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THE ECONOMICS OF FERTILITY: THE PUERTO RICAN EXPERIENCE

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THE ECONOMICS OF FERTILITY:

THE PUERTO RICAN EXPERIENCE

by

CARLOS CANDELARIO

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To my father, Cecilio Candelario

Abstract

THE ECONOMICS OF FERTILITY:
THE PUERTO RICAN EXPERIENCE

by

Carlos Candelario

Adviser: Professor Michael Grossman

Using data obtained from the 1970 Census of Puerto Rico, two demand equations are estimated; one for the number of children desired by utility maximizing parents and the second for the "quality" of these children where the quality of children is approximated by the average level of education attained.

Estimation of the model takes into account various socio-economic determinants of the dependent variables such as wage rates of parents, education of parents, rural or urban setting and employment status of the household head. Estimation of the equations is performed using Ordinary Least Squares and two simultaneous equations techniques in order to take into consideration possible joint determination of the two endogenous variables. Alternative specifications of the model are also presented due to the existence of multicollinearity between explanatory variables and low R squares obtained for the estimates of the instrumental variables obtained for the first stage results of the simultaneous equations estimating techniques.

Results obtained in this dissertation confirm the majority of predictions made by economic theory. In addition, the hypothesis that couples view numbers and quality of children as substitute inputs in the production of child services was consistently reinforced.

ACKNOWLEDGMENTS

Contrary to popular belief, a dissertation is not the work of solely one individual but rather reflects the ideas and support of a variety of individuals whose numbers, in this case, are legion and I would like to take this opportunity to thank them one and all.

This work would not have been possible without the intellectual guidance and moral support provided by my principle advisor, Professor Michael Grossman, whose patience bordered on the miraculous. In addition, I am extremely grateful to Professors Damodar Gujarati and Elliot Zupnick, who served as members of my committee and provided insights and suggestions imperative to the successful conclusion of my degree requirements.

Finally, I would like to express my appreciation to the Candelario family and our friends for their encouragement in my darkest hours and most of all to the memory of my beloved father, Cecilio Candelario, to whom this dissertation is dedicated.

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CHAPTER I

Introduction

In the realm of the Social Sciences, demographic studies have implied that a widespread desire to limit family size is accompanied by, or sometimes preceded by, rapid industrialization and the corresponding phenomenon of urbanization and increasing per capita income. To put it another way, family size decreases with economic growth. Here economic growth, in a very simple sense, is defined as a sustained increase in real per capita output of a society.

Urbanization and increased per capita income are, of course, not the only correlates to industrialization. Demographic changes complementary to a newly industrialized urban system also include increases in employment levels, opportunities for higher educational levels and higher demand for skilled and semi-skilled workers. These increased requirements for formal education have made children more expensive to rear as more jobs have come to require more education for initial placement and subsequent promotion. As Schmidt writes:

> The children must be groomed to leave the family in due time and be adequately prepared to seek employment elsewhere. From being assets in the traditional system, they have increasingly become economic liabilities.[1]

Although "liabilities" may be an excessive term used to represent these children since basically, increased expenditures

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1. Carlos Schmidt-Sanchez, Changing Patterns of Population Fertility in Puerto Rico (Urbana: University of Illinois, 1967) p. 10.

on the education of children can be considered as investments which may result in substantial pecuniary and nonpecuniary returns to the family unit as a whole, there is little doubt that increases in compulsary and desired levels of education for children are most costly in terms of direct outlays and opportunity costs to the family.

In the particular case of Puerto Rico, rapid industrialization began with Operation Bootstrap and continued through the 1940's and 1950's. This industrialization helped cause a rather spectacular rise in per capita personal income during the two decades.[2] At this point one should realize that this uncommon economic development is a very special case due, to a large extent, to the commonwealth status of the island with the United States. The advantages of this relationship with the mainland include a tremendous source of investment capital, social welfare payments, the lack of a need to maintain a national defense force and of course a place to which surplus population can migrate easily and freely. Most of these advantages obviously did not exist while Puerto Rico was a possession of Spain before 1898.

Prior to Operation Bootstrap, births per 1,000 remained relatively constant. This demographic experience is similar to that of other underdeveloped, preindustrialized societies.[3] One notices a substantial change in births between the years 1950 and 1960. The period between 1960 and 1965 exhibits an even more dramatic decrease. This decrease in births corresponds to the period of intense industrialization and rising per capita incomes in Puerto Rico.

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2. See table 1.

3. See table 2.

TABLE 1

PUERTO RICAN PER CAPITA PI IN CONSTANT 1954 DOLLARS

YR	PI
1940	213
1948	296
1952	394
1956	462
1960	539
1965	748

Source: Presser, p. 46.

TABLE 2

PUERTO RICAN BIRTHS PER 1000 POPULATION

PERIOD	BIRTHS
1899-1910	40.5
1910-1920	40.4
1920-1930	39.3
1930-1940	39.6
1940-1950	40.7
1950-1960	35.0
1960-1965	30.8

Source: Presser, p. 43.

The decrease cannot, a priori, be totally attributed to the occurrence of rapid industrialization and other economic stimuli per se. Other factors may have contributed to the decline. For example, this period was also characterized by a decrease in the mortality rate. Again, demographic studies predict a decrease in the birth rate once a decrease in the mortality rate becomes noticeable, given an own price elasticity less than one in absolute value.[4]

One might also question the use of per capita income as a measure of the change in economic well being of the average individual in the society without taking into consideration the changes in the distribution of income. However, industrialization and economic development in general have combined to decrease the level of income inequality on the island. The Gini Coefficient,[5] sometimes called the concentration ratio,

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4. I am indebted to M. Grossman for the following. Consider a utility function with two inputs n and x, where n represents number of expected surviving children and x an aggregate commodity. Define P_x=\$1, p=survival rate, b=number of births and π = cost of a birth (abstracting from costs of rearing children). Form the Lagrangean $L=U(n,x)+\lambda(I-x-\pi b)$ where I represent income. Now the number of expected surviving children, n=pb or b=n/p. Therefore we can rewrite L as $U(n,x)+\lambda(I-x-\pi/p(n))$. The first order conditions imply $U_n/U_x=\pi/p=\pi^*$ which is the relative price of n. Since b=n/p, lnb=lnn-lnp. Taking derivatives and dividing by ∂lnp, we can write $\partial \ln b/\partial \ln p=\partial \ln n/\partial \ln p-1$ or, $\partial \ln b/\partial \ln p=\partial \ln n/\partial \ln \pi^*(\partial \ln \pi^*/\partial \ln p)-1$, where $\partial \ln n/\partial \ln \pi^*=-E$, E being the own price elasticity of demand. Therefore, $\partial \ln b/\partial \ln p=-E\,\partial \ln \pi^*/\partial \ln p-1$. We can therefore write $\partial \ln b/\partial \ln p=E-1$, which is less than zero when E is less than one.

5. The Gini coefficient is given by the area between the Lorenz curve and the line of perfect equality divided by the area of maximum inequality which is given by the triangle under the diagonal. The highest value the Gini coefficient can attain is therefore one, representing a totally inequitable distribution of income. The lowest value is zero representing a totally equal distribution of income.

has decreased from a value of .45 in 1941, to a value of .30 in 1953 for wage-earning families.[6]

Concerning particular family size, Schmidt has determined from a sample of 1,261 Puerto Rican urban wives that the ideal number of children desired converges on a rather small number. Sixty-five per cent of the wives selected three children as ideal. The average goal was 2.92. Interestingly enough, he also found that older women regard as ideal a larger family than younger women,[7] reflecting perhaps the changing socio-economic values of families as industrialization and economic development continue.

The experience of the United States, during its period of industrialization, was similar if somewhat less dramatic. This period extended over approximately the entire 19th century. By 1860, although the value of manufactured products was less than the value of the three major American crops and total capital investment in industry was less than one sixth the value of farm land and building, the United States was second only to Great Britain in manufacturing.[8]

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6. Fuat M. Andic, <u>Distribution of Family Incomes in Puerto Rico</u> (Rio Pietras: University of Puerto Rico, 1965), p. 138.

7. See table 3.

8. Ross M. Robertson, <u>History of the American Economy</u> (New York: Harcourt Brace Jovanovich, 1973), p. 221.

The birth rate in the United States, at the beginning of the nineteenth century was noticeably higher than any of the European countries. By 1900, the United States had reduced its birth rate to the level then current in Great Britain. This phenomenon could have been predicted due to the prior industrialization of Europe.

The long term trend of fertility in the United States has been generally downward throughout the period of industrialization and well into the twentieth century for the White population. Distinct troughs in the birth rates occurred during major wars because of mobilization and during the Depression of the 1930's. Another dominant feature of the data is a sustained recovery of the birth rate after the Second World War.[9]

Although demographic studies have dealt with population related questions for many years, it has not been until recently that economic analysis has been directly applied to family decision-making in the home affecting fertility behavior. The result has been a proliferation of economic studies in this area with accompanying critiques.

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9. Ansley J. Coale and Melvin Zelnik, New Estimates of Fertility and Population in the United States (Princeton: Princeton University Press, 1963), pp. 21-25.

TABLE 3

PUERTO RICAN MEAN IDEAL NUMBER OF CHILDREN

WIFE'S AGE	MEAN IDEAL
under 25	2.68
25-29	2.73
30-34	2.77
35-39	2.74
40-44	3.10

Source: Schmidt, p. 112.

Previously, questions concerning fertility were investigated mainly on a macroeconomic level. The most interesting and important question, as envisaged by economists, concerned the equilibrium level of population achieved by a society. The neo-classical approach, espoused originally by early English economists and adhered to today in a revised form by a number of individuals across a wide spectrum of academic disciplines, resulted in the acronym of the "dismal science" being assigned to economics.

In a nutshell, the dire predictions of the theory involved a static level of productive natural resources and a dynamically increasing human population resulting in a decreasing return to labor. Eventually, population growth would abruptly stop due to the inability of the land to support further additions to the population. The resulting equilibrium implied a subsistence level of wages relegated to the vast majority of the human race. Alleviation of this somber spectre would only be realized by a decrease in population size, if not brought about by voluntary abstinance than perhaps by war, famine and disease. By the mid-1900's, the conventional wisdom had progressed to the concept of Zero Population Growth again due to the realization of a constant level of certain world resources.

TABLE 4

U.S. PER CAPITA DISPOSABLE P.I.

(1972 DOLLARS)

YR	DPI
1911	$1,445
1915	1,514
1920	1,367
1925	1,518
1930	1,635
1935	1,495
1940	1,825
1945	2,376
1950	2,386
1955	2,577
1960	2,697
1965	3,152
1970	3,619
1975	4,007

Source: Facts & Figures on Govt. Finance 19th Biennial Ed. 1977.

TABLE 5

U.S. BIRTHS PER 1000 WHITE POPULATION

YR	BIRTH RATE
1855	42.8
1860	41.8
1865	35.4
1870	37.1
1875	36.8
1880	33.6
1885	33.3
1890	31.2
1895	30.8
1900	28.5
1905	27.9
1910	27.3
1915	26.2
1920	25.0
1925	22.4
1930	19.4
1935	17.1
1940	17.8
1945	18.9
1950	22.4
1955	23.2
1960	22.2

Source: New Estimates of Fertility & Population in the U.S.
Coale & Zelnik.

Most recently, the emphasis in the literature has undergone a change. Economists are now probing population equilibrium not solely in a macroeconomic context, but also in a microeconomic context where the basic microeconomic unit is the family. This change in emphasis has encouraged criticisms of the sort which suggest that economists are destroying the very concept of family as a social institution.

Rather, by their inquiries, economists have extended the concept of family to include the corresponding concepts of investment in human capital, the value and allocation of human time and the household production function.

It is my intention in this thesis to examine the demand for the number and quality of children in Puerto Rico.

Basically, couples have children because they serve as a source of child services although the postulated reasons for having children may often seem diverse. These reasons include: (1) children as an investment good -- very often stated as an important reason for having children in underdeveloped countries with poorly developed or nonexistent social security programs, (2) children as a source of labor -- used to explain why rural families are on the average larger than urban families and (3) children as a "consumption commodity" entering directly into the parents' utility function.

Central to the issue of the demand for the number and quality of children is the question concerning the sign of the income elasticity of demand for children. None of the above stated reasons for having children would necessarily lead one to expect a negative sign for the income elasticity of demand for children a priori. On the contrary, any commodity requiring a relatively large share of a family's budget would be expected to have a positive income elasticity of demand. Yet, a negative or a small positive correlation has often been found to exist between income and number of children in fertility studies (Tomes 1978). This negative or small positive income elasticity has been explained in different ways.

One explanation involves the opportunity cost of the mother's time. It is frequently found that higher income males marry females with high income potential.[10] The higher the income potential of the female, the higher is her opportunity cost. This implies a higher cost of bearing and rearing children. This negative effect of higher opportunity cost on the equilibrium number of children a couple desires can conceivably overcome any positive effect of income on the demand for children leading to an observed income elasticity of demand which is negative. Of course one must also realize that, assuming the higher opportunity cost of mother's time is due to higher levels of education, implies that higher opportunity cost women should have higher productivity levels in home production. The higher opportunity cost may therefore

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10. The simple correlation coefficient between husbands' and wives' wages in this study was .2364 and significant.

have a twofold effect, opposite in sign, on number of children produced.[11]

Still another explanation involved the positive correlation between income and birth control knowledge. Given that increased levels of birth control knowledge reduce numbers of children, the observed effect of income might be to depress numbers of children since the income variable is now picking up the birth control effects.

