives effectively.

Income of the husband has a statistically significant positive effect on children alive; its sign is positive but not significant in the ARAT regressions. (The ARAT measure is based on children-ever-born; income might affect it less if the principal effect of higher income is to suppress infant and child mortality.) The income results indicate a notable income effect on quantity of children, once parents' education, representing price-of-time, is controlled.[25] This indicates that during this period in Colombia, the income elasticity of quantity of children was not necessarily less (or if less, not substantially less) than the income elasticity of quality of children. Thus reductions in family size must be due directly to the price effect of increasing value of parents' time, rather than to upward shifts in the taste for quality in children. This is consistent with the structural estimation result (discussed below) showing a direct causal link from lower fertility to greater per-child investment. The similarly positive effect of income on per-child investment (Table 7) demonstrates that the income effect can be simultaneously positive on both quantity and quality in children.

The age of wife-schooling of wife interaction term is positive and statistically significant in the children alive regression. This is somewhat surprising, since we might expect the positive effect of age to be attenuated, rather than increased, by increased schooling (if for example the more-educated of the older women had been better able to process new information regarding contraceptives in the early 1960s). There are two possible reasons: One is a timing effect; more-educated women delay childbearing, but then space births closely so as to concentrate the period of childbearing; thus at somewhat earlier ages they may have what is temporarily higher fertility than their less-schooled contemporaries. A second possibility is that for those older women with more education, infant mortality was not as high as for their contemporaries; this is consistent with the fact that the interaction term is less positive and not significant (at the 5 percent level) in the ARAT regression, ARAT being based on children-ever-born rather than children currently alive.

2. *Investment Results.* The per-child educational investment regressions are shown in Table 7 for the two dependent variables described above: SC (family's score relative to other families in terms of current spending on education, standardized for expected expenditure given the age and sex of their children) and EDI (family's educational index, based on children's educational attainment compared to others in their age-sex group). A comparison of the effect of the independent variables on number-of-children and on investment-per-child is instructive. Education of parents has the expected opposite effects, reducing fertility and increasing investment. As noted above, the direct effect of the mother's education on investment will be overestimated in the reduced-form if, as seems the case, her education reduces fertility. On the other hand, income has a strong positive effect on both N and Q; thus its direct effect on one or both is underestimated in these reduced-forms.

YSBC (years since the household arrived in one of the four big cities) and MIGD (migrant dummy) are continuous and discrete versions of the same variable (with the expected signs reversed), and by definition should have opposite effects in the fertility and investment regressions. As expected, recent migrants have higher fertility and lower investment than longer-term residents, though again from the reduced-forms we cannot tell to what extent the fertility behavior influences investment behavior, and vice versa. Interestingly, the effect of migrant status on *current* expenditures (Table 7,

Table 7. Reduced-Form Regressions of Per-Child Educational Investment (n=1255)

Explanatory variables:	(1) Dependent variable: SC (expenditure score)[1]	(2)	(3) Dependent variable: EDI (educational attainment score)[2]	(4)
Constant	-1.91	-1.76	-0.853	-0.551
	(-12.3)	(-12.4)	(-3.93)	(-2.80)
SCW	0.0358	0.0341	0.0388	0.0346
	(6.13)	(5.77)	(4.76)	(4.21)
SCH	0.0188	0.0193	0.0315	0.0326
	(3.37)	(3.46)	(4.05)	(4.21)
LYH	0.287	0.289	0.186	0.195
	(11.7)	(11.4)	(5.30)	(5.54)
YSBC	0.0167	—	0.0304	—
	(1.66)		(2.16)	
MIGD	—	-0.0878	—	-0.152
		(-1.55)		(-1.93)
BOGD	—	0.0254	—	-0.0270
		(0.536)		(-0.411)
CALD	—	-0.0824	—	-0.127
		(-1.61)		(-1.79)
MEDD	—	-0.0307	—	-0.244
		(-0.621)		(-3.55)
	$R^2 = .35$	$R^2 = .35$	$R^2 = .20$	$R^2 = .21$

[1] For families with a child between 6 and 18 years, using score #4, as derived in the Appendix.
[2] For families with a child between 6 and 18 years.
The t-statistic for each coefficient is in parentheses.

columns 1 and 2) is not statistically significant at the 5 percent level, though the effect on their children's overall educational attainment is. This is as we might expect: the latter dependent variable reflects a series of past decisions regarding schooling, many made presumably in a rural environment. The current spending variable better reflects the migrant households' current urban environment, indicating migrant households act like other households in terms of their current spending, so that there must be a rapid catch-up effect operating on their children's educational achievement.[26]

