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DIFFERENTIAL INVESTMENT IN CHILDREN:

SEX-SPECIFIC CHILD QUALITY, FERTILITY

AND EDUCATIONAL EXPENDITURES

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Recently economists have been paying increased attention to the differences in the human capital invested in men and women in order to account for some part of the male-female earnings differential.[1] At the same time, economists primarily interested in the determinants of population change have developed models which demonstrate that family size is only one dimension of household child investment, that the parental decisions concerning the desired quantity of children are closely related to decisions concerning the level of resources devoted to each prospective child, or child quality.[2] Empirical analysis in this area, however, has been for the most part confined to testing the fertility implications of these models[3] and no attention has been paid to the possibility that the family resources invested in children may differ along sex lines. Conlisk (1969) has shown that the variation in one proxy for the quality investment in children, school enrollment, is dominated by changes in family variables. That the urban enrollment rates of male and female teen-agers have been significantly different, as displayed in Table I for recent decades, may thus be evidence of such household-level sex-specific differential child investment, though not necessarily of intra-family "discrimination." To the extent that these early differentials are important, an analysis of the determinants of sex-specific household investment may provide some further understanding of the observed sex-differentials in the earnings of adults.

In this study, it is shown that not only the recent decline in birth rates, but the differential levels of and changes in male and female teen-age school rates, and the rise in per-pupil schooling expenditures[4] are mainly

the joint products of changes in parameters pertaining to the child investment decisions of parents, particularly women in the home. In part I, a household production model of the family's child investment behavior which explicitly considers the possibility of the differential allocation of resources to male and female children is outlined and the differential influences of the educational attainment and time values of the husband and the wife on the quality and quantity of children and on the derived demand for the goods used in the production of these commodities are analyzed. In part II, the implications derived from the framework described in part I are tested empirically with aggregate state data from the 1960 Census of Population: proxies for household production variables are related to the average completed family size, the male and female teen-age school enrollment rates, and the public school expenditures of residents of urban areas.

I. The Theoretical Framework

a. The Production of Child Services

The fundamental insight of the household production analysis in its general form is that the ultimate objects of consumer satisfaction, called "commodities," are produced in the home with goods purchased in the market and the time of the family members. In order to

highlight the sex-specific child investment decisions of the household, in thi

analysis the set of commodities is aggregated into four-- the

quantity of children N, the quality per child of female children, Q_F ,

the quality per child of male children, Q_M, and S, a composite of

all other commodities produced in the home which are alternative

sources of satisfaction for the family. It is assumed that the

two parents desire to maximize their lifetime utility with respect

to these commodities and thus the stochastic and sequential nature

of child investment is not considered.

If f is the proportion of total children who are female,[5] then

the total amount of female child services produced in the household

is fNQ_F; total male child services is similarly $(1-f) NQ_M$.

The production of these child services and S are described by the

household production functions (1), (2), and (3)

$$fNQ_F = f(X_F, T_{WF}, T_{HF}, E_F) \qquad (1)$$

$$(1-f)NQ_M = g(X_M, T_{WM}, T_{HM}, E_M) \qquad (2)$$

$$S = h(X_S, T_{WS}, E_S) \qquad (3)$$

where the production inputs in each commodity are the time of the

husband and wife, T_{Hi}, T_{Wi}, and purchased goods X_i ; the E_i are vectors

of "environmental" variables, which influence the productivity of

the inputs but have no direct effect on the amount of commodities

produced. Two of these "E" variables, the education of each parent

are discussed below.

Dividing functions (1) and (2) by the quantities of female and male children respectively yields (4) and (5), the relation between average inputs of parental time, t_{Wi}, t_{Hi}, and goods, x_i, and the amounts of quality per male and female child:[5]

$$Q_F = f\left(\frac{X_F}{fN}, \frac{T_{WF}}{fN}, \frac{T_{HF}}{fN}; \ell_F\right) = f(x_F, t_{WF}, t_{HF}, \ell_F) \qquad (4)$$

$$Q_M = g\left(\frac{X_M}{(1-f)N}, \frac{T_{WM}}{(1-f)N}, \frac{T_{HM}}{(1-f)N}, \ell_M\right) = g(x_M, t_{WM}, t_{HM}, \ell_M) \qquad (5)$$