A third explanation involves the substitution of quality of children for quantity as family income rises. That is, higher income parents can be expected to increase expenditures on child services. Since the number of children and their quality can be viewed as objects of choice of parents, the period of increasing income may be characterized by increased expenditures per child. These expenditures may be in such areas as health, intellectual development and social adjustment and would represent differences in the quality of the children. If the resulting income elasticity for quality were greater than the resulting income elasticity for quantity, the observed or empirically obtained income elasticity for quantity might be a small number or could even be negative. This second explanation will be under investigation in

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11. I might add that for high income households where a large proportion of income is derived from capital, rather than labor, the increased income should unequivocally be associated with a higher demand for children since the marginal cost of mother's time is not now directly related to family income.

this dissertation in conjunction with the quality-quantity substitution effect in the context of a model that takes into account various determinants of numbers of children and schooling, such as wage rates, education of parents, rural or urban setting and employment status of the household head.

CHAPTER II

Analytical Framework

Central to the study of the substitution between quality and quanity of children are the quality-quantity interaction model of Becker and Lewis (1973), the household production function of Becker (Becker 1965) and the Willis model of fertility behavior (Willis 1973).

In household production, commodities are both produced and consumed by members of the family. The family utility function is therefore a function of the home produced commodities or Z-goods. That is,

$$(1) \quad U = U\ (Z_1,\ Z_2,\ \cdots,\ Z_n)$$

Embodied in this representation of a collective utility function is the assumption of non-interdependent utility functions for the individual family members and no "public" type family goods or jointly consumed Z-goods, since any unit of Z_i consumed by one individual in the family implies an equal amount subtracted from the total units of Z_i available to the family.

The Z-commodities are produced with inputs supplied by the husband and wife. The production function for any family produced commodity Z_i can, therefore, be written as

$$(2) \quad Z_i = f_i\ (t_i1,\ t_i2,\ X_i) \qquad t_i1,\ t_i2,\ X_i \geq 0$$

where t_i1 would represent the time input of say the wife, t_i2

the time input of the husband and X_i a vector of goods purchased in the market place and used as physical inputs in the production of the i^{th} Z-good.

The arguments entering the family utility function, which are of interest, are child services and other services which serve as sources of satisfaction to parents and determine the family standard of living. These latter services shall be conceptually aggregated and presented as the commodity S. Child services, in turn, can be thought of as the total quality of all children residing in the home.

If the same level of quality is allocated to each child by the parents, we can define total child services, C, as total number of children multiplied by quality per child,

$$(3) \quad C = NQ$$

The family utility function can therefore be expressed as

$$(4) \quad U = U\ (Q,\ N,\ S)$$

where the homogeneous household production functions for S, Q and C may be written as $S = f_s\ (t_s1,\ t_s2,\ X_s)$, $Q = f_q\ (t_{q1/N},\ t_{q2/N},\ X_{q/N})$ and $C = NQ = f_c\ (t_{c1},\ t_{c2},\ X_c)$. N represents total number of children in the home and Q represents quality per child.

The production of child services is constrained by technology, which is embodied in the form of the production function, and by the availability of lifetime resources. Time entering into the production function of child services will be restricted to the mother's and father's time allocated to

C and the vector of commodities entering the production function will be restricted by lifelong family wealth.[12] These conditions imply that

$$(5) \quad S\,\pi_s + C\,\pi_c \leq Y_w + Y_h + V = I$$

which in turn implies that the household cannot spend more on household production than lifelong family wealth, where $S\,\pi_s$ is total expenditures on the production of aggregate services, $C\,\pi_c$ is total expenditures on child services, Y_w is the lifetime wage earnings of the wife, Y_h is the lifetime wage earnings of husband and V is any other sources of lifetime income such as an initial endowment and/or wealth transfer.[13]

If we equate the present value of income to the present value of consumption, which would allow for savings in some periods, we might then write

$$(6) \quad I = C\,\pi_c + S\,\pi_s \qquad \text{or}$$

$$(7) \quad I = NQ\,\pi_c + S\,\pi_s$$

which now becomes our budget constraint.

Using the Lagrangean technique of constrained optimization, the following first order conditions are obtained[14]

12. Throughout it will be assumed that only the resources and time provided by the parents will enter the production functions or equivalently that there does not exist other contributing adult members in the household.

13. The π's will represent marginal cost of producing Z-commodities and are dubbed shadow prices due to the fact that the "prices" of producing and consuming these commodities do not appear in the market place.

14. See Mathematical Appendix A.

$$(8) \quad \frac{U_n}{Q\pi_c} = \frac{U_q}{N\pi_c} = \frac{U_s}{\pi_s}$$

which imply that, in equilibrium, the family will equate the ratio of marginal utilities to their respective marginal costs where $Q\pi_c$ is the cost incurred by the family when "producing" an additional child of a given quality, $N\pi_c$ is the cost incurred when increasing the quality of every child by one unit and π_s is the cost incurred when increasing the standard of living of the family by one unit. I might add that we can expect a strong inverse relationship between numbers and quality. This, of course, occurs because of the positive relationship between the marginal cost of children and the level of quality per child, and between the marginal cost of quality and the number of childre

The marginal utilities U_n, U_Q and U_s are functions of N, Q and S. Therefore by applying Cramer's Rule to the first order conditions, we obtain the following demand functions for N, Q and

$$(9) \quad N = N(\pi_s, \pi_c, I)$$

$$(10) \quad Q = Q(\pi_s, \pi_c, I)$$

$$(11) \quad S = S(\pi_s, \pi_c, I)$$

all in terms of the exogenous variables π_s, π_c, and I.

Of particular interest, at this point, are the income elasticities of N, Q, S and C. (In order to simplify the calculations, with no loss of generality, π_s is chosen as numeraire and set equal to one.) A normal commodity would be a good with a positive income elasticity; i.e., as income rises, the desired amount of the commodity also rises, relative prices remaining constant. The normalcy of this commodity would of course depend on the shape of the individual's preference map as defined by the individual's taste. In the cases of N, Q, S and C, the signs of the income elasticities are in all cases ambiguous.[15]

Although the straightforward mathematical analysis of income elasticities was of little help, a diagrammatic exposition may be of use in shedding some light on various possibilities.

Suppose money income were to increase with π_c and π_s remaining constant. Rather than investigating the effects in C-S space, let us investigate the effects in Q-N space.

Although π_c / π_s remains constant in C-S space, P_N/P_Q may not remain constant in Q-N space. The reason is that in equilibrium, our first order conditions imply that $P_N = Q\pi_c$ and $P_Q = N\pi_c$ which in turn imply that $P_N/P_Q = Q/_N$. Therefore, P_N/P_Q is independent of π_c and could vary with changes in money income. If the utility function has a bias toward quality, as money income increases quality will also increase. This will increase P_N relative to P_Q which in turn will cause a substitution of Q for N. The upshot is that the observed income elasticity for the number of children may be small or even negative.

Another theoretical possibility is that the individual may be biased towards N. That is to say, the income elasticity for numbers may be greater than the income elasticity for quality. In this case, the effect of an increase in money income would be to increase N which would increase P_Q relative to P_N. This would cause a substitution of N for Q and the observed income elasticity would then be small or even negative. However, empirical results seem to imply a positive income elasticity for quality.

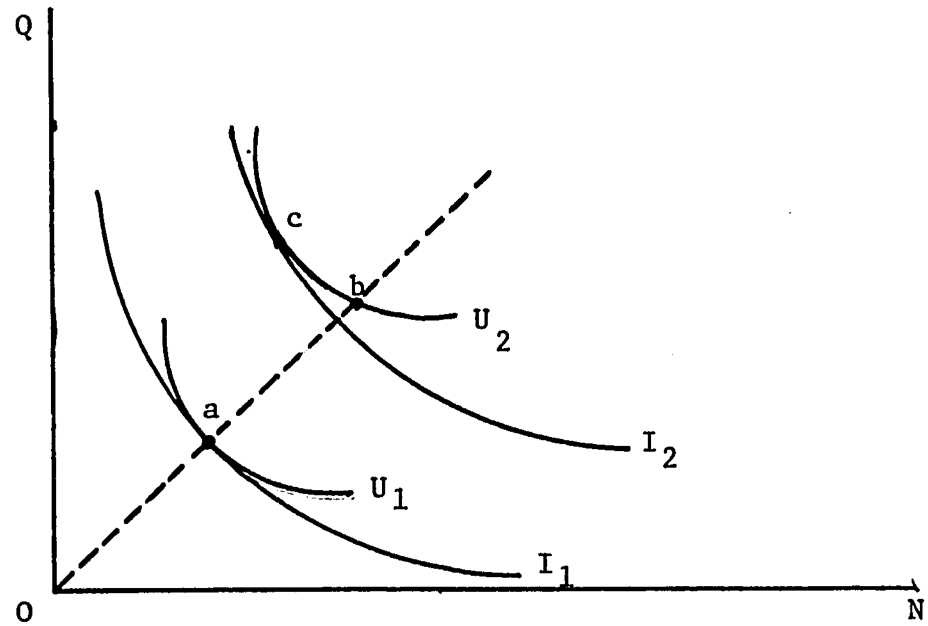
15. See Mathematical Appendices B and C.

Figure 1 below will help clarify this approach. In Q-N space, the budget constraint, $I = NQ\pi_c + S\pi_s$, appears as a rectangular hyperbola. The second order conditions assure us of an equilibrium solution and therefore the indifference curve must be more convex to the origin than the budget constraint. If this were not so, the family's "equilibrium" or utility maximization point in the diagram would occur on one axis.

Point "a" in the diagram represents an initial equilibrium on utility level U_1, given an income of I_1. Allow money income to increase to I_2, π_c/π_s remaining constant. If P_N/P_Q were to also remain constant, the family would move from point "a" to a new equilibrium point such as point "b" on a higher indifference curve, say U_2. Assuming a homothetic utility function, the marginal rates of substitution would be the same at point "a" and point "b". Points "o", "a" and "b" would therefore lie along a ray out of the origin.

If the family were biased towards quality, the new equilibrium point would be to the left of "b", at a point such as "c". Here the marginal rate of substitution would be higher and P_N/P_Q would also have increased. If, on the other hand, the family had been biased towards number of children, the new equilibrium would have occurred to the right of "b". In any case, the movement along I_2, away from "b" represents a substitution effect between Q and N which would accompany the pure change in money income.

Figure 1



Let η_Q, η_N, η_C represent the income elasticities of quality of children, number of children and child services respectively. As Willis shows, the relationship between the three elasticities is

(12) $\eta_c = \eta_N + \eta_Q$ 16

Assuming child services and child quality to be normal commodities, η_N may again be seen to be small or negative depending on the relative magnitues of η_c and η_Q.

As previously mentioned, low or negative values for the income elasticity of demand for children have often been observed but the problem remained of how to take into consideration the possible substitution of quality for quantity as income increased and to empirically estimate the "true" income elasticities so that they could be compared to the observed.

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16. See Mathematical Appendix D.

Nerlove and Schultz (1970) argue that various aspects of behavior attributable to the family are jointly determined and in order to correctly specify the relevant behavioral relations, a simultaneous equations approach must be used. Utilizing Puerto Rican census data for 1950 and 1960, the authors extend the single equation approach to a jointly determined simultaneous equation system. Although their aim is basically to investigate the joint determination of fertility, female labor force participation, migration, income and the character of marital unions, their results suggest that a negative association between fertility and income based on cross-sectional data dissolves when account is taken of the simultaneous nature of the behavior relations and the cross-sectional data is examined over time.

Tomes (1978) makes the important observation that the structural demand functions reflect the "true" behavioral parameters and the reduced form demand functions reflect the "observed" behavioral parameters in a simultaneous equation model jointly determining fertility and children's schooling. The emphasis of his approach is the interaction between fertility and the human capital investments in children under various assumptions of intergenerational transfers of material wealth affecting financial constraints faced by the family.

In a sample consisting of 1,468 children from the California school system with IQ's of 135 or more, Tomes observed that number of children was negatively correlated to his measures of family income in the reduced form, seemingly implying that children were an inferior commodity. Once he held schooling constant, however, family size was found to be positively correlated to family income in the structural form of the demand equation. He also detected that fertility was directly related to women's productivity, as measured by female education, once schooling was held constant. In the observed or reduced form he had found fertility and mother's education unrelated. This latter result seems to conflict with the predictions of other microeconomic models of fertility (Ben-Porath (1973)) which predict a negative correlation between fertility and productivity of the wife due to the relative time intensity of children. However, the Ben-Porath prediction is based on the reduced form and is not inconsistent with the finding of a positive effect of female education in the structural form.