The city dummies (Bogota, Cali, Medellin, with Barranquilla the omitted category) generally have contrary effects, as would be expected, on the two dependent variables, though not always, indicating there are price differences either for schooling (e.g., tuition fees) or births (e.g., contraceptive costs) across the cities which attenuate the simple negative correlation between N and Q. Medellin is clearly a high-fertility low-investment city relative to Bogota and Barranquilla. Cali exhibits lower fertility but lower investment (the latter not at statistically significant levels) as well. The

Medellin result may reflect greater continuing attachment to surrounding rural regions in Medellin, which is the major city in the smallholding coffee region of Colombia;[27] in any event, more investigation of these clear effects of differing economic or social environments is warranted. In these reduced-forms, it is not possible to isolate whether, for example, Medellin residents have comparatively high fertility and low per-child investment because high fertility causes low investment, low investment causes high fertility, or both are caused by other factors.

C. Two-Stage Least Squares Estimates

Finally, I present two-stage least squares estimates of the investment equation suggested by the jointly-determined model:

$$N = \alpha_0 + \alpha_1 Q_1 + \alpha_2 SCW + \alpha_3 SCJ + \alpha_4 LYH + \sum_i \alpha_i Z_i + \epsilon_1$$

$$Q = \beta_0 + \beta_1 N + \beta_2 SCW + \beta_3 SCJ + \beta_4 LYH + \sum_j \alpha_j W_j + \epsilon_2$$

These estimates of the Q equation above, in contrast to the ordinary least squares estimates in section A, have the statistical property of consistency, since the fertility variable, N, is treated as endogenous.

Unfortunately, estimation of this system is by no means straightforward, because of the difficulty of identifying the two equations. It is the Z_i and W_i, i.e., those variables representing respectively factors which influence number of children but not investment per child, and vice versa, which would permit identification of the equations. The fertility equation is virtually impossible to identify in any data set; an identifying variable would be some proxy for the *fixed* costs of quality in children, i.e., a cost unassociated with number of children. (If parents were not allowed to move, an exogenous increase in, for example, the property tax which funded local schooling, would qualify, since all households pay the tax, regardless of number of children.[28]) Thus the structural fertility equation is not estimated at all. The ideal identifying variable for the investment equation is the cost of contraceptives; lower contraceptive costs cause a relative increase in the fixed cost of child numbers at a given rate of sexual intercourse. The investment equation is identified in two ways. One is the use of a schooling age-of-wife interaction term in the fertility equation; this term probably reflects differences in timing of births due to differing price of time constraints for women by education. Timing of births will not affect educational investment (independent of income and other parent characteristics). Secondly, the two variables representing whether parents recently migrated to one of the four large cities are entered into the fertility equation, on the grounds that the cost of obtaining and using generally less-accessible contraceptives was less in these cities than elsewhere in Colombia. Insofar as this could also be true for obtaining education for children, the assumption that these migration-related variables affect fertility but not educational investment is a weak one. However, it is more justifiably excluded from that investment equation where the dependent variable is *current* spending, than from that equation where the dependent variable reflects to a greater extent past investment, i.e., where it is educational attainment to date of children. Thus the two-stage least squares method is used only to estimate the investment equation in which the dependent variable is current spending.

In Table 8 are the results from estimating this structural investment equation in which the dependent variable is the household's "score" relative to other households in the sample on current spending on education, standardized for each household in terms of the ages and sexes of children aged 6 to 22 (columns 1 to 3) and 6 to 18 (columns 4 to 6). The column 1 regression, using children alive, indicates a clear negative effect of number of children on per-child spending, as predicted. The coefficient of the alternative fertility measure, ARAT, is not statistically significant (and is of the wrong sign) in column 2, probably reflecting the difficulty of identifying the investment equation and the sensitivity of estimates to the identification procedure. The regression in column 3 is based on use of an instrumental variable, predicted ARAT, estimated using the sample of all households, including those with no school age children and those with no children at all. Such use of an instrumental variable based on a prediction from a different sample (columns 3 and 6) produces estimates which are inconsistent in the statistical sense; on the other hand, the endogenous fertility variables in columns 1, 2, 4, and 5, from the sample including only households with school age children, are derived from the first stage of a two-stage estimation technique which contains sample bias (however, this does not make the structural estimates of Table 8 inconsistent). At any rate, probably because predicted ARAT from the full sample takes account of the additional information regarding demand for fertility, it is of the expected negative sign and close to significance in the column 3 equation.

The same regressions are shown for the smaller sample of households with children 6 to 18 years old, and none older. The coefficients on children alive in column 4 and on the predicted fertility variable in column 6 are not statistically significant at the 5 percent level, but are of the same sign as in the columns 1 and 3 regressions.