Quality per child can thus be represented by the total resources devoted to, or the resource intensity of, each child, which is assumed to be subject to the choice of the parents. Note that the amounts of inputs per unit of quality per child may differ between male and female children if the technical properties of the production functions differ, i.e., if raising male and female children to the same level of quality efficiently requires different combinations and amounts of inputs. The "price" of an additional unit of child services, male or female, is the cost of producing that additional unit, i.e., marginal cost. This cost is equal to the sum of the costs of the additional production inputs required, which is in turn related to the amounts and prices of those inputs. Under the assumption of the linear homogenity of the production functions, every unit of quality per child requires the same amounts of time and goods (for efficient production), thus the marginal (=average) quantities of inputs are t_{Wi}, t_{Hi}, and x_i. If P_W, P_H, and P_{xi} are the prices of the wife's time, the husband's time, and the price index of the composite good used in the production of commodity i, then the shadow prices of male and female child services, π_F and π_M, are:

$$\pi_F = t_{WF} \, P_W = t_{HF} \, P_H + x_F \, P_{xF} \qquad (6)$$

$$\pi_M = t_{WM} \, P_W + t_{HM} \, P_H + x_M \, P_{xM} \qquad (7)$$

As can be seen, if the production technologies of male and female child services are dissimilar, their shadow prices will also differ. Similarly, the commodity, S, which is also produced in the household, has its own shadow price:

$$\pi_S = t_{WS} P_W + t_{HS} \, P_H + x_S \, P_{xS} \qquad (8)$$

Since both the quantity of children, N, and the per-child sex-specific quality commodities, Q_F and Q_M, enter the utility function of the family separately (are unique sources of satisfaction), their shadow prices must be distinguished in order to describe the consumption behavior of the parents. The shadow price of quality per female child is the increase in the total expenditures on child services necessitated by a unit increase in the production of Q_F <u>holding constant the number of female children.</u> Since total expenditures on child services is $N f \, Q_F \pi_F + N(1-f) \, Q_M \pi_M$, the shadow price of Q_F is therefore equal to $N f \pi_F$, the fixed number of female children times the shadow price of female child services. Thus the larger the number of female children, fN, the more "expensive" is female quality per child since the additional unit of quality must be allocated to every female child. Similarly, the shadow price of Q_M, quality per male child, is $(1-f)N \pi_M$ and is a positive function of

the quantity of male children.

The shadow price of the total quality of children, N, the increase in total expenditures on child services induced by a unit increase in the number of children, <u>for given levels of quality per child</u>, is $fQ_F \pi_F + (1-f) Q_M \pi_M$; the higher the amounts of child quality chosen, the more costly are increases in family size.

The family family maximizes its utility function (9) subject to constraints on the lifetime resources of goods and time: the total amount of market goods purchased cannot exceed the lifetime earnings of the

$$U = U(N, Q_F, Q_M, S) \qquad (9)$$

two parents and the amount of time each parent spends in household production and in the labor market, L_W and L_H, must not be greater then the total time available to each, T_W and T_H. If it is assumed that both the husband and the wife spend some part of their life-time in the labor force for the purpose of earning income,[7] at life-time wage rates W_H and W_W, then the lifetime expenditure constraint is:

$$L_W W_W + L_H W_H = P_{xF} X_F + P_{xM} X_M + P_{xS} X_S \qquad (10)$$

The parental time constraints are:

$$T_W = T_{WF} + T_{WM} + T_{WS} + L_W \qquad (11)$$

$$T_H = T_{HF} + T_{HM} + T_{HS} + L_H \qquad (12)$$

The time and expenditure constraints (10), (11), and (12) can be combined into one "full income" constraint, (13), by noting that goods can be traded for time in the labor market at the market wage rates and that the prices of time of the husband and wife, P_W and P_H, are equal to their market wages , w_H and w_F .[8]

$$T_W w_W + T_H w_H = \pi_F f N Q_F + \pi_M (1-f) N Q_M + \pi_S S \qquad (13)$$

Necessary conditions for achieving maximum satisfaction from the consumption of the four commodities subject to the full income constraint are that the ratio of the marginal utilities of each pair of commodities equal the ratio of their shadow prices, as defined above; i.e.:

$$\frac{U_{Q_F}}{U_S} = \frac{f N \pi_F}{\pi_S} \qquad (14)$$

$$\frac{U_{Q_M}}{U_S} = \frac{(1-f) N \pi_M}{\pi_S} \qquad (15)$$

$$\frac{U_N}{U_S} = \frac{f Q_F \pi_F + (1-f) Q_M \pi_M}{\pi_S} \qquad (16)$$

$$\frac{U_N}{U_{Q_F}} = \frac{f Q_F \pi_F + (1-f) Q_M \pi_M}{f N \pi_F} \qquad (17)$$

$$\frac{U_N}{U_S} = \frac{f Q_F \pi_F + (1-f) Q_M \pi_M}{(1-f) N \pi_M} \qquad (18)$$

$$\frac{U_{Q_F}}{U_{Q_M}} = \frac{f \pi_F}{(1-f) \pi_M} \qquad (19)$$

Before analyzing in more detail the roles of the husband and wife in the optimal production of the commodities, a number of implications for child quality investment and fertility can be drawn from these first-order conditions. First, from expressions

(17) and (18), it can be seen that any phenomenon which reduces

fertility (N) will also diminish the shadow prices of child quality.