The results of a study by De Tray (1978), published by the Rand Corporation and based on a subsample of the 1967 National Longitudinal Survey of men ages 45 to 59, follow the by now, familiar path. Of 5,000 families in the sample, 1,163 white families were selected on the basis of having children living away from home, implying a high probability that the children on which the subsample is based had completed their education. Without the inclusion of child schooling, income was observed to have a negative influence on family size.

Once the full structural equations are estimated with numbers and quality of children as endogenous variables, the substitutability of N and Q can be confirmed and the coefficient of the income variable becomes positive.

De Tray assumes that the husband's time does not enter household production. This simplifying assumption implies that changes in husband's earnings will result in a pure income effect. Changes in the earnings of the wife, on the other hand, will reflect both an income and a substitution effect. Since the income and substitution effects will influence the demand for children in opposite directions, the coefficient of wife's earnings can be expected to be smaller than the husband's.

De Tray also presents a methodology for estimating the value of the wife's time, which is used often in fertility studies as a proxy of the cost of children. Since there is no direct measure for the value of time if the wife does not work, the author has a choice between using a proxy variable or imputing a wage to women with no labor force participation.

The usual proxy for the value of time is education. De Tray raises objections to the use of this variable as a proxy for the value of the wife's time on the grounds that education of the wife may affect fertility both negatively and positively at the same time. Specifically, since child rearing is assumed to be time intensive, fertility and value of the wife's time, as measured by education, can be expected to be negatively related to fertility. However, education also increases the efficiency of home production and in this respect might have a positive influence on the demand for relatively time intensive commodities including all forms of child services.[17] Therefore, argues De Tray, education as a proxy for value of the wife's time could produce misleading results.

The remaining choice of imputing a wage rate to non-working women is winner by default. The question remains as to how to estimate this imputed wage.

Due to the possible simultaneous determination of market wages and fertility, we should be aware of the probable introduction of simultaneous bias in the estimation of wives' wages. This joint determination of wages and fertility can readily be seen in the case of those women whose market wages are lower than they normally would have been due to time taken from labor force participation in order to bear and rear children.

Another possible source of bias is a participation selectivity bias which occurs because market wage offers are measured for workers but not for non-participants in the labor market. Since the criterion for selecting the

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17. Mother's education actually has an ambiguous effect on number of children since an increase in education is equivalent to a decrease in π_c and as previously noted, Q/N is independent of a change in π_c. See Mathematical Appendix E.

working sample is the wage rate compared to the individual's own reservation wage,[18] the workers' wages may be higher than expected and/or reservation wages lower than expected.

Both sources of bias imply the endogeneity of wages, which should ideally be handled by the inclusion of an equation with wages as the dependent variable, in a model of fertility behavior. This method, however, is beyond the scope of this study and will be investigated at a later date.

McCabe and Rosenzweig (1976) in their study of female employment and fertility in Puerto Rico, estimate wage rates for both husbands and wives from regressions involving never married working women and all married men over eighteen. Independent variables used to obtain these estimates included age of the individual, schooling and age squared.

The female's predicted wage was then entered in a simultaneous equation system where the dependent variables were number of children and labor force participation of wife. The authors find that the wives' wage varied directly with both labor force participation and numbers of children and argue that these relationships are possible if mothers find substitutes for their time in household production, or engage in occupations which are comparable

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18. The reservation wage is defined as that wage which signifies the point of entry into the market.

with raising children as the value of their time increases, a result which is consistent with their empirical work as implied by the positive relationship between the presence of adult relatives in the household and wives' wage.

In addition to findings related to various aspects of labor force participation, McCabe and Rosenzweig also found female schooling negatively related to family size. This is consistent with the birth control hypothesis since, once we control for wage effects, female schooling can be predicted to be negatively related to fertility due to the positive correlation between education and contraceptive knowledge.

Birdsall (1979), in her study of fertility and human capital investments in Columbia, obtained similar results, with the exception that the second equation in her model had a quality measure of children rather than labor force participation of women as the dependent variable. In her OLS estimations, schooling of husband and wife depressed fertility consistently and significantly. Husband's income was found to regularly have a positive effect on family size.

The effect of wife's schooling was particularly interesting since Birdsall did not include the female wage as an independent variable, thereby allowing wife's education to pick up the impact of both the wage and efficiency effects of wife's schooling. The positive relation between education and contraceptive knowledge therefore seems to dominate effects between fertility and the education of the wife. Furthermore, as economic theory predicts, the magnitude of the coefficient of wife's education was greater than the magnitude of the coefficient of husband's education supporting the hypothesis that the rearing of children is more intensive in the time of the mother rather than the time of the father.

CHAPTER III

Data and Measurement of Variables

The working sample chosen for this study was obtained from the 1970 Census of Puerto Rico. The sample size is one in one hundred or one sample unit, for example a household, for every one hundred such units in the population. Information is provided about the housing unit and characteristics of all individuals living therein.

The Puerto Rican census contains three Public Use Samples which are mutually exclusive and contain much the same data with the exception of items pertaining to geography. Due to the fact that the Neighborhood Characteristics Public Use Sample contains only aggregated data, it was not used in forming the working sample. The State and Municipio Group Public Use Samples were combined and in effect formed a two per cent sample of Puerto Rico.

From this two per cent sample, a total of 1606 families were chosen where the husband, wife and at least one child were present in the household.[19] The number of children varied anywhere from one to twelve, with the mode equal to 2 and the mean equal to 4.6. The wife is assumed to be the mother of the children residing in the household.

Age of the wife, in 1970, was restricted to between 35 and 44 inclusive. This particular range was chosen so that

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19. There is a possibility that due to the exclusion of broken homes, poor families may be underrepresented, particularly if a positive correlation exists between the incidence of broken homes and poor families.

firstly, most of the children would probably still be residing at home; secondly, so that the head of the household would probably still be economically active; and thirdly, so that the fertility cycle of the family would be more or less complete.

Children under three years old and above 20 were dropped from the working sample in order to increase the probability that the children residing at home would be attending school and to decrease the probability of unrealistic ages of children such as those cases where reported childrens' ages were greater than the age of either parent. After deletions, total number of children in the working sample was found to be 5,662.

The imputed wage alluded to in the previous chapter, was obtained from a subsample of all women who reported earned wages in 1969 and hours of work during the reference week. The wage obtained is an hourly wage. In the OLS regression, the dependent variable was the natural logarithm of hourly wage. The regressors used were age of the wife (AGEW), schooling of wife (EDUCW) and age of wife squared. The natural log of wages and of wife squared were used to account for the non-linearity of the earnings function. The equation fit, in mathematical form, was:

$$(13) \quad \ln WIFEW = \alpha + B_1 \, AGEW + B_2 \, EDUCW + B_3 \, AGEW^2$$

All coefficients were significant with relatively small standard errors, and their signs were consistent with economic theory. The signs of the AGEW and EDUCW coefficients were both positive implying monotonically increasing wages with respect to both age and schooling. The coefficient of the $AGEW^2$ variable was negative demonstrating the concavity of the earnings function with respect to age.

The negative intercept is also consistent since the natural log of small positive values of WIFEW associated with small values of age and schooling, are negative.

The results of this regression were used to impute hourly wages for women who reported either zero weeks worked in 1969 or zero hours worked in the reference week. For women who reported a positive number of weeks worked and hours worked, the hourly wage was calculated by the simple formula:

(14) WIFEW = EARN/(HOURS X WEEKS)

where EARN represents total wages, salary, commission, bonuses and tips from all jobs in 1969, HOURS is the total hours of work in the reference weeks and WEEKS the total number of weeks worked in 1969.

A wage rate was also imputed for a husband, using a similar technique, if he reported zero weeks or zero hours in the reference week.

The dependent variables in the final regressions are children ever born and a proxy variable for the quality of children. Children ever born was defined in the census in a straightforward manner as total live births for all women age fourteen or over, regardless of marital status. Respondents were instructed to exclude stepchildren or adopted children

TABLE 1

WIFE'S IMPUTED WAGE

VARIABLE	COEFFICIENT	STD ERROR	F	PROB>F
INTERCEPT	-1.37536944	-	-	-
AGEW	0.03821593	.00555309	47.36	0.0001
EDUCW	0.07912161	.00292073	733.85	0.0001
$AGEW^2$	-0.00040906	.00007058	33.59	0.0001

$R^2 = .20$ N = 3,261

but could include children born to the woman before her present marriage, children no longer living and children living away from home.

The proxy used for the quality of children took more thought. Availability of data was, of course, of prime consideration. Generally, child quality variables fall into three broad categories: (1) health related variables (Edwards and Grossman (1978)), (2) school attainment (Edwards (1975)), (Sanguinetty (1978)) and (3) expenditure on children as a measures of investment in human capital (Birdsall (1979)).

Using the data set entitled Cycle II of the Health Examination Survey, Edwards and Grossman investigate the relationship between the health of children and certain family characteristics including family size. In their study, the authors did find a negative relationship between family size and certain measure of child health such as a periodontal index and parental assessment of child's health; again, helping to substantiate the a priori assumption of substitutability beteen numbers and quality.

In his study done for the United Nations Development Programme, Sanguinetty analyzes a data set consisting of household samples taken in three Latin American cities. The author estimates two separate single equation models where children's years of schooling is the dependent variable. Sanguinetty repeatedly estimates the equations for each of his age groups rather than pool his data across ages. Although not always significant, the estimates of the coefficient for number of siblings was usually negative.

Edwards, in her study on white teenage enrollment rates, does not use number of children as a regressor but does find that the coefficient of per pupil school expenditures is large and consistently significant when used to explain teenage enrollment rates cross-sectionally and in time series. Both variables may therefore be relatively good proxies for child quality.

Birdsall not only uses two different measures of quality, but two different measures of fertility as well, based on an income and expenditure survey undertaken of 2,949 households in Columbia. The first measure for quantity of children Birdsall discusses is children currently alive as representing the best measure of a family's desired number of children since children that die can be replaced. However, she argues that a measure of fertility, standardized for mother's age using a natural fertility schedule, produces more precise estimates of certain coefficients.

The two measures of quality include an expenditure dependent variable determined by forming the ratio of a household's actual educational expenditures to its predicted expenditures. Alternatively, the human capital investment variable of children's educational attainment with respect to other children in the sample is used, without considering monetary outlays.

Using the Two Stage Least Squares technique, Birdsall estimates a demand for educational investment function and finds that the income of the household head has a positive effect on quality. Results were also consistent with the hypothesis that quantity and quality of children were substitutes.

Tomes, in his study, uses the straightforward level of schooling of the child as his measure of quality. As he points out, this proxy for child quality has the advantage of being a "global" measure of parental transfers of human capital, although it neglects preschool investments and quality of schooling which, is in most cases, very difficult to estimate.

Due to the fact that his basic unit of observation is the family, De Tray uses the average educational level of children not living at home as his measure of quality, where children not living at home and age of wife forty or over, help to insure completed fertility for the parents and completed schooling for the children. De Tray also argues that since formal schooling is complementary to preschool imputs, a rise in the level of preschool investments will be directly related to the amount of formal schooling children receive.

The measure of child quality I have chosen to use is similar to that used by De Tray and Birdsall. Both authors use a measure which is family specific rather than child specific, as is done in this study. In addition, Birdsall's measure is compared to age and sex equivalent peers, whereas the measure I have chosen is compared to simply age equivalent peers.

Let L_i be defined as average level of education for all children in the sample of the same age as the i^{th} child in family k ($i = 1,\ldots,m$).

$$L_i = \sum_{j=1}^{n} ED_j / n$$

The average educational attainment of the i^{th} child may therefore be written as $Q_i = H_i / L_i$ where H_i is the highest grade attained by the i^{th} child. To obtain the mean quality variable M_k for the k^{th} family, it is necessary to average the Q variable over the m children in the family. The family specific quality variable M_k may therefore be defined as

$$M_k = \frac{\sum_{i=1}^{m} \frac{H_i}{L_i}}{m} = \frac{\sum_{i=1}^{m} Q_i}{m}$$

As Birdsall notes, this type of average educational attainment variable may be overstated for families with relatively young children, since in the future some will most likely drop out of school, and understated for families with children who are late starters and/or repeaters.

TABLE 2

MEAN YEARS OF SCHOOLING BY AGE

n	MEAN*	VARIANCE*	AGE
173	.08	.18	3
195	.27	.46	4
233	.86	1.21	5
254	2.26	2.05	6
296	3.35	1.45	7
299	4.37	.99	8
345	5.32	1.21	9
399	6.08	1.79	10
425	6.94	2.22	11
420	7.92	2.19	12
428	8.76	3.04	13
451	9.45	4.68	14
444	10.40	4.56	15
383	10.93	7.09	16
345	11.61	9.73	17
246	11.83	11.88	18
198	12.30	11.04	19
128	12.30	16.70	20
5,662			

*Mean and Variance rounded off to two decimal places.

CHAPTER IV

Empirical Estimates

The endogenous and exogenous variables used to obtain empirical estimates are listed in table 1. Accompanying the list of variables are the description of each and the corresponding descriptive statistics.

The two endogenous variables are children ever born to the mother and the average child schooling per family compared to all children in the sample.

All exogenous variables pertaining to the ages and education levels of the parents are measured in years. Wage rates for the husband and wife are measured in dollars and cents per hour. Family income is measured in dollars and cents per year.