The positive effect of income is only slightly greater in this structural equation than in the reduced-form investment equation. Insofar as the true structural effect is well-reflected in the investment reduced-form, we can assume its true effect is underestimated in the fertility reduced-form, again pointing to a positive income elasticity for numbers of children.

In these regressions, in contrast to the reduced-forms, the effect of parents' education on investment can be interpreted as structural, purged of additional positive effects education may have on Q through its negative

Table 8. Regressions on Household Educational Expenditure Scores

	(1) (2SLS)	(2) (2SLS)	(3) (instrumental variable estimate)	(4) (2SLS)	(5) (2SLS)	(6) (instrumental variable estimate)
	Households with at least one child aged 6 to 22 (n = 1559)			Households with at least one child aged 6 to 18, and none aged 19 to 22 (n = 1255)		
Constant	−1.395	−2.02	−1.273	−1.483	−2.019	−1.187
	(−7.79)	(−7.91)	(−4.11)	(−5.99)	(−7.50)	(−3.33)
SCW	0.0254	0.034	0.0244	0.0310	0.0375	0.0259
	(4.26)	(6.02)	(3.52)	(4.60)	(6.04)	(3.28)
SCH	0.00997	0.025	0.0134	0.0138	0.0213	0.00996
	(1.58)	(3.92)	(2.10)	(2.10)	(3.41)	(1.36)
LYH	0.303	0.280	0.277	0.295	0.295	0.287
	(12.4)	(12.5)	(12.7)	(11.3)	(11.1)	(11.4)
CHL*	−0.075	—	—	−0.0585	—	—
	(−2.70)			(−1.54)		
ARAT*	—	0.357	—	—	0.261	—
		(1.26)			(.960)	
ARAT**	—	—	−0.676	—	—	−0.874
			(−1.63)			(−1.85)
			$R^2 = .34$			$R^2 = .34$

The t-statistic for each coefficient is in parentheses.
*Endogenous variables in two-stage least squares estimation. See text.
**Endogenous variable, predicted using larger sample. See text.

effect on N. The coefficient of wife's education continues to be greater than that of husband's, contradicting the expectation that its greater magnitude in the reduced-form reflected primarily its theoretically stronger negative effect on N. However, husband's education is highly correlated with his income, dictating caution in comparing coefficients of husband's and wife's education.

The results confirm a causal effect of number of children on investment per child. Since the dependent variable is a score relative to other households, and since relative shifts in the score will vary for children at different ages, it is difficult to specify the negative effect of siblings in terms of years of schooling lost. However, based on the coefficient of the log of income (.303) and of children alive (–0.075) evaluated at the means of the variables, an increase of one in the number of children causes a 20 percent reduction in the family's score; to offset that reduction would require about a 30 percent increase in husband's income, from 614 (the antilog of the mean log of income) to 804 pesos quarterly.[29] This result points to a not inconsiderable "cost of siblings." The result is consistent with the model linking quality and quantity, and despite identification problems, indicates clearly that large family size causes a reduction in parental investment per child. To the extent that large families are more prevalent among poor families with less-educated parents, lower per-child investments by such families may perpetuate poverty from one generation to the next. On the other hand, exogenous changes in prices parents face which would reduce fertility would lead to concomitant increases in investment; similarly, if the costs of investment were exogenously reduced, fertility could fall.

ACKNOWLEDGEMENTS

*An earlier version of this paper was presented at the annual meeting of the Population Association of America, Atlanta, 1978. The author thanks the members of the Yale Labor and Population Workshop, especially Mark Rosenzweig and T. Paul Schultz, for many useful comments; Philip Musgrove for his suggestions and help; and David Bruce for computer assistance. Financial support from the Ford-Rockefeller Foundation Population and Development Policy Research Program, and from the Battelle Memorial Institute Population and Development Policy Program, is gratefully acknowledged.

APPENDIX

Designation of "Enrolled" Children and Results of Regressions of Household Educational Expenditures on Enrolled Children by Age and Sex

Four different age standards for educational attainment were attempted, as outlined in the following table:

Amount of education ⩾	Definitely enrolled	Probably enrolled	More definitely enrolled	Less probably enrolled
knows alphabet	6	6		6
1	7	7–8	6–7	7–8
2	8	9	8	9
3	9	10	9	10
4	10	11–12	10	11
6	11–12	13	11	12
7	13	14	12	13
8	14	15	13	14
9	15	16	14	15
10	16	17	15	16
11	17	18	16	17
12	18	19	17	18
13	19	20	18	19
14	20	21	19	20
15	21	22	20	21
16	22		21	22
16			22	

The resulting predicted costs by age-sex category are based on the equation:

$$EXED_j = C + \sum_{i=1}^{n_j} \beta_i ECD_{ixs} + \epsilon$$

where $\sum ECD_{ixs}$ is a series of age-sex dummies for enrolled children, with 9-year-old boys the excluded category.