If the use of more efficient birth control techniques lowers actual

fertility, for given levels of desired family size, then the

greater the efficiencywith which contraception is utilized the

higher will be the levels of quality per child. If the educational

attainment of the wife is positively associated with contraceptive ef-

ficiency [9] then her schooling should be both negatively correlated

with fertility and positively correlated with child quality. The

human capital embodied in the parents, however, may have other

influences on child investment, through home productivity and

"taste" effects, and these are discussed below.

A second inference that can be drawn from conditions (14)through

(19)pertains to the differential investment in children of different

sex. Ratio (19) shows that the shadow price of

Q_M relative to Q_F depends on the relative amounts of male and female

children; thus, for instance, families with a greater proportion

of female children will desire a higher level of male than female

child quality. Since in the aggregate population $f \approx 5$, it would

seem that only differential preferences for Q_F and Q_M, or technolog-

ical differences, could result in different levels of male and

female quality in the total population. However, evidence exists

that, at least in some societies families whose first offspring are

female bear more total children than families whose first child is male. [10]

This "son-biased" behavior would produce a negative correlation
between N, total fertility, and (1-f), the proportion of children
who are male in these societies and would result in 1) a lower
average quality per child, since the shadow prices of both Q_F
and Q_M would be higher in these societies due to the higher
number of children, and 2) a greater level of quality per male
child than per female child, since f would probably exceed 1-f
and thus the average shadow price of Q_F would be greater than
that of Q_M [11]. Preference for <u>quantity</u> of males thus also results
in higher investment in male children even if tastes for Q_F and
Q_M are not dissimilar.

A third implication of these shadow price relationships is
that compulsory education laws, to the extent that they are effective,
that is, that they actually induce a rise in quality per child
beyond the level deemed optimal by the parents, should have a negative
effect on fertility since the shadow price of quantity would be
increased with the legislated increases in Q_F and Q_M. Such
schooling legislation thus makes children more "expensive".
Moreover, these laws may have a differential impact on male and
female quality levels due, perhaps, to differential enforcement
according to sex. This phenomenon, the existence of which is
tested in Part II, would be an example of societal and not familial bias.

A final implication derived from the dependence of the shadow price of child quantity on the desired level of child quality is that "pure" income increases will raise the shadow price of quantity if preferences are biased towards child quality, that is, if the pure income elasticity of child quality exceeds that of quantity. Thus even if π_F and π_M remain constant, a rise in income could lead to increases in the quality investment in children and a decline in fertility if the negative shadow price effect was stronger than the presumed positive pure income effect with respect to the total quantity of children.[12]

Changes in π_F, π_M, π_S, for constant levels of real income,[13] however, may have stronger effects on the decisions concerning the production of male and female child quality and numbers of children. While such prices are not directly observable, the prices of their components , parental time and goods, can be measured. In the next section the relationships between the wages and schooling levels of the husband and wife and the demand for numbers of children, sex-specific child quality, and the mixture of imputs used in the production of these commodities are analyzed.

b. Child Investment and the Parents

Changes in the price of time (wage rates) of the husband and wife will result in shifts in the proportions of commodities consumed if such changes alter the child services prices, π_F and π_M, and the price of S, π_S . An increase in the wage rate of either parent would raise all three prices, since parental time is assumed to be

used in the production of every commodity, but the ratio of the
prices would remain unchanged only if the value shares of parents'
time in every π_i were equal.[14] The effect of variations in paren-
tal wage rates on the consumption mix will thus depend on the
relative earnings shares, or time-value intensities, of each
parent in the three π's and on the effects of changes on the π's
on the consumption of each commodity. Moreover, because the rela-
tive time intensities of the husband and wife may differ, the
effects of changes in their respective wages may also be dissimilar.
Making some plausible assumptions about the effects of changes in
the commodity shadow prices and about the ranking of parental time
intensities among the commodities yields a number of empirically
testable hypothesis concerning the magnitude and direction of the
influence of changes in the wife's price of time relative to that
of the husband on the investment in children-- on the relative
amounts of child quantity and child quality per male and female
child produced by the family.

The (compensated) effect of a change in the wife's wage on N,
the total number of children desired, expressed in elasticity terms, is

$$E_{N,w_W} = E_{N,\pi_F}(\alpha_{FW} - \alpha_{FS}) + E_{N,\pi_M}(\alpha_{MW} - \alpha_{SW}) \qquad (20)$$

where α_{FW}, α_{MW} are the wife's earnings shares in the shadow price of
male and female child services, α_{SW} is the wife's earnings share in
π_S, and E_{N,π_i}[15] are the elasticities of total child quantity with
respect to changes in π_F and π_M. If it can be assumed that increases
in the shadow prices of male and female child services decrease the

demand for the quantity of children, i.e. E_{N,π_F}, $E_{N,\pi_M} < 0,$[16] then expression (20) will be negative if both male and female child services are more time-value intensive (with respect to the wife's time) than S.