Two proportions are included as predetermined variables. They are the proportion of female children living at home and the proportion of children in the family who attend private schools. Also included as exogenous variables are two interaction terms. The first was formed as the product of the wife's wage and her labor force participation where labor force participation is equal to one if the mother works and zero otherwise. The second is the interaction of husband's and wife's education. More will be said concerning this variable below.

TABLE 1

VARIABLE DEFINITIONS AND DESCRIPTIVE STATISTICS

		Mean	Std. Dev.
ENDOGENOUS VARIABLES			
NKIDS	Children ever born	4.63	2.85
SCOOL	Average child schooling	1.01	0.42
EXOGENOUS VARIABLES			
FAMINC	Family yearly income	$5,584.79	$5,611.23
EDUCH	Husband's education	10.31	5.15
SELFEMPLOY	Class of worker	0.18	0.37
AGEW	Wife's age	39.10	2.84
EDUCW	Wife's education	9.68	5.07
PROFEM	Proportion of female children	0.49	0.32
PROPRI	Proportion of children attending private school	0.14	0.31
HUSBW	Husband's hourly wage	1.97	1.98
WIFEW	Wife's hourly wage	1.51	1.27
INTERW	Wife's Wage Labor Force participation interaction	0.53	1.46
INTED	Husband's and Wife's education interaction	116.71	98.49
FARM	Industry	0.09	0.29

Finally, two dichotomous variables are defined in the analysis. The first, entitled class of workers, was ascertained for persons fourteen years of age or over in the experienced civilian labor force. The original census report contained seven categories. These seven categories were condensed to two in order to form the dummy variable which I call SELFEMPLOY. This variable pertains to the head of the household, where a value of zero implies the head is an employee and a value of one implies the head is self-employed.

The second dichotomous variable is defined on the husband's industry. The industry variable in the original census report consisted of hundreds of occupation classifications. These categories were reduced to farm/non-farm, where the variable takes on a value of one if the husband's occupation falls under the farming category and a value of zero otherwise.

Table 2 is a matrix of simple correlation coefficients of all endogenous and exogenous variables used in the model. The top figure is the actual coefficient and the bottom figure appearing below each coefficient is the probability that a value of the correlation coefficient as large or larger in absolute value than the one calculated would have arisen by chance, were the two variables truly uncorrelated.

The first empirical estimates to be discussed will be OLS estimations of the reduced form equations. The first equation will have children ever born as the dependent variable. In its simplest form the demand equation may be depicted as follows:

$$(15)\quad N = a_{10} + a_{11}\ \text{WIFEW} + a_{12}\ \text{HUSBW} + a_{13}\ X + e_{11}$$

TABLE 2

SIMPLE CORRELATION COEFFICIENTS

	NKIDS	SCOOL	FAMINC	EDUCH	SELF EMPLOY	AGEW	EDUCW	PROFEM	PROPRI	HUSBW	WIFEW	INTERW	INTED	FARM
NKIDS	1.0000	-0.1440	-0.2775	-0.4138	-0.0172	0.1651	-0.4347	-0.0371	-0.2386	-0.1987	-0.2167	-0.1606	-0.4372	0.2275
	0.0000	0.0001	0.0001	0.0001	0.4912	0.0001	0.0001	0.1370	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
SCOOL		1.0000	0.1482	0.1779	0.0163	0.0061	0.1899	0.0913	0.1611	0.0958	0.1319	0.0964	0.1900	-0.1018
		0.0000	0.0001	0.0001	0.5139	0.8062	0.0001	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
FAMINC			1.0000	0.5772	0.0552	0.0033	0.5630	0.0504	0.4554	0.5961	0.4166	0.3325	0.6660	-0.1873
			0.0000	0.0001	0.0277	0.8944	0.0001	0.0440	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
EDUCH				1.0000	-0.0120	-0.1095	0.6500	0.0578	0.3868	0.4394	0.3817	0.2453	0.8701	-0.3113
				0.0000	0.6322	0.0001	0.0001	0.0207	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
SELF EMPLOY					1.0000	0.0121	0.0558	-0.0475	0.1166	-0.2596	0.0398	-0.0025	0.0256	0.0184
					0.0000	0.6271	0.0254	0.0569	0.0001	0.0001	0.1112	0.9197	0.3054	0.4606
AGEW						1.0000	-0.1109	-0.0300	0.0070	-0.0234	-0.0281	-0.0418	-0.1091	0.0663
						0.0000	0.0001	0.2293	0.7777	0.3500	0.2603	0.0941	0.0001	0.0079
EDUCW							1.0000	0.0577	0.3984	0.3423	0.5259	0.3352	0.8849	-0.2704
							0.0000	0.0208	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
PROFEM								1.0000	0.0642	0.0838	0.0269	0.0196	0.0657	-0.0293
								0.0000	0.0101	0.0008	0.2811	0.4328	0.0085	0.2414
PROPRI									1.0000	0.3017	0.2412	0.1426	0.4677	-0.1174
									0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
HUSBW										1.0000	0.2364	0.1284	0.4563	-0.1238
										0.0000	0.0001	0.0001	0.0001	0.0001
WIFEW											1.0000	0.8760	0.5196	-0.0991
											0.0000	0.0001	0.0001	0.0001
INTERW												1.0000	0.3424	-0.0525
												0.0000	0.0001	0.0354
INTED													1.0000	-0.2621
													0.0000	0.0001
FARM														1.0000
														0.0000

where WIFEW is the wife's actual or imputed wage, HUSBW is the husband's actual or imputed wage, X is a column vector of other independent variables discussed below (implying a_{13} is a row vector of coefficients) and e_{11} is the error term.

The X vector of independent variables will contain parent's education, mother's age, the interaction terms and the dichotomous variables.

Assuming the husband's time does not enter into household production, we could expect a_{12} to reflect a pure income effect. However, the husband's wage coefficient should be positive, if children are a normal commodity in the structural form of the model, which implies an ambiguous sign for the coefficient of income in the reduced form. The sign of a_{12} cannot therefore be predicted.[20]

The wife's wage will produce both income and substitution effects given the female time intensity of child rearing. There can therefore be no a priori sign prediction for the coefficient of the wife's wage either. Furthermore, if the substitution effect of an increase in the wife's wage outweighs a possible positive income effect, we may obtain a negative effect of the wife's wage on a family's desire for additional children. In any case, the income effect of wife's wage is presumed positive in the structural form of the model which gives no insight into the income effect in the reduced form.

Mother's age is expected to be positively related to numbers of children due to declining fertility rates in Puerto Rico and the increased exposure to pregnancy for older women.

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20. See Mathematical Appendix F.

The coefficients of parent's schooling are expected to be negative despite the existence of a positive effect of parents' education on fertility which is explained below. Better educated parents may have higher aspirations for children and consequently face higher rearing and schooling costs. Anticipation of these higher costs may lead them to restrict family size. Improved access to the more modern and reliable birth control methods, due to their higher levels of education, will facilitate limiting the number of children.

In order to investigate the effects of labor force participation on the desired number of children, we can rewrite the estimate of equation (15) as:

$$\text{(15A)} \quad N = \alpha_0 + \alpha_1 \text{WIFEW} + \alpha_2 \text{ INTERW} + \alpha_3 \text{ Y}$$

where Y is a vector of other independent variables and the α's represent the regression coefficients, α_3 being a vector of coefficients. For non-working wives we therefore have α_1 representing the wage effect on numbers of children and for working wives $\alpha_1 + \alpha_2$ represents the wage effect.

Labor force participation often reflects the desire of women to allocate their time more heavily in the labor market and less intensively in child rearing activities. To the extent that this supposition is true, those women who favor greater labor force participation will most likely desire smaller family sizes.[21] This effect should make itself felt through the wage coefficients and although, as stated, no a priori prediction can

21. Although an inverse relationship between female labor force participation and fertility is assumed to exist, no causal association is presupposed. In all likelihood, the wife's labor force participation and her fertility are jointly determined by a set of exogenous variables such as the wife's and husband's market wage rates.

be made concerning the sign of the wife's wage on fertility, we can predict that $\alpha_1 + \alpha_2 < \alpha_1$ or $\alpha_2 < 0$.[22]

The negative effect of labor force participation on number of children is based on an assumption of incompatibility of child rearing with the occupation of the wife. The actual relationship will depend on the importance of cottage industries in the society and the existence of occupations which may be totally compatible with child care. In the Far East, for examples, it is not uncommon for mothers to be seen tending fields while carrying infants on their backs. In this case, children may not be very intensive in the wife's time.

Certain demographic characteristics may be associated with demand for children as a source of labor. In particular, farming families and self-employed families can in general be expected to desire larger numbers of children than those families whose other socioeconomic characteristics are similar.

The coefficient of the interaction term of parent's education is expected to be positive because of what Becker terms optimal sorting criteria (Becker 1977). Discrepancies between mates and marriage longevity vary inversely; i.e. the less discrepancies, such as race, religion and intelligence, between husband and wife, the longer the marriage can be expected to last. The longer a marriage is expected to last, the greater will be the investment of marital-specific capital such as children. Therefore, we can predict a direct relationship

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22. $\alpha_1 + \alpha_2$ represents the wage coefficient for working wives and α_1 the wage coefficient for non-working wives. α_2 W represents the difference in means between working wives and non-working wives, other factors held constant, and varies with the wage rate.

between the interaction of parent's education and the demand for children.

Table 3 contains the results of the first model which was estimated. The number of observations will generally be less than the sample size due to the existence of missing values for one or more variables which causes the entire observation to be deleted from the analysis.

Appearing in the table are the intercept term, the estimated coefficient for each independent variable, the corresponding T value and the probability that a larger coefficient in absolute value would have occurred by chance. We see that at the ten per cent level of significance most of the coefficients are significant with the exception of husband's wage, the class of worker dummy variable and the proportionate variable PROFEM.

As expected, education of husband and wife depress fertility with both coefficients being highly significant. The coefficient of wife's age is also of the expected sign and significant.

The coefficient of the interaction between wife' wage and labor force participation is negative and significant supporting the hypothesis that child rearing is not very compatible with working and is intensive in the wife's time. Also implied is that cottage industries may not be very important in Puerto Rico.

TABLE 3

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM DEPENDENT VARIABLE = NKIDS

N = 1599 F = 46.517 RSQUARE = 0.24

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI*
INTERCEPT	3.2536	3.4827	0.0005
INTED	0.0058	2.2341	0.0256
AGEW	0.1071	4.8417	0.0001
HUSBW	-0.0273	-0.7171	0.4734
WIFEW	0.3091	2.5736	0.0102
INTERW	-0.2503	-2.6807	0.0074
EDUCW	-0.2205	-6.8222	0.0001
FARM	0.7324	3.1152	0.0019
SELFEMPLOY	-0.0879	-0.4889	0.6250
PROFEM	-0.0215	-0.1107	0.9119
PROPRI	-0.6059	-2.6309	0.0086
EDUCH	-0.1556	-5.1920	0.0001

*The probabilities listed are the probabilities that values of the correlation coefficients are as large or larger in absolute value. The probabilities therefore refer to a two-tailed test. The critical t-values at the 5 per cent level of significance are 1.645 for a one-tailed test and 1.960 for a two-tailed test. The critical t-values at the 10 per cent level of significance are 1.282 for a one-tailed test and 1.645 for a two-tailed test.

The regression results also suggest that although wife's wage affects fertility positively, within the subgroup of working women, changes in wages have very little effect on numbers of children. This is evident by the fact that $\alpha_1 + \alpha_2$ = .0588 from the results in table 3.

The supposition that farm families have larger families is also upheld given the positive correlation between the FARM dummy variable and NKIDS. Interestingly, the coefficient of the SELFEMPLOY dummy is negative, although not significant, which was counter to our expectations.

One possible explanation for the negative coefficient of the SELFEMPLOY variable is the existence of a professional subgroup within the self-employed individuals in the sample. Professionally self-employed individuals would not necessarily be expected to regard children as a source of labor. The uncertainty of self-employment may also contribute to a negative correlation between NKIDS AND SELFEMPLOY.

The most surprising result was the coefficients of the wage variables. As so often is the case, the variable representing the income effect, i.e. husband's wage, had a negative coefficient. Whereas the coefficient of the wife's wage which was predicted not only to be smaller than the coefficient of the husband's wage but possibly negative, was seen to be positive. Although the coefficient of the husband's wage was not significant, the wife's wage coefficient was significant. Inasmuch as this particular specification of the model does not consider substitution of quantity and quality, reflections on these coefficients will be held in abeyance.

Finally, the coefficient of the educational interaction term was found to be positive and significant as expected.

The second equation investigated will have the quality variable as the dependent variable and will be of the form:

$$(16) \quad SCOOL = b_{10} + b_{11}\ EDUCW + b_{12}\ EDUCH + b_{13}\ Y + e_{12}$$

where Y is a vector of independent variables affecting SCOOL. In this equation, coefficients of parental education and income variables are expected to be positive.