The following matrices show predicted expenditures for each age-sex category, based on the constant plus coefficients from the regressions for definitely, probably, and less probably enrolled (the more definitely enrolled category appeared too stringent, based on the number of cases), with the constant entered for nine-year-old boys. The number of households with an enrolled child by each standard is also indicated. An asterisk indicates that the corresponding coefficient was statistically significant at the 5 percent level.

Definitely enrolled; number of children apparently enrolled by this definition is 1161.

	Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Sex	B	24	34	56	26	91*	94*	45	107*	109*	80*	145*	164*	253*	75	203*	115*	102*
	G	27	62*	76*	107*	78*	120*	53	73*	98*	65*	174*	113*	134*	112*	78*	82	200*

Probably enrolled; number of children apparently enrolled by this definition is 1409.

	Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Sex	B	26	33	19	19	54*	79*	36	82*	58*	50	85*	116*	191*	68	215*	92*	113*
	G	16	52*	46*	43	59*	78*	31	47*	75*	58*	124*	84*	128*	90*	83*	56	206*

Less probably enrolled; number of children apparently enrolled by this definition is 1316.

	Age	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Sex	B	23	33	27	22	58*	80*	40	104*	91*	77*	139*	162*	259*	65	200*	106*	106*
	G	22	56*	47*	51*	61*	82*	47	71*	98*	65*	179*	106*	134*	110*	82*	86	190*

FOOTNOTES

1. Though this problem is not the concern of this paper, underinvestment may be caused simply because of an intergenerational externality, apart from the presence or absence of siblings. Though the family is posited as an institution which minimizes such underinvestment, parents may stop short of a socially optimal level of investment in children. The child might be willing to compensate parents to invest directly in him or her, but the parents would have no certainty that the child would repay them, and the child cannot borrow easily. Lazear (1975) develops a model showing the likelihood of such an externality; he points out that parents may also underinvest in their own human capital if they fail to take into account the returns to their children from their own increased capital.

2. Zajonc (1976), Terhune (1974), Wray (1971), Lindert (1978, Ch. 6). Number of siblings has also been linked to adults' occupational status (Lindert 1978) and earnings (Bowles 1972). Simon and Pilarski (1979), using a cross-section of countries, find only a very weak negative relation between the proportion of children in national populations and per-child government spending on education, controlling for per-capita income. Such a finding using aggregate data is not inconsistent with reductions in households' private spending on per-child education as number of children increases.

3. This data set, collected by the Center for the Study of Economic Development (CEDE), Universidad de los Andes, Bogota, is described in Prieto (1977) and Musgrove (1978).

4. Such analyses of the Colombia data include Prieto (1977), Musgrove (1978), and Rodriguez and Gomez (1977). Brown and Deaton (1972) provide a review of the literature on consumer budget analysis. Prais and Houthakker (1955) deal specifically with family composition and economies of scale effects, developing and testing various computational techniques. See also Sydenstricker and King (1921) and Friedman (1952).

5. In a recent discussion of expenditure analyses, Muellbauer (1977) alludes to the fact that, though children *constrain* current household consumption, over the parents' lifetime they more properly enter the utility function, so that family size and composition are endogenous (p. 461).

6. Leibenstein (1975), Duesenberry (1960), Caldwell (1976). Easterlin, with his "relative income" and "relative status" arguments (1973), attributes allocation of resources by parents between themselves and children to the parents' own childhood experience, which he suggests influences their aspirations for a certain standard of living for themselves and for spending on the quality of their children.

An example of the logical error of assuming a direct causal link between family size and child well-being is the following: studies of children's consumption and work contribution in certain rural societies suggest that under some circumstances children involve negative costs, or positive value, to parents, at given rates of discount, time preference, etc. (Cain 1977, White 1973; Mueller (1976) comes to the opposite conclusion.) If we find that these children from large families who work on their parents' small family farms receive less schooling than their urban counterparts, should we conclude they receive less schooling *because* they have many siblings? Clearly not—more likely they both have many siblings and receive limited schooling because of the economic setting in which they are raised. This is the implication of an analysis of fertility, schooling, and children's work contribution in India, by Rosenzweig and Evenson (1977).

7. Analysis of the 1973 census indicates a rapid decline in Columbian fertility, beginning in the mid-Sixties. Fertility differentials by residence (urban-rural) and education have been and continue to be considerable. However, the composition of the population by residence and education has changed considerably. See Potter, Ordonez and Measham (1976).

8. Willis (1973), Becker and Lewis (1973). See also DeTray (1973). Becker's 1965 article on

FOOTNOTES

1. Though this problem is not the concern of this paper, underinvestment may be caused simply because of an intergenerational externality, apart from the presence or absence of siblings. Though the family is posited as an institution which minimizes such underinvestment, parents may stop short of a socially optimal level of investment in children. The child might be willing to compensate parents to invest directly in him or her, but the parents would have no certainty that the child would repay them, and the child cannot borrow easily. Lazear (1975) develops a model showing the likelihood of such an externality; he points out that parents may also underinvest in their own human capital if they fail to take into account the returns to their children from their own increased capital.

2. Zajonc (1976), Terhune (1974), Wray (1971), Lindert (1978, Ch. 6). Number of siblings has also been linked to adults' occupational status (Lindert 1978) and earnings (Bowles 1972). Simon and Pilarski (1979), using a cross-section of countries, find only a very weak negative relation between the proportion of children in national populations and per-child government spending on education, controlling for per-capita income. Such a finding using aggregate data is not inconsistent with reductions in households' private spending on per-child education as number of children increases.

3. This data set, collected by the Center for the Study of Economic Development (CEDE), Universidad de los Andes, Bogota, is described in Prieto (1977) and Musgrove (1978).

4. Such analyses of the Colombia data include Prieto (1977), Musgrove (1978), and Rodriguez and Gomez (1977). Brown and Deaton (1972) provide a review of the literature on consumer budget analysis. Prais and Houthakker (1955) deal specifically with family composition and economies of scale effects, developing and testing various computational techniques. See also Sydenstricker and King (1921) and Friedman (1952).

5. In a recent discussion of expenditure analyses, Muellbauer (1977) alludes to the fact that, though children *constrain* current household consumption, over the parents' lifetime they more properly enter the utility function, so that family size and composition are endogenous (p. 461).

6. Leibenstein (1975), Duesenberry (1960), Caldwell (1976). Easterlin, with his "relative income" and "relative status" arguments (1973), attributes allocation of resources by parents between themselves and children to the parents' own childhood experience, which he suggests influences their aspirations for a certain standard of living for themselves and for spending on the quality of their children.

An example of the logical error of assuming a direct causal link between family size and child well-being is the following: studies of children's consumption and work contribution in certain rural societies suggest that under some circumstances children involve negative costs, or positive value, to parents, at given rates of discount, time preference, etc. (Cain 1977, White 1973, Mueller (1976) comes to the opposite conclusion.) If we find that these children from large families who work on their parents' small family farms receive less schooling than their urban counterparts, should we conclude they receive less schooling *because* they have many siblings? Clearly not—more likely they both have many siblings and receive limited schooling because of the economic setting in which they are raised. This is the implication of an analysis of fertility, schooling, and children's work contribution in India, by Rosenzweig and Evenson (1977).

7. Analysis of the 1973 census indicates a rapid decline in Colombian fertility, beginning in the mid-Sixties. Fertility differentials by residence (urban-rural) and education have been and continue to be considerable. However, the composition of the population by residence and education has changed considerably. See Potter, Ordonez and Measham (1976).

8. Willis (1973), Becker and Lewis (1973). See also DeTray (1973). Becker's 1965 article on

the theory of time allocation fathered what has come to be called the "new home economics" approach to studying the effect of economic factors on fertility.

9. There is thus an important distinction between high-*wage* households in which all income is earned through labor, and high-*income* households where much or all income is from capital. In the latter households, increased income should be associated unequivocally with increased demand for child services, since there is no additional cost of spending more time with children when additional income is not associated with working time of parents (assuming the wife works).

10. This follows immediately from the first-order conditions for maximizing the utility function subject to the budget constraint, $I = NQ\pi_C + Z\pi_Z$. With the assumption of same quality of each child in the household, the first-order conditions include:

$$MU_N = \lambda Q\pi_C; MU_Q = \lambda N\pi_C; MU_Z = \lambda\pi_Z.$$

Becker and Lewis, in discussing price effects, generalize the budget constraint so that the shadow prices for N and Q each contain a "fixed" component:

$$I = NQ\pi_C + N\pi_N + Q\pi_Q + Z\pi_Z.$$

The shadow prices are then:

$$P_N = Q\pi_C + \pi_N; P_Q = N\pi_C + \pi_Q; \ P_Z = \pi_Z.$$

It is the fixed components which in principle make it possible to identify price effects on consumption of N and Q.

Rosenzweig and Wolpin (1978) have shown that it is not possible to distinguish empirically between this model, with interaction between Q and N, and a simple fixed price model, without interaction, without some restrictions on the characteristics of the utility function. They use the random occurrence of multiple births to represent variation in the fixed price of N in a cross-section of households; then with the restriction that both Q and Z are substitutes for N, they can test the interactive model. It is accepted, given that restriction and given certain bounds on the cross-price elasticity between P_N and Q.