Education of parents is expected to influence schooling positively because of the assumption that better educated parents are more efficient at producing human capital in their children and have higher aspirations for their offspring. The mother's schooling variable is predicted to have a larger impact than father's schooling which would be consistent with the belief that child rearing is more intensive in mother's time.[23]

The income variables are expected to be positively correlated with SCOOL for two basic reasons. First of all, income is a measure of the family's ability to forgo the child's income. In developing countries this may be an important factor for families at the lower end of the income scale. In Puerto Rico young children can be seen working in the fields in rural areas and peddling newspapers on street corners in the cities and towns. In many cases, their income marks the difference between hunger and satiety for the family.

23. There may be a negative component of parent's education in the quality equation due to the fact that the value of parent's time increases with their education. If quality is relatively time intensive, there would therefore be an incentive to decrease quality as parent's education increases.

Secondly, the income variables are a measure of the ability to pay for the child's schooling. This factor becomes more important as schooling levels increase and in cases of imperfect capital markets.

Also included as independent variable are the proportion of female children and the proportion of children attending private school. The latter is predicted to enter with a positive coefficient simply because parents who can afford to send their children to private schools are expected to regard amounts and quality of education as very desirable commodities.

No predication is made as to the sign of the coefficient of PROFEM. If the sex composition of children in the family does in fact influence the average education levels of children, the direction of this effect is not clear.

Table 4 lists the results of this regression. The education variables entered the equation as expected with significant t-values with wife's education having the larger impact although the difference is small. The wife's wage coefficient is of the expected sign but insignificant. The coefficient of the husband's wage is also insignificant.

The variable PROPRI enters the schooling equation positively, as expected. PROFEM also enters the equation positively perhaps simply reflecting a tendency for females to remain in school longer than males.

Next to be estimated were the structural forms of the demand equations by ordinary least squares, where the structural forms are given by:

TABLE 4

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM DEPENDENT VARIABLE = SCOOL

N = 1599 F = 9.225 R SQUARE = 0.06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.5999	3.8951	0.0001
INTED	-0.0007	-1.5577	0.1195
AGEW	0.0040	1.0961	0.2732
HUSBW	0.0004	0.0566	0.9548
WIFEW	0.0068	0.3443	0.7306
INTERW	0.0074	0.4793	0.6318
EDUCW	0.0135	2.5385	0.0112
FARM	-0.0674	-1.7382	0.0824
SELFEMPLOY	0.0009	0.0302	0.9759
PROFEM	0.0983	3.0760	0.0021
PROPRI	0.1278	3.3663	0.0008
EDUCH	0.0119	2.4030	0.0164

$$(17) \quad NKIDS = a_{20} + a_{21}\ WIFEW + a_{22}\ HUSBW + a_{23}\ X + a_{24}\ SCO + e_{21}$$

and

$$(18) \quad SCOOL = b_{20} + b_{21}\ EDUCW + b_{22}\ EDUCH + b_{23}\ Y + b_{24}\ NKIDS + e_{22}$$

If, as supposed, numbers of children are in actuality a normal commodity, we would observe a positive coefficient for HUSBW. This should particularly be true when controlling for schooling. Again, the coefficient of wife's wage may be negative or positive.

Most importantly, however, the structural form will test the hypothesis of the substitutability of numbers and quality. The prediction is that a_{24} in the NKIDS equation and b_{24} in the SCOOL equation will both be negative.

The results for the OLS structural estimates are given in tables 5 and 6. The inclusion of the endogenous explanatory variables had little effect on t-values or magnitudes of coefficients. The most interesting result, however, is that the coefficients of the quality and numbers variables in (17) and (18) are negative and significant in both cases confirming the basic assumption that parents view numbers of children and quality of children as substitutable factors in the production of the child services entering their utility function.

Contrary to expectations, however, the coefficient of HUSBW in the NKIDS equation is negative although insignificant and the coefficient of WIFEW is larger in magnitude, positive and significant.

TABLE 5

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = NKIDS

N = 1592 F = 51.008 R SQUARE = 0.24

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	3.6060	3.8562	0.0001
HUSBW	-0.0389	-1.0309	0.3027
EDUCH	-0.1447	-4.7999	0.0001
SELFEMPLOY	-0.1647	-0.9271	0.3540
AGEW	0.1058	4.7718	0.0001
EDUCW	-0.2099	-6.4437	0.0001
INTERW	-0.2393	-2.5574	0.0106
INTED	0.0043	1.6557	0.0980
FARM	0.7149	3.0326	0.0025
WIFEW	0.3048	2.5346	0.0114
SCOOL	-0.3893	-2.5634	0.0105

TABLE 6

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = SCOOL

N = 1592 F = 11.041 R SQUARE = .06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.8017	13.9315	0.0001
HUSBW	0.0017	0.2837	0.7767
EDUCH	0.0122	2.5119	0.0121
EDUCW	0.0135	2.5350	0.0113
PROFEM	0.1003	3.1430	0.0017
PROPRI	0.1196	3.1942	0.0014
INTERW	0.0060	0.3919	0.6952
INTED	-0.0008	-1.8723	0.0613
WIFEW	0.0089	0.4505	0.6524
NKIDS	-0.0096	-2.3405	0.0194

As in the reduced form, education of parents affected NKIDS negatively and SCOOL positively. FARM, AGEW and INTED were positively correlated to NKIDS and the proportionate variables were positively related to SCOOL. The SELFEMPLOY coefficient was again of the "wrong" sign and insignificant.

A problem arises involving the OLS estimates if, as was posited, quality and numbers of children are jointly determined. Due to the two way or simultaneous relationship between the two endogenous variables, the OLS estimators will be biased for both finite and infinite sample sizes (inconsistent), although the direction of the bias is not clear. The reason for this biasedness is the correlation between the disturbance terms and the explanatory endogenous variables in (17) and (18).[24]

The solution to this problem lies in using a simultaneous equation estimation technique, two of which are investigated below.

Previous to estimation by either a limited information method or a full information method,[25] consideration must be given to the identification problem. This problem arises due to the lack of a sufficient number of coefficients obtained from the reduced form of a simultaneous equations system, to estimate the structural coefficients. Too few reduced form coefficients will lead to a case of underidentification and too

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24. Damodar Gujarati, Basic Econometrics (New York: McGraw-Hill Book Company, 1978), pp. 342-343.

25. Limited information methods are called single-equation methods because they consider one equation of a simultaneous equations system at a time without actually considering restrictions placed by other equations, with the exception of identification restrictions. On the other hand, full information methods such as Three Stage Least Squares, actually estimate all equations in the system simultaneously taking into account all restrictions placed on all equations.

many reduced form coefficients will lead to a case of overidentification. If the number of reduced form coefficients exactly equals the number of structural coefficients, we are in a position where the number of equations equals the number of unknowns and we should therefore obtain unique values for the structural coefficients.

In the case of overidentification, we may obtain estimates of structural coefficients which are not unique. This situation is analogous to having the number of equations greater than the number of unknowns. However, overidentification is not necessarily an undesirable situation since various techniques can handle the problem.

On the other hand, underidentification is serious since the estimates of the structural coefficients become impossible to obtain.

The practical solution is to include at least one identifying variable in each equation which will act as a shift parameter, thereby identifying the other equations.

The variables identifying the quality equation, and therefore exluded from it, are AGEW and the FARM and SELFEMPLOY dichotomous variables. Although identifying variables are sometimes chosen somewhat arbitrarily, these specific variables were chosen because they were hypothesized to particularly affect numbers of children.

The variables used to identify the numbers equation were the two proportion variables PROPRI and PROFEM. They were therefore excluded from the NKIDS equation and included in the SCOOL equation.

The first simultaneous equations technique used to estimate the model was 2SLS. This method is a single equation technique and although the estimates may not satisfy small sample properties, they are at least consistent.

Basically, the approach involves substituting an instrumental variable for the endogenous explanatory variable in each equation. The instrumental variable used is an estimate of the endogenous explanatory variable obtained by regressing it on a linear combination of all the nonstochastic exogenous variables in the model. 2SLS provides unique estimates of the structural coefficients in cases of overidentification, as in the case of the model suggested by (17) and (18), unlike other single equation estimating techniques such as the indirect Least Squares method of estimation.

The lowered levels of significance in table 7, to a large extent, reflect the problems of multicollinearity and identification, in particular for the quality equation which in many cases is difficult to identify. Alternative specifications are presented in the next chapter.

These are not the only sources of possible problems in the 2SLS estimates, however. Another factor to be considered is low R squares obtained when forming the instrumental variables in the first stage of the 2SLS. The R square for the instrumental variable representing NKIDS was 0.24 and the R square for the estimate of SCOOL was 0.03. Low R squares imply that the instrumental variable is a poor substitute for the endogenous explanatory variable.

Not only were t-values of estimated coefficients not significantly increased by 2SLS estimation but signs of coefficients also remained the same. This was particularly distressing in the case of the "misbehaving" variable HUSBW, consistently suggesting that numbers of children is viewed as an inferior commodity by parents.

Ideally, one should estimate a simultaneous equation system using a full information method. In the case of three Stage Least Squares a gain in asymptotic efficiency is obtained over 2SLS, when the disturbances in the structural equations are contemporaneously correlated. The results of the 3SLS estimation procedure are given in table 8. In some cases t values increased for the estimated coefficients and decreased in others. The same regression coefficients remained insignificant in both the 2SLS and 3SLS methods of estimation. No change in the signs of any coefficient was noted. Again, the coefficients of HUSBW was negative.

One possible reason for these results is misspecification of the model. In a full information method of estimation, the misspecification of any structural equation will be reverberated and magnified throughout the entire system. For this reason, alternative specifications are considered in the next section.

In addition, due to the fact that the coefficient of NKIDS for both 2SLS and 3SLS was insignificant, we must question the supposition that parents jointly determine numbers

TABLE 7

TWO STAGE LEAST SQUARES ESTIMATION

DEPENDENT VARIABLE = NKIDS

N = 1589

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	5.0477	3.8083	0.0001
HUSBW	-0.0305	-0.7475	0.4548
EDUCH	-0.1215	-3.4518	0.0006
SELFEMPLOY	-0.1245	-0.6523	0.5143
AGEW	0.1158	4.7405	0.0001
EDUCW	-0.1818	-4.6986	0.0001
INTERW	-0.2276	-2.2670	0.0235
INTED	0.0035	1.2575	0.2087
FARM	0.5546	2.0498	0.0405
WIFEW	0.3242	2.5156	0.0120
SCOOL	-2.6751	-1.9166	0.0555

DEPENDENT VARIABLE = SCOOL

N = 1590

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.7365	3.2398	0.0012
HUSBW	0.0005	0.0818	0.9348
EDUCH	0.0136	1.9162	0.0555
EDUCW	0.0149	1.6925	0.0907
PROFEM	0.0980	3.0662	0.0022
PROPRI	0.1308	3.2069	0.0014
INTERW	0.0062	0.3614	0.7178
INTED	-0.0008	-1.6831	0.0926
WIFEW	0.0079	0.3566	0.7214
NKIDS	-0.0010	-0.0360	0.9713

TABLE 8

THREE STAGE LEAST SQUARES ESTIMATION

DEPENDENT VARIABLE = NKIDS

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	5.3365	4.0500	0.0001
HUSBW	-0.0297	-0.7333	0.4635
EDUCH	-0.1174	-3.3420	0.0009
SELFEMPLOY	-0.1207	-0.6778	0.4980
AGEW	0.1061	4.4333	0.0001
EDUCW	-0.1784	-4.6165	0.0001
INTERW	-0.2297	-2.2897	0.0222
INTED	0.0032	1.1587	0.2468
FARM	0.7129	2.7533	0.0060
WIFEW	0.3254	2.5271	0.0116
SCOOL	-2.6452	-1.8965	0.0581

DEPENDENT VARIABLE = SCOOL

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.7462	3.2839	0.0010
HUSBW	0.0004	0.0662	0.9472
EDUCH	0.0137	1.9227	0.0547
EDUCW	0.0149	1.6945	0.0904
PROFEM	0.0847	2.7541	0.0060
PROPRI	0.1447	3.6363	0.0003
INTERW	0.0064	0.3708	0.7108
INTED	-0.0008	-1.7385	0.0823
WIFEW	0.0077	0.3486	0.7274
NKIDS	-0.0015	-0.0540	0.9569

and quality of children. A plausible alternative is that the system of equations is recursive in the sense that parents may determine amounts of schooling allocated to children after these children are born and have demonstrated their intellectual capabilities. Gifted children may then receive enhanced educations and plans for additional children may then be postponed or shelved completely.

We now turn to a discussion of some of the more significant and consistent coefficients obtained by 3SLS estimation for the NKIDS equation. These coefficients are partial derivatives and therefore represent the change in (the mean of) NKIDS, per unit change in the independent variable, holding all other exogenous variables constant.

The coefficients in table 8, therefore, imply that a one year increase in the education of the husband, decreases the number of children desired by 1/7 and a one year increase in the education of the wife, decreased the number of children desired by 1/5 of a child. As expected, changes in the wife's education have a more pronounced effect on NKIDS than do changes in the education of the husband.

Also implied is that a one year increase in the age of the wife increases the number of children in the family by approximately 1/10. The coefficient of WIFEW may seem at first surprising since it suggests that a $1.00 rise in the female value of time will increase the number of children in the family by 1/3, but it is worthwhile repeating that this variable measures an hourly increment and that a one dollar increase represents a yearly change of approximately two thousand dollars.

The most difficult coefficient to interpret is the partial derivative of NKIDS with respect to SCOOL due to the relatively complicated definition of the SCOOL variable. Suffice it to say that the coefficient is significant, of the expected sign and that a 15 per cent decrease in the expected number of children will be accompanied by a 25 per cent increase in the average level of schooling for the children in the family as compared to the schooling levels of their age equivalent peers in the sample (elasticity at the mean is approximately -.61).

Another rather surprising result was the relationship between the "observed" and "true" income elasticities evaluated at the mean. The observed income elasticity, which was obtained from the reduced form, was evaluated as -.012 for the NKIDS equation and the true income elasticity, which was obtained from the structural form of the model estimated by the 2SLS technique, was equal to -.013 to three decimal places.

In the case of the SCOOL equation the observed income elasticity again calculated to three decimal places, was found to be .001. The same result was obtained for the true income elasticity in the structural form. The true income elasticities were therefore not found to differ markedly from the observed elasticities.

In Chapter II it was stated in (12) that

$$\eta_c = \eta_N + \eta_Q$$

Therefore, the elasticity for child services for the reduced form is -.011 and -.012 for the structural form. Although the elasticities are of a relatively small magnitude, they do suggest that families in Puerto Rico view child services as an inferior commodity when using husband's wage as the measure of income. However, in both cases a positive elasticity for quality was obtained, although its magnitude was smaller than the elasticity for numbers in absolute value.

CHAPTER V

Alternative Specifications

Due to the problems mentioned in the previous section, in particular multicollinearity and the "misbehavior" of the income variable represented by HUSBW, certain modifications of the model were performed. In the first alternative specification of the model investigated, it was decided to replace HUSBW with FAMINC.

The results for the OLS estimates of the coefficients for the NKIDS equation are presented in table 1. The t-values for some independent variables increased slightly and decreased slightly for others, in particular SELFEMPLOY, INTERW, INTED and WIFEW. The number of coefficients with insignificant t-values remained the same.

The signs of all coefficients remained the same. However, the sign of the FAMINC coefficient was positive, although insignificant, whereas the coefficient of HUSBW in the basic specification had been negative and insignificant.

Results for the OLS estimates of the coefficients for the SCOOL equation are presented in table 2. Again, some t-values increased and others decreased. The most discernable gain was in the significance of the INTED coefficient which had been insignificant in the basic specification. There was a change in the sign of the coefficient of the SELFEMPLOY variable but the coefficient was insignificant in both cases.

TABLE 1

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM

DEPENDENT VARIABLE = NKIDS

N = 1592 F = 46.406 R SQUARE = .24

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	3.2494	3.4629	0.0005
FAMINC	0.000009	0.5845	0.5590
EDUCH	-0.1548	-5.1250	0.0001
SELFEMPLOY	-0.0602	-0.3525	0.7245
AGEW	0.1059	4.7488	0.0001
EDUCW	-0.2161	-6.6573	0.0001
PROFEM	-0.0250	-0.1286	0.8977
PROPRI	-0.6690	-2.8671	0.0042
INTERW	-0.2455	-2.6236	0.0088
INTED	0.0051	1.8978	0.0579
FARM	0.7368	3.1249	0.0018
WIFEW	0.2986	2.4976	0.0126

TABLE 2

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM

DEPENDENT VARIABLE = SCOOL

N = 1592 F = 8.920 R SQUARE = 0.06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.6166	3.9940	0.0001
FAMINC	0.000001	0.5758	0.5648
EDUCH	0.0120	2.4165	0.0158
SELFEMPLOY	-0.0051	-0.1808	0.8565
AGEW	0.0035	0.9602	0.3371
EDUCW	0.0142	2.6612	0.0079
PROFEM	0.1010	3.1619	0.0016
PROPRI	0.1191	3.1013	0.0020
INTERW	0.0078	0.5093	0.6106
INTED	-0.0008	-1.7520	0.0800
FARM	-0.0681	-1.7547	0.0795
WIFEW	0.0061	0.3079	0.7582

Little was gained by the substitution of FAMINC for HUSBW in the OLS estimates of the model as presented in tables 3 and 4. Actually, one less variable, INTED in the NKIDS equation, had a significant coefficient.

Similarly, no overall gain was obtained by 2SLS or 3SLS estimation over the basic specification of the model. Again, the most profound change was the appearance of a positive coefficient for the income variable in the NKIDS equation in both 2SLS and 3SLS estimations. In the basic specification model, the coefficient of HUSBW had in both cases been negative. 2SLS and 3SLS estimates for the alternative specification are presented in tables 5 and 6.

The income elasticities calculated at the mean were .011 for the NKIDS equation and .006 for the SCOOL equation in the reduced form of the model. In the structural form, the corresponding elasticities were .011 and .011. Although income elasticities were equal for the NKIDS equation in both reduced and structural equations, the income elasticity for the SCOOL equation was twice as large in the structural form as in the reduced form implying that the true elasticity for quality is larger than the observed.

Income elasticity for child services, η_C, is equal to .016 in the reduced form and equal to 0.22 in the structural form.

In the second alternative specification of the model, the income variable was dropped from both equations in order

TABLE 3

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = NKIDS

N = 1592 F = 50.868 R SQUARE = 0.24

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	3.5822	3.8245	0.0001
FAMINC	0.000001	0.0578	0.9539
EDUCH	-0.1448	-4.7988	0.0001
SELFEMPLOY	-0.1095	-0.6457	0.5186
AGEW	0.1051	4.7162	0.0001
EDUCW	-0.2054	-6.3261	0.0001
INTERW	-0.2286	-2.4453	0.0146
INTED	0.0037	1.4087	0.1591
FARM	0.7178	3.0412	0.0024
WIFEW	0.2905	2.4302	0.0152
SCOOL	-0.3931	-2.5867	0.0098

TABLE 4

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = SCOOL

N = 1592 F = 11.104 R SQUARE = 0.06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.7990	13.8955	0.0001
FAMINC	0.000002	0.7850	0.4326
EDUCH	0.0123	2.5377	0.0113
EDUCW	0.0136	2.5698	0.0103
PROFEM	0.1009	3.1654	0.0016
PROPRI	0.1140	2.9857	0.0029
INTERW	0.0043	0.2827	0.7775
INTED	-0.0009	-1.9849	0.0473
WIFEW	0.0098	0.5026	0.6153
NKIDS	-0.0097	-2.3615	0.0183

TABLE 5

TWO STAGE LEAST SQUARES ESTIMATION

DEPENDENT VARIABLE = NKIDS

N = 1582

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	5.2220	3.7615	0.0002
FAMINC	0.000009	0.5264	0.5987
EDUCH	-0.1176	-3.2422	0.0012
SELFEMPLOY	-0.1106	-0.6028	0.5467
AGEW	0.1143	4.6304	0.0001
EDUCW	-0.1723	-4.3074	0.0001
INTERW	-0.2156	-2.1263	0.0336
INTED	0.0024	0.7931	0.4278
FARM	0.5413	1.9682	0.0492
WIFEW	0.3098	2.3872	0.0171
SCOOL	-2.8836	-1.9874	0.0470

DEPENDENT VARIABLE = SCOOL

N = 1593

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.7616	3.3401	0.0009
FAMINC	0.000002	0.7494	0.4537
EDUCH	0.0132	1.8473	0.0649
EDUCW	0.0148	1.6851	0.0922
PROFEM	0.1011	3.1684	0.0016
PROPRI	0.1171	2.7667	0.0057
INTERW	0.0057	0.3291	0.7421
INTED	-0.0009	-1.8894	0.0590
WIFEW	0.0081	0.3697	0.7117
NKIDS	-0.0049	-0.1701	0.8649

TABLE 6

THREE STAGE LEAST SQUARE ESTIMATION

DEPENDENT VARIABLE = NKIDS

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	5.5551	4.0327	0.0001
FAMINC	0.000001	0.5889	0.5560
EDUCH	-0.1126	-3.1115	0.0019
SELFEMPLOY	-0.0898	-0.5360	0.5920
AGEW	0.1035	4.3056	0.0001
EDUCW	-0.1683	-4.2118	0.0001
INTERW	-0.2180	-2.1519	0.0316
INTED	0.0020	0.6715	0.5020
FARM	0.7151	2.7466	0.0061
WIFEW	0.3111	2.3983	0.0166
SCOOL	-2.8681	-1.9771	0.0482

DEPENDENT VARIABLE = SCOOL

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > ITI
INTERCEPT	0.7735	3.3938	0.0007
FAMINC	0.000002	0.6429	0.5204
EDUCH	0.0133	1.8573	0.0635
EDUCW	0.0148	1.6880	0.0916
PROFEM	0.0847	2.7743	0.0056
PROPRI	0.1367	3.3447	0.0008
INTERW	0.0061	0.3534	0.7238
INTED	-0.0009	-1.9453	0.0519
WIFEW	0.0078	0.3541	0.7233
NKIDS	-0.0054	-0.1896	0.8496

to investigate possible effects of multicollinearity between the income measure and other independent variables. However, the results obtained were very similar to the basic specification and are not presented in the text.[26] Very small changes were observed in t-values and signs of coefficients did not change.

Still another specification was investigated, where WIFEW and INTERW were deleted from the first alternative specification and wife's schooling was allowed to pick up both wage and efficiency effects. The results were less than spectacular and again are omitted. Some t-values did increase, especially the t-values for wife's schooling in the NKIDS equation, but explanatory power was lost and at times, signs of coefficients ran counter to economic a priori assumptions such as the sign of the NKIDS variable in the SCOOL equation when the model was estimated by 3SLS.

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26. See Appendix G for alternative specifications not presented in the text.

CHAPTER VI

Conclusions and Implications

In chapter II a model was presented which stipulated the simultaneous existence of numbers and quality of children as inputs in the production of the family Z-good which was dubbed child services. Empirically, the relationship between the two inputs was estimated using an average schooling variable for all siblings in a family as a proxy for the quality of the children. The joint determination of these two entering arguments into the parents' utility function suggests that one input cannot be investigated without taking into consideration the existence of the other.

Mathematically, this joint determination implies that the demand equations for numbers and quality of children must take into consideration the appearance of these two variables as both endogenous and explanatory endogenous variables in a simultaneous system of equations. For this reason, estimates were obtained not only by ordinary least squares, but also by two stage least squares, because of consistency considerations, and three stage least squares, in order to take advantage of the availability of a systems method which estimates all equations simultaneously.

The primary results of this dissertation consistently reinforce the hypothesis that couples view numbers and quality as substitute inputs in the production of child services, in particular for the utility maximizing Puerto Rican parents included in the 1970 Census. Also confirmed were the predictions that the education of both husbands and wives would depress fertility, that urban families would have lower demand for children and that the age of the wife would be positively correlated with number of children. The interaction term of parents' education varied directly with fertility, as predicted in optimal sorting theory.

Unfortunately, the income variables were usually insignificant and negatively related to numbers of children which ran counter to expectations, as did the employ variable, which makes one question its value as an identifying variable for the SCOOL equation.

In the SCOOL equation, parents' education had the expected influence on child schooling with mothers' education having the anticipated larger influence. The income variables were consistently positively correlated with SCOOL supporting the a priori assumptions made in chapter IV.

Both of the fertility identifying variables included in the SCOOL equation, PROFEM and PROPRI, were significant and positively related to SCOOL, supporting their choice as identifying variables.

The implications of the above analysis are obvious and important for developing nations; in particular, possible causal links between educational levels and fertility. Actually, the perpetuation of poverty is a problem faced by both developing and developed nations with poor, high-fertility groups.

The NKIDS equation strongly suggests how this cycle can be reversed. There are socio-economic variables which significantly depress fertility. Two of the most significant are the educational levels of the parents. In addition, these higher educational levels positively affect the schooling levels of offspring as evident in the SCOOL equation and therefore will depress levels of fertility in the next generation.

By decreasing costs of schooling, the intergenerational transfer of poverty can be reduced and the intergenerational transfer of human capital can be enhanced.

Although most a priori specifications of the model were satisfied, the system of equations remains far from complete. Exploration for proxies for the shadow prices of both numbers and quality of children must be continued. These statistically significant shadow prices could then serve as the ideal identifying variables in a simultaneous equations system.

A possible extension to the model would be to include the labor force participation rate of married women as an endogenous variable in an additional equation, where LFPR would be a dichotomous dependent variable interpreted as the conditional probability that a wife would participate in the labor force given various values of the independent variables. A further possible extension might be to include time series data and test cause and effect between fertility, quality and labor force participation. Only with the addition of at least some of these suggestions can a model for the demand of child services be anywhere near complete.