11. The proportion of persons aged 12 to 19 enrolled in school was 5 percent in 1951, 12 percent in 1964, and 24 percent in 1973; despite rapid increases in the size of this population, the rate of increase in proportions enrolled was higher in the late sixties than in the fifties. Between 1950 and 1958, spending at all levels of government on education was about 22 percent of total spending; between 1958 and 1967, the proportion spent on education rose to about 45 percent. (DANE, 1975, p. 110, and 1971, p. 128.)

12. Lindert, 1978, p. 195, finds, using U.S. data, that family size is a more important determinant of predicted inputs into each child than are birth order and spacing.

13. Birdsall (1979).

14. Sample sizes also differ somewhat because of missing data on some variables; only male-headed households are included in the reduced-form and two-stage least squares estimates; for certain investment regressions, families with any children aged 19 to 22 were excluded, as such children could affect the 6 to 18 year old based scores.

15. We have no simple way to measure the quality of education, and use the strong assumption throughout that price differences in schooling reflect quality differences, i.e., parents who pay more get more.

16. Parameter estimates from regressions using the score calculated for children up to 22 do not differ significantly in the reduced-form regressions, and are not reported. They are reported below in the one case where they are different, using two-stage least squares.

17. The expenditure score variable captures to some extent the opportunity cost to parents of keeping their children in school and foregoing their home or labor market contribution to the household. However, in this dependent variable, these opportunity costs are combined with direct costs. The two-stage least squares estimation might therefore overstate the (negative)

effect of increasing family size if parents with more children tend to substitute their own time for market expenditures in producing their children's human capital. Since education-at-home is possible with greater economies of scale than education-at-school, this is theoretically plausible. On the other hand, analyses of U.S. time budget data have indicated that parents (generally of lower income) do not increase overall time spent with children as number of children increases, and thus do decrease time per child (even assuming some economies of scale in time inputs to children). (Leibowitz 1974, Lindert 1978, Appendix C). Parents thus seem to treat time and goods as complements in the production of child human capital. Furthermore, it is likely that the goods-intensive nature of children increases as children grow older so that for school-age children, differences in money expenditures by family size reflect fairly well differences in total parental investment, both time and goods, in children. Gronau (1977) suggests children are not always home-time intensive: "Thus, while in the range where children's goods are produced at home, an increase in wage increases the price of children, when these goods are replaced by market goods, the increase in wage reduces it. . . . The goods-intensive nature of children becomes ... more explicit as the child grows older. . . ." (pp. 30–31)

18. Rosenzweig (1977) uses this index for Indian data.

19. For parents to replace children who die requires that the demand for surviving children be price inelastic; that it is, is indicated where evidence shows a positive association between child mortality and fertility. See Schultz (1976).

20. Boulier and Rosenzweig (1978) suggest a measure of fertility which is standardized for the age-fecundity relationship using an age-specific natural fertility schedule and for exposure to the risk of conception associated with marriage duration ("DRAT"). The measure used here, "ARAT," is not standardized for marriage duration, since age at marriage itself is endogenous in terms of the household decisionmaking process being analyzed, e.g., better-educated women may choose to marry later.

21. The correlation between husband's income and total household income is .95. Unearned income was also tried, but is reported for very few families; its coefficient was never significantly different from zero.

22. Spending and income amounts are not annual, but quarterly.

23. In fact, both the N and Q equations should include variables representing prices of N and Q (each independent of the amounts "purchased" by households, i.e., the fixed prices of footnote 10), but such prices are difficult to obtain. N and Q, each entered in the other regression, can be conceived of as quantity proxies for prices (with expected coefficient signs reversed), so a qualitative relationship between the price of N and the Q consumed, or vice versa, can be estimated. See Rosenzweig and Wolpin (1978).

24. Lindert (1974) interprets results of his U.S. data analysis as indicating that higher-income, higher-status wives do not spend more time in child care than lower-status counterparts. They do tend to spend more time *per child* by having fewer children (pp. 67–69). There is no evidence that higher-status mothers spend *in toto* less time, however. Leibowitz (1974) finds more-educated mothers to be more efficient in production at home of children's human capital.

25. Since education and income of husband are highly correlated positively (.64), the positive income effect may reflect unexpected income, or income over what a family anticipates, given the husband's education. This result is consistent with Easterlin's relative income hypothesis (Easterlin, 1973) and with positive effects on fertility of upswings in the business cycle in developed country time-series (Lindert, 1978).

The positive correlation between husband's education and income does suggest caution in comparing the coefficients of husband's and wife's education.

26. Expenditure data were collected at four different times of the year; regressions with dummy variables included for the period when a household was surveyed indicated spending on education varied systematically by period because of the schooling cycle. However,

coefficients of variables of interest were not different from those in Table 7. Migrant families were equally represented in the different periods.