MATHEMATICAL APPENDIX

A. First Order Conditions

Form the augmented objective function

$$Z = U\ (N,Q,S) + \lambda(NQ\ \Pi_c + S\ \Pi_s - I)$$

where λ is the Lagrange multiplier. Partially differentiating I obtain the following 1st order conditions:

$$Z_N \equiv \partial Z/\partial N = U_N + \lambda Q\ \Pi_c = 0$$

$$Z_Q \equiv \partial Z/\partial Q = U_Q + \lambda N\ \Pi_c = 0$$

$$Z_S \equiv \partial Z/\partial S = U_S + \lambda \Pi_s = 0$$

$$Z_\lambda \equiv \partial Z/\partial \lambda = N_Q\ \Pi_c + S\ \Pi_s - I = 0$$

B. Second Order Conditions

Totally differentiating the 1st order condition, I obtain

$$U_{NN}\ dN + (U_{NQ} + \lambda \Pi_c)\ dQ + U_{NS}\ dS + Q\ \Pi_c\ d\lambda = -\lambda Q\ d\Pi_c$$

$$(U_{QN} + \lambda\Pi_c)\ dN + U_{QQ}\ dQ + U_{QS}\ dS + N\Pi_c\ d\lambda = -\lambda N\ d\Pi_c$$

$$U_{SN}\ dN + U_{SQ}\ dQ + U_{SS}\ dS + \Pi_s\ d\lambda = -\lambda\ d\Pi_s$$

$$Q\Pi_c\ dN + N\Pi_c\ dQ + \Pi_s\ dS = -NQ\ d\Pi_c - S\ d\Pi_s + dI$$

Rewritten in matrix form, the above system of equations becomes

$$\begin{bmatrix} U_{NN} & (U_{NQ} + \lambda\Pi_c) & U_{NS} & Q\Pi_c \\ (U_{QN} + \lambda\Pi_c) & U_{QQ} & U_{QS} & N\Pi_c \\ U_{SN} & U_{SQ} & U_{SS} & \Pi_s \\ Q\Pi_c & N\Pi_c & \Pi_s & 0 \end{bmatrix} \begin{bmatrix} dN \\ dQ \\ dS \\ d\lambda \end{bmatrix} = \begin{bmatrix} -\lambda Q & 0 & 0 \\ -\lambda N & 0 & 0 \\ 0 & -\lambda & 0 \\ -NQ & -S & 1 \end{bmatrix} \begin{bmatrix} d\Pi_c \\ d\Pi_s \\ dI \end{bmatrix}$$

where the matrix on the left is the bordered Hession. For utility maximization the following must hold; D_{11}, D_{22}, $D_{33} > 0$, and $D < 0$, where the D_{ii}'s are the cofactors of the corresponding elements of the principle diagonal and D is the determinant of the bordered Hession.

C. Income Effects

In order to investigate income effects, I solve for the total differentials dN, dQ, dS and dC from the second order conditions in Mathematical Appendix B. I obtain by Cramer's rule

$$dN = \begin{vmatrix} -\lambda Q\, d\pi_c & U_{NQ} + \lambda\pi_c & U_{NS} & Q\pi_c \\ -\lambda N\, d\pi_c & U_{QQ} & U_{QS} & N\pi_c \\ 0 & U_{SQ} & U_{SS} & \pi_S \\ -NQ\, d\pi_c + dI & N\pi_c & \pi_S & 0 \end{vmatrix} \frac{1}{D}$$

Expanding the numerator by the first column, I obtain

$$= \left[-\lambda\, (QD_{11} - ND_{21})\, d\pi_c - D_{41}\, (-NQ\, d\pi_c + dI) \right] / D$$

$$dQ = \begin{vmatrix} U_{NN} & -\lambda Q\, d\pi_c & U_{NS} & Q\pi_c \\ U_{QN} + \lambda\pi_c & -\lambda N\, d\pi_c & U_{QS} & N\pi_c \\ U_{SN} & 0 & U_{SS} & \pi_S \\ Q\pi_c & -NQ\, d\pi_c + dI & \pi_S & 0 \end{vmatrix} \frac{1}{D}$$

Expanding the numerator by the second column, I obtain

$$= \left[-\lambda(-QD_{12} + ND_{22})\, d\pi_c + D_{42}\, (dI - NQ\, d\pi_c) \right] / D$$

$$dS = \begin{vmatrix} U_{NN} & U_{NQ} + \lambda\pi_c & -\lambda Q\, d\pi_c & Q\pi_c \\ U_{QN} + \lambda\pi_c & U_{QQ} & -\lambda N\, d\pi_c & N\pi_c \\ U_{SN} & U_{SQ} & 0 & \pi_S \\ Q\pi_c & N\pi_c & -NQ\pi_c + dI & 0 \end{vmatrix} \frac{1}{D}$$

Expanding the numerator by the third column, I obtain

$$= \left[-\lambda\, (QD_{13} - ND_{23})\, d\pi_c - D_{43}\, (dI - NQ\, d\pi_c) \right] / D$$

Totally differentiating C=NQ, I obtain dC=Q dN+N dQ. Therefore

$$dC=\{[-\lambda(Q^2D_{11}-NQD_{21})\,d\pi_c-D_{41}(Q\,dI-NQ^2\,d\pi_c)]$$
$$+[-\lambda(-NQD_{12}+N^2D_{22})\,d\pi_c+D_{42}(N\,dI-N^2Q\,d\pi_c)]\}\,/D$$
$$=[-\lambda(Q^2D_{11}+N^2D_{22}-2NQD_{12})\,d\pi_c+(-QD_{41}+ND_{42})\,(dI-NQ\,d\pi_c)]\,/D$$

Setting $d\pi_c$, $d\pi_s = 0$, the income effects become

$$dN= -D_{41}\,dI/D$$
$$dQ= D_{42}\,dI/D$$
$$dS= -D_{43}\,dI/D$$
$$dC=(ND_{42}-QD_{41})\,dI/D$$

The Second order conditions put sign restrictions on neither D_{41}, D_{42} nor D_{43}. The sign of our total differentials are therefore ambiguous which implies that the signs of our income elasticities will also be ambiguous.

D. Income Elasticities

Since child services has been defined as the multiplication of the number of children and the quality per child,

$$C=NQ$$

Totally differentiating I obtain

$$dC= N\,dQ + Q\,dN$$

Dividing each term by C and multiplying by I/dI, I obtain

$$\frac{dC}{C}\frac{I}{dI} = \frac{N}{C}\, dQ\, \frac{I}{dI} + \frac{Q}{C}\, dN\, \frac{I}{dI}$$

$$= \frac{N}{NQ}\, dQ\, \frac{I}{dI} + \frac{Q}{NQ}\, dN\, \frac{I}{dI}$$

$$= \frac{dQ}{Q}\frac{I}{dI} + \frac{dN}{N}\frac{I}{dI}$$

or

$$\eta_c = \eta_Q + \eta_N$$

E. Comparative Statics of a Change in π_c

From Mathematical Appendix D, $dC=N\,dQ + Q\,dN$. Dividing by C and multiplying by $\pi_c/d\pi_c$, I obtain

$$\frac{dC}{C}\frac{\pi_c}{d\pi_c} = \frac{N}{C}\, dQ\, \frac{\pi_c}{d\pi_c} + \frac{Q}{C}\, dN\, \frac{\pi_c}{d\pi_c}$$

$$= \frac{N}{NQ}\, dQ\, \frac{\pi_c}{d\pi_c} + \frac{Q}{NQ}\, dN\, \frac{\pi_c}{d\pi_c}$$

$$= \frac{dQ}{Q}\frac{\pi_c}{d\pi_c} + \frac{dN}{N}\frac{\pi_c}{d\pi_c}$$

or

$$\sigma_c = \sigma_Q + \sigma_N$$

where the σ's represent price elasticities with respect to π_c. In order to determine the compensated price elasticities, utility is held constant by setting $dU=0$, which implies that the left hand side of the fourth equation in Mathematical Appendix B is equal to zero. The first two price elasticities I wish to obtain from Mathematical Appendix C now become

$$\sigma_N \equiv \frac{dN}{N}\frac{\Pi_c}{d\Pi_c} = \left(\frac{-\lambda\Pi_c}{D}\right)\left(\frac{QD_{11}}{N} - D_{21}\right)$$

and

$$\sigma_Q \equiv \frac{dQ}{Q}\frac{\Pi_c}{d\Pi_c} = \left(\frac{-\lambda\Pi_c}{D}\right)\left(\frac{ND_{22}}{Q} - D_{12}\right)$$

which are both ambiguous in sign. The third price elasticity is given by

$$\sigma_S \equiv \frac{dS}{S}\frac{\Pi_c}{d\Pi_c} = \left(\frac{-\lambda\Pi_c}{SD}\right)(QD_{13} - ND_{23})$$

However,

$$QD_{13} = Q\begin{vmatrix} U_{QN} + \lambda\Pi_c & U_{QQ} & N\Pi_c \\ U_{SN} & U_{SQ} & \Pi_s \\ Q\Pi_c & N\Pi_c & 0 \end{vmatrix}$$

$$= QN^2U_{SN}\Pi_c{}^2 - U_{SQ}NQ^2 - \Pi_c{}^2 - U_{QN}QN\Pi_s\Pi_c - NQ\lambda\Pi_s\Pi_c{}^2 + Q^2U_{QQ}\Pi_c\Pi_s$$

and

$$-ND_{23} = -N\begin{vmatrix} U_{NN} & U_{NQ} + \lambda\Pi_c & Q\Pi_c \\ U_{SN} & U_{SQ} & \Pi_s \\ Q\Pi_c & N\Pi_c & 0 \end{vmatrix}$$

$$= -N^2U_{SN}Q\Pi_c{}^2 + NQ^2\Pi_c{}^2U_{SQ} + N^2U_{NN}\Pi_s\Pi_c - U_{NQ}QN\Pi_s\Pi_c - NQ\lambda\Pi_s\Pi_c{}^2$$

and therefore

$$QD_{13} - ND_{23} = Q^2U_{QQ}\Pi_c\Pi_s - 2QNU_{QN}\Pi_c\Pi_s - 2NQ\lambda\Pi_s\Pi_c{}^2 + N^2U_{NN}\Pi_c\Pi_s$$

Also,

$$-\frac{\Pi_s}{\Pi_c}D_{33} = -\frac{\Pi_s}{\Pi_c}\begin{vmatrix} U_{NN} & U_{NQ} + \lambda\Pi_c & Q\Pi_c \\ U_{QN} + \lambda\Pi_c & U_{QQ} & N\Pi_c \\ Q\Pi_c & N\Pi_c & 0 \end{vmatrix}$$

$$= Q^2U_{QQ}\Pi_s\Pi_c - 2QNU_{QN}\Pi_s\Pi_c - 2QN\lambda\Pi_s\Pi_c{}^2 + N^2U_{NN}\Pi_c\Pi_s$$

Therefore

$$QD_{13}-ND_{23} = -\frac{\pi_s}{\pi_c} D_{33}$$

and

$$\sigma_s = \frac{1}{D}\left(\frac{\lambda\pi_s D_{33}}{S}\right) > 0$$

because of the second order conditions stated in Mathematical Appendix B. Similarly,

$$\sigma_c \equiv \frac{dC}{C}\frac{\pi_c}{d\pi_c} = -\frac{\lambda\pi_c}{CD}(Q^2D_{11}+N^2D_{22}-2NQD_{12})$$

where

$$Q^2D_{11} = Q^2\begin{vmatrix} U_{QQ} & U_{QS} & N\pi_c \\ U_{SQ} & U_{SS} & \pi_s \\ N\pi_c & \pi_s & 0 \end{vmatrix}$$

$$= Q^2N\pi_c\pi_sU_{SQ}-Q^2N^2\pi_c{}^2U_{SS}-Q^2\pi_s{}^2U_{QQ}+Q^2N\pi_s\pi_cU_{QS},$$

$$N^2D_{22} = N^2\begin{vmatrix} U_{NN} & U_{NS} & Q\pi_c \\ U_{SN} & U_{SS} & \pi_s \\ Q\pi_c & \pi_s & 0 \end{vmatrix}$$

$$= N^2Q\pi_c\pi_sU_{SN}-N^2Q^2\pi_c{}^2U_{SS}-N^2\pi_s{}^2U_{NN}+N^2Q\pi_s\pi_cU_{NS}$$

and

$$-2NQD_{12} = -2NQ\begin{vmatrix} U_{QN}+\lambda\pi_c & U_{QS} & N\pi_c \\ U_{SN} & U_{SS} & \pi_s \\ Q\pi_c & \pi_s & 0 \end{vmatrix}$$

$$=-2N^2Q\pi_c\pi_sU_{SN}+2N^2Q^2\pi_c{}^2U_{SS}+2NQ\pi_s{}^2U_{QN}+2NQ\lambda\pi_s{}^2\pi_c-2NQ^2\pi_s\pi_cU_{QS}$$

Therefore

$$Q^2D_{11}+N^2D_{22}-2NQD_{12}=-Q^2\pi_s{}^2U_{QQ}-N^2\pi_s{}^2U_{NN}+2NQ\pi_s{}^2U_{QN}+2NQ\lambda\pi_s{}^2\pi_c$$

Now

$$\left(\frac{\Pi_s}{\Pi_c}\right)^2 D_{33} = \left(\frac{\Pi_s}{\Pi_c}\right)^2 \begin{vmatrix} U_{NN} & U_{NQ} + \lambda\Pi_c & Q\Pi_c \\ U_{QN} + \lambda\Pi_c & U_{QQ} & N\Pi_c \\ Q\Pi_c & N\Pi_c & 0 \end{vmatrix}$$

$$= -Q^2\Pi_s{}^2U_{QQ} - N^2\Pi_s{}^2U_{NN} + 2NQ\ U_{QN}\ \Pi_s{}^2 + 2QN\lambda\Pi_c\Pi_s{}^2$$

and therefore

$$Q^2D_{11} + N^2D_{22} - 2NQD_{12} = \left(\frac{\Pi_s}{\Pi_c}\right)^2 D_{33}$$

which in turn implies that

$$\sigma_c = -\frac{\lambda\Pi_s{}^2}{C\ \Pi_c} \left(\frac{D_{33}}{D}\right)$$

From the second order conditions, we can conclude $\sigma_c < 0$.