For discussion of the hypothesis that migrants achieve earnings similar to longtime residents within 5 to 10 years, see Yap (1976).

27. Walton (1977) states in describing early 20th century Medellin: "The fervently Catholic labor force was not secularized by these trends toward modernization. Traditionally conservative beliefs persisted . . ." (p. 71). Medellin is the industrial center of a region, Antioquia, which has a reputation for independence and regional identity. It has not been a center for in-migrants from other regions, as Cali and Bogota have been. Musgrove (personal correspondence) suggests Medellin has higher overall fertility because of a more highly skewed distribution of income, with more families characterized by low income and high fertility.

28. Such an increase in the fixed cost of child quality would lower the relative price of child numbers, given they are substitutes, and lead to an increase in number of children.

29. Dividing the coefficient of CHL (.075) by .4, the mean investment score for this sample, gives .19, or about a 20 percent reduction in the score with one additional child. To obtain the compensating 20 percent increase in the score, we use .3, the coefficient of income:

$$\frac{.3(x)}{.4} = .20 \rightarrow x = .27$$

The mean log of income is 6.42, and $e^{6.42} = 614$. 6.42 (1.27) = 6.69, and $e^{6.69} = 804$.

REFERENCES

Becker, Gary, "An Economic Analysis of Fertility," in *Demographic and Economic Change in Developed Countries*. Princeton: Princeton University Press, 1960.

Becker, Gary, "A Theory of the Allocation of Time," *Economic Journal*, Vol. 75 (September 1965), pp. 493–517.

Becker, Gary and H. Gregg Lewis, "Interaction between Quantity and Quality in Children," *Journal of Political Economy*, Vol. 81, No. 2, Part 2 (March/April 1973), pp. S279–88.

Birdsall, Nancy, "An Economic Approach to Birth-Order Effects," Yale University Economic Growth Center Discussion Paper No. 313, May 1979.

Boulier, Bryan and Mark R. Rosenzweig, "Age, Biological Factors and Socioeconomic Determinants of Fertility: A New Measure of Cumulative Fertility for Use in the Empirical Analysis of Family Size," *Demography*, Vol. 15 (November 1978), pp 487–498.

Bowles, S, "Schooling and Inequality from Generation to Generation," *Journal of Political Economy*, Vol. 80, No. 3, Part 2 (May/June 1972), pp. S219–51.

Brown, Alan and Angus Deaton, "Surveys in Applied Economics: Models of Consumer Behaviour," *Economic Journal*, 1972.

Cain, Mead T, "The Economic Activities of Children in a Village in Bangladesh," *Population and Development Review*, Vol. 3, No. 3 (September 1977), pp. 201–28.

Caldwell, John, "Toward a Restatement of Demographic Transition Theory," *Population and Development Review*, Vol. 2, Nos. 3,4 (December 1976), pp. 321–66.

Departamento Administrativo Nacional de Estadistica, "Organizacion y Funcionamiento del Sistema Educativo Colombiano," *Boletin Mensual de Estadistica*, No. 243 (October 1971), pp. 75–156.

Departamento Administrativo Nacional de Estadistica, *Boletin Mensual de Estadistica*, No. 293 (December 1975).

DeTray, Dennis N., "Child Quality and the Demand for Children," *Journal of Political Economy*, Vol. 81, No. 2, Part 2 (March-April 1973), pp. S70–95.

Duesenberry, James, Comment on "An Economic Analysis of Fertility" by Gary S. Becker, in

Demographic and Economic Change in Developed Countries, Princeton: Princeton University Press, 1960.

Easterlin, Richard A., "Relative Economic Status and American Fertility Swings," in *Family Economic Behavior*, Eleanor B. Sheldon, ed., Philadelphia: Lippincott, 1973.

Espenshade, Thomas J., "Estimating the Cost of Children and Some Results from Urban United States," University of California, Berkeley, International Population and Urban Research, 1973.

Friedman, Milton, "A Method of Comparing Incomes of Families Differing in Composition," *Studies in Income and Wealth*, National Bureau of Economic Research, 1952.

Gronau, Reuben, "Leisure, Home Production and Work—The Theory of the Allocation of Time Revisited,". *Journal of Political Economy*, Vol. 85, No. 6 (December 1977), pp. 1099–124.

Lazear, Edward, "Intergenerational Externalities." Mimeo, University of Chicago, 1975.

Leibenstein, Harvey, "The Economic Theory of Fertility Decline," *Quarterly Journal of Economics*, Vol. 89 (February 1975), pp. 1-31.

Leibowitz, Arleen, "Education and Home Production," *American Economic Review*, Vol. 64 (1974), pp. 243–50.