F. Reduced and Structural Coefficients

Consider the following simplified estimated structure of the simultaneous equation model represented by (17) and (18):

$$N = a_0 + a_1Y + a_2Q$$

$$Q = b_0 + b_1Y + b_2N$$

where N is the measure of fertility, Q the measure of child quality and Y represents the income variable. Given the presumed substitutability between N and Q, we can predict that $a_2, b_2 < 0$. The reduced form of the above stated structure can be written as:

$$N = \frac{a_0 + a_2b_0}{1 - a_2b_2} + \left(\frac{a_1 + a_2b_1}{1 - a_2b_2}\right) Y$$

$$Q = \frac{b_0 + b_2a_0}{1 - a_2b_2} + \left(\frac{b_1 + b_2a_1}{1 - a_2b_2}\right) Y$$

or

$$N = c_0 + c_1 Y$$

$$Q = d_0 + d_1 Y$$

where

$$c_0 = \frac{a_0 + a_2 b_0}{1 - a_2 b_2}, \quad c_1 = \frac{a_1 + a_2 b_1}{1 - a_2 b_2}, \quad d_0 = \frac{b_0 + b_2 a_0}{1 - a_2 b_2} \text{ and } d_1 = \frac{b_1 + b_2 a_1}{1 - a_2 b_2}$$

The signs of c_1 and d_1 are ambiguous. The sign of the numerator cannot be determined. Even the further assumptions that $b_1 > a_1$ and $b_1, a_1 > 0$ in the structural form of the model and equality of a_2 and b_2 are of no assistance in determining the effect of income on the dependent variables of the reduced form.
To see this, let a_1, $b_1 > 0$, $b_1 > a_1$ and $a_2 = b_2$. Consider c_1. $a_2 b_1 < 0$ but the sign of $a_1 + a_2 b_1$ will depend on the relative magnitudes of a_1 and $a_2 b_1$. A similarly ambiguous result is obtained for d_1.

What our assumptions concerning the structure do allow us to predict is that the ratio of quality to quantity income effects of the reduced form will be larger than the ratio of quality to quantity income effects of the structural form.
Let $a_2 = b_2 = k$. Therefore,

$$\frac{d_1}{c_1} = \frac{b_1 + k a_1}{a_1 + k b_1}$$

$$= \frac{b_1/a_1 + k}{1 + k b_1/a_1}$$

Let $d_1/c_1 = \alpha$ and $b_1/a_1 = \beta$.

$$\alpha = \frac{\beta + k}{1 + k}$$

$$\alpha - \beta = \frac{\beta + k}{1 + k\beta} - \beta$$

$$= \frac{\beta + k - \beta\,(1+k)}{1 + k\beta}$$

$$= \frac{k - k\beta^2}{1 + k\beta}$$

$$= \frac{k\,(1 - \beta^2)}{1 + k\beta}$$

where $k < 0$ and $1 - \beta^2 < 0$ since $\beta > 1$. Therefore, assuming $a_1 + kb_1 > 0$, $\alpha - \beta > 0$ which in turn implies $d_1/c_1 > b_1/a_1$.

G. Alternative Specifications

2ND ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM

DEPENDENT VARIABLE = NKIDS

N = 1602 F = 51.547 R SQUARE = .24

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > T
INTERCEPT	3.3696	3.6111	0.0003
EDUCH	-0.1615	-5.4003	0.0001
SELFEMPLOY	-0.0541	-0.3174	0.7510
AGEW	0.1047	4.7352	0.0001
EDUCW	-0.2212	-6.8861	0.0001
PROFEM	-0.0219	-0.1128	0.9102
PROPRI	-0.6302	-2.7640	0.0058
INTERW	-0.2451	-2.6387	0.0084
INTED	0.0058	2.2680	0.0235
FARM	0.7107	3.0224	0.0025
WW	0.3017	2.5260	0.0116

2ND ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM

DEPENDENT VARIABLE = SCOOL

N = 1602 F = 10.204 R SQUARE = .06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>/T/
INTERCEPT	0.5988	3.8994	0.0001
EDUCH	0.0120	2.4369	0.0149
SELFEMPLOY	0.0002	0.0077	0.9939
AGEW	0.0040	1.1029	0.2702
EDUCW	0.0135	2.5484	0.0109
PROFEM	0.0995	3.1228	0.0018
PROPRI	0.1278	3.4052	0.0007
INTERW	0.0072	0.4705	0.6381
INTED	-0.0007	-1.5799	0.1143
FARM	-0.0675	-1.7435	0.0814
WW	0.0070	0.3579	0.7205

2ND ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = NKIDS

N = 1592 F = 56.555 R SQUARE = .24

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	3.5790	3.8288	0.0001
EDUCH	-0.1449	-4.8083	0.0001
SELFEMPLOY	-0.1089	-0.6435	0.5200
AGEW	0.1052	4.7496	0.0001
EDUCW	-0.2056	-6.3643	0.0001
INTERW	-0.2280	-2.4535	0.0143
INTED	0.0038	1.4879	0.1370
FARM	0.7172	3.0425	0.0024
WW	0.2903	2.4303	0.0152
SCOOL	-0.3928	-2.5870	0.0098

2ND ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = SCOOL

N = 1592   F = 12.418   R SQUARE = .06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB /T/
INTERCEPT	0.8033	14.0329	0.0001
EDUCH	0.0122	2.5214	0.0118
EDUCW	0.0133	2.5199	0.0118
PROFEM	0.1009	3.1657	0.0016
PROPRI	0.1208	3.2437	0.0012
INTERW	0.0056	0.3680	0.7129
INTED	-0.0008	-1.8513	0.0643
WW	0.0094	0.4787	0.6322
NKIDS	-0.0096	-2.3448	0.0192

2ND ALTERNATIVE SPECIFICATION

TWO STAGE LEAST SQUARES ESTIMATION

DEPENDENT VARIABLE = NKIDS

N = 1593

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	5.2249	3.9419	0.0001
EDUCH	-0.1258	-3.5623	0.0004
SELFEMPLOY	-0.0883	-0.4850	0.6278
AGEW	0.1137	4.6319	0.0001
EDUCW	-0.1808	-4.7278	0.0001
INTERW	-0.2209	-2.2053	0.0276
INTED	0.0034	1.2337	0.2175
FARM	0.5265	1.9380	0.0528
WW	0.3163	2.4529	0.0143
SCOOL	-2.7706	-2.0044	0.0452

DEPENDENT VARIABLE = SCOOL

N = 1594

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	0.7340	3.1496	0.0017
EDUCH	0.0138	1.8915	0.0587
EDUCW	0.0149	1.6695	0.0952
PROFEM	0.0993	3.1183	0.0019
PROPRI	0.1310	3.2002	0.0014
INTERW	0.0061	0.3548	0.7228
INTED	-0.0008	-1.6927	0.0907
WW	0.0080	0.3631	0.7166
NKIDS	-0.0007	-0.0254	0.9797

2ND ALTERNATIVE SPECIFICATION

THREE STAGE LEAST SQUARE ESTIMATION

DEPENDENT VARIABLE = NKIDS

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	5.5217	4.1917	0.0001
EDUCH	-0.1216	-3.4493	0.0006
SELFEMPLOY	-0.0834	-0.4932	0.6220
AGEW	0.1037	4.3144	0.0001
EDUCW	-0.1774	-4.6438	0.0001
INTERW	-0.2232	-2.2292	0.0259
INTED	0.0031	1.1331	0.2573
FARM	0.6911	2.6666	0.0077
WW	0.3178	2.4651	0.0138
SCOOL	-2.7369	-1.9805	0.0478

DEPENDENT VARIABLE = SCOOL

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	0.7452	3.1992	0.0014
EDUCH	0.0138	1.8952	0.0583
EDUCW	0.0149	1.6696	0.0952
PROFEM	0.0851	2.7820	0.0055
PROPRI	0.1458	3.6587	0.0003
INTERW	0.0063	0.3643	0.7157
INTED	-0.0008	-1.7538	0.0797
WW	0.0078	0.3550	0.7226
NKIDS	-0.0014	-0.0481	0.9616

3RD ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM

DEPENDENT VARIABLE = NKIDS

N = 1601 F = 62.439 R SQUARE = .24

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	2.6295	2.9079	0.0037
HUSBW	-0.0006	-0.0158	0.9874
EDUCH	-0.1015	-5.9016	0.0001
SELFEMPLOY	-0.0073	-0.0406	0.9676
AGEW	0.1133	5.1225	0.0001
EDUCW	-0.1433	-8.5840	0.0001
PROFEM	-0.0264	-0.1360	0.8918
PROPRI	-0.5050	-2.2230	0.0264
FARM	0.8814	3.8168	0.0001

3RD ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF REDUCED FORM

DEPENDENT VARIABLE = SCOOL

N = 1601 F = 11.778 R SQUARE = .06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > |T|
INTERCEPT	0.6455	4.3287	0.0001
HUSBW	-0.0007	-0.1080	0.9140
EDUCH	0.0053	1.8708	0.0616
SELFEMPLOY	0.0055	0.1873	0.8514
AGEW	0.0043	1.1709	0.2418
EDUCW	0.0084	3.0579	0.0023
PROFEM	0.0986	3.0764	0.0021
PROPRI	0.1160	3.0974	0.0020
FARM	-0.0653	-1.7144	0.0866

3RD ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = NKIDS

N = 1599 F = 75.392 R SQUARE = .22

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	2.4718	2.7449	0.0061
HUSBW	-0.0821	-2.3167	0.0206
AGEW	0.1183	5.3113	0.0001
EDUCW	-0.2014	-14.3960	0.0001
SELFEMPLOY	-0.1280	-0.7177	0.4730
FARM	1.0549	4.5821	0.0001
SCOOL	-0.4368	-2.8585	0.0043

3RD ALTERNATIVE SPECIFICATION

ORDINARY LEAST SQUARE ESTIMATION OF STRUCTURAL FORM

DEPENDENT VARIABLE = SCOOL

N = 1599 F = 16.250 R SQUARE = .06

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB > |T|
INTERCEPT	0.8666	20.7499	0.0001
HUSBW	-0.0010	-0.1645	0.8693
EDUCH	0.0055	1.9398	0.0526
EDUCW	0.0068	2.4436	0.0146
PROFEM	0.0973	3.0479	0.0023
PROPRI	0.1143	3.1135	0.0019
NKIDS	-0.0096	-2.3514	0.0188

3RD ALTERNATIVE SPECIFICATION

TWO STAGE LEAST SQUARES ESTIMATION

DEPENDENT VARIABLE = NKIDS

N = 1595

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	5.8068	3.6576	0.0003
HUSBW	-0.0425	-0.8977	0.3695
AGEW	0.1403	4.7724	0.0001
EDUCW	-0.1340	-4.8100	0.0001
SELFEMPLOY	-0.0034	-0.0146	0.9883
FARM	0.7100	2.2106	0.0272
SCOOL	-5.3184	-3.3903	0.0007

DEPENDENT VARIABLE = SCOOL

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>|T|
INTERCEPT	0.8171	4.2667	0.0001
HUSBW	-0.0010	-0.1789	0.8581
EDUCH	0.0057	1.3809	0.1675
EDUCW	0.0083	1.7319	0.0835
PROFEM	0.0979	3.0528	0.0023
PROPRI	0.1176	3.0668	0.0022
NKIDS	-0.0025	-0.0981	0.9218

3RD ALTERNATIVE SPECIFICATION

THREE STAGE LEAST SQUARE ESTIMATION

DEPENDENT VARIABLE = NKIDS

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB>/T/
INTERCEPT	6.4751	4.1991	0.0001
HUSBW	-0.0425	-0.9166	0.3595
AGEW	0.1192	4.4166	0.0001
EDUCW	-0.1328	-4.7709	0.0001
SELFEMPLOY	-0.0213	-0.1199	0.9046
FARM	0.0067	3.5650	0.0004
SCOOL	-5.1929	-3.3199	0.0009

DEPENDENT VARIABLE = SCOOL

EXPLANATORY VARIABLE	COEFFICIENT	T VALUE	PROB /T/
INTERCEPT	0.7577	3.9980	0.0001
HUSBW	-0.0040	-0.6802	0.4965
EDUCH	0.0122	3.3542	0.0008
EDUCW	0.0066	1.3734	0.1698
PROFEM	0.0587	2.1264	0.0336
PROPRI	0.1119	3.2855	0.0010
NKIDS	0.0051	0.2014	0.8404

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