Lindert, Peter H., "Child Costs and Economic Development." Mimeo, University of Wisconsin, 1976.

Lindert, Peter H., "Sibling Position and Achievement," *The Journal of Human Resources*, Vol. XII, No. 2 (1977), pp. 198-209.

Lindert, Peter H., *Fertility and Scarcity in America*, Princeton, Princeton University Press, 1978.

Muellbauer, John, "Testing the Barten Model of Household Composition Effects and the Cost of Children," *The Economic Journal*, Vol. 87 (September 1977): pp. 460-87.

Mueller, Eva, "The Economic Value of Children in Peasant Agriculture," in *Population and Development: The Search for Selective Interventions*, ed. Ronald G. Ridker, Baltimore: Johns Hopkins University Press, 1976.

Musgrove, Philip, *Income and Spending of Urban Families in Latin America: The ECIEL Consumption Study*, Washington D.C.: Brookings Institution, 1978.

Potter, Joseph E., Miriam G. Ordonez and Anthony R. Measham, "The Rapid Decline in Colombian Fertility," *Population and Development Review*, Vol. 2, Nos. 3,4 (September/December 1976), pp. 509–28.

Prais, S.J., and H.S. Houthakker, *The Analysis of Family Budgets*, Cambridge: Cambridge University Press, 1955.

Prieto Duran, Rafael, "Gasto y Ingreso Familiar Urbano en Colombia," *Ensayos Eciel* (August 1977), pp. 45–120.

Rodriguez, Cecilia Lopez and Hernando Gomez Buendia, *Familia y Consumo en la Ciudad Colombiana*, Colciencias: Bogota, 1977.

Rosenzweig, Mark R., "Schooling, Allocative Ability and the Green Revolution." Mimeo, Yale University, 1977.

Rosenzweig, Mark R., and Robert Evenson, "Fertility, Schooling and the Economic Contribution of Children in Rural India: An Econometric Analysis," *Econometrica*, Vol. 45, No. 5 (July 1977), pp. 1065–80.

Rosenzweig, Mark R. and Kenneth I. Wolpin, "Testing the Quantity-Quality Fertility Model: Results from a Natural Experiment," Economic Growth Center Discussion Paper No. 288, Yale University, 1978.

Ruprecht, Theodore K., and Frank I. Jewett, *The Micro-Economics of Demographic Change: Family Planning and Economic Well-Being*, New York: Praeger, 1975.

Schultz, T. Paul, "Interrelationships Between Mortality and Fertility," in *Population and Development: The Search for Selective Interventions*", Baltimore. Johns Hopkins University Press, 1976.

Simon, Julian L. and Adam M. Pilarski, "The Effect of Population Growth Upon the Quantity of Education Children Receive," *Review of Economics and Statistics*, Vol. 61, No. 4 (November 1979) pp. 572–584.

Sydenstricker, E. and W.I. King, "The Measurement of the Relative Economic Status of Families," *Journal of the American Statistical Association*, 1921.

Terhune, Kenneth, *A Review of the Actual and Expected Consequences of Family Size*, National Institute of Health, Washington, D.C., 1974.

Walton, John, *Elites and Economic Development: Comparative Studies on the Political Economy of Latin American Cities*, Austin: University of Texas Press, 1977.

White, Benjamin, "The Economic Importance of Children in a Javanese Village." Mimeo, New York: International Institute for the Study of Human Reproduction, Columbia University, 1973.

Willis, R.J., "A New Approach to the Economic Theory of Fertility Behavior," *Journal of Political Economy*, Vol. 81, No. 2, Part 2 (March/April 1973), pp. S14–64.

Wray, Joe D., "Population Pressure on Families: Family Size and Child Spacing," *Reports on Population/Family Planning No. 9*, 1971.

Yap, Lorene Y.L., "Rural-Urban Migration and Urban Underemployment in Brazil," *Journal of Development Economics*, Vol. 3, No. 3 (September 1976), pp. 227–43.

Zajonc, R.B., "Family Configuration and Intelligence," *Science*, Vol. 192, No. 4236 (April 16, 1976), pp. 227–36.

THE WORLD BANK
Headquarters:
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.
European Office:
66, avenue d'Iéna
75116 Paris, France
Tokyo Office:
Kokusai Building,
1-1 Marunouchi 3-chome
Chiyoda-ku, Tokyo 100, Japan

The full range of World Bank publications, both free and for sale, is described in the *World Bank Catalog of Publications*, and of the continuing research program of the World Bank, in *World Bank Research Program: Abstracts of Current Studies*. The most recent edition of each is available without charge from:

PUBLICATIONS UNIT
THE WORLD BANK
1818 H STREET, N.W.
WASHINGTON, D.C. 20433
U.S.A.