The assumption that child services production is intensive in the wife's time is not only intuitively appealing but is consistent with the evidence of a negative effect of the presence of children in the home on the labor force participation of married women found by Mincer (1962), Cain (1966), Bowen and Finegan (1969), and Smith (1972)-- women who choose more children spend more time in household production. Thus it would be expected that increases in the wife's wage would reduce desired levels of family size.

The relation between changes in the husband's wage and N is of similar form to expression (20) except that the α's refer to the value intensities of the husband's time in the shadow prices of child services and S. It can be seen that if the husband distributes his time equally in the production of the household commodities, $\alpha_{FH} \simeq \alpha_{MH} \simeq \alpha_{SH}$, or if his participation in household production is not great, then changes in his price of time will have a negligible influence on fertility. Evidence that the husband spends more time in the production of non-child commodities (S) than in child investment, means that an increase in the husband's wage may even have a small positive effect on family size.[17]

The assumption of greater differences in the wife's time-value intensities between commodities (specialization in child investment)

and of her greater participation in household production in general, compared to the husband's allocation of time, means that it is variations in the wife's price of time which will also dominate changes in the levels of quality per male and female child. Expressions (21 and (22), derived from the model, display the effects of changes in the wife's wage, in elasticity terms, on the demand for female, (21) and male (22), quality per child:

$$E_{Q_F, W_W} = E_{Q, \pi_F} (\alpha_{FW} - \alpha_{FS}) + E_{Q, \pi_M} (\alpha_{MW} - \alpha_{SW}) \qquad (21)$$

$$E_{Q_M, W_W} = E_{Q, \pi_M} (\alpha_{MW} - \alpha_{SW}) + E_{Q_M, \pi_F} (\alpha_{FW} - \alpha_{SW}) \qquad (22)$$

E_{Q_F, π_M} and E_{Q_M, π_F}, are cross elasticities, expressing the effect of a change in the parent's demand for the level of male (female) quality with respect to a change in the shadow price of female (male) child services, and are positive if it is assumed that male and female child quality are substitutes in consumption. Thus, if increases in the shadow price of male and female child services decrease quality per child as well as the quantity of children (E_{Q_M, π_M}, $E_{Q_F, \pi_F} < 0$) and the substitutibility between male and female quality levels is not large, the wife's wage would be negatively correlated with the quality of children, ceteris paribus.

Expressions (21) and (22) also show that differences in the response of quality levels per child to variations in the wife's wage, for male and female children, i.e., differential investment in

children according to sex, could be due to any combination of two factors: 1) preferences for Q_F and Q_M differ, that is $\alpha_{MW} = \alpha_{FW}$ but $E_{Q_F, \pi_F} \neq E_{Q_M, \pi_M}$ and 2) the time value intensities of male and female child services are dissimilar, $E_{Q_F, \pi_F} = E_{Q_M, \pi_M}$ but $\alpha_{MW} \neq \alpha_{FW}$. The latter would be true if the household production technologies of Q_F and Q_M were not identical, presumably because of innate differences between the sexes; the former corresponds more closely to the notion of "discrimination", but at the household level.

The greater influence of changes in the wife's price of time compared to that of the husband on child investment also applies to the relative effects of parental human capital. Education, as an environmental production variable, may influence the shadow price of the commodities if it alters the marginal productivity of time in household production. If education raised the productivity of time equally in the production of every commodity [18] then the correlations between educational attainment and child quality and quantity would be opposite to those characterizing the wage rate-child investment relationships; high levels of the wife's schooling would be associated with high levels of fertility and child quality. The prediction of a positive association between fertility and the wife's educational attainment based on the household production efficiency hypothesis, however, is opposite to that arising from the notion that contraceptive efficiency and the wife's schooling are positively correlated, as discussed in

the preceeding section. If schooling were not also correlated
with "tastes", the estimated sign of the female schooling coefficient in
a fertility regression also containing wage rates would indicate
which education effect is dominant. The level of the husband's
schooling, if household production efficiency were the only influence
on education, would have little effect on child investment given
the small amount and even distribution of his time devoted to
household production.

Changes in the value of the wife's price of time and her
educational attainment will also influence the allocation of the
production inputs used in child investment. An increase in the
wife's wage, for instance, would induce her to substitute market
goods for her more expensive time per unit of child services
produced. This positive relation between the wife's wage and the
per-unit goods input used in the production of male and female
child services would be stronger the more time-value intensive
are child services[19] and the greater the ease with which goods
and time can be substituted in household production. The response
of the total amount of child quality goods input demanded due to
changes in the female wage will, however, also depend on the change in the
level, or number of units, of child services produced, the sub-
stitution effect in consumption . Given the assumption of the time-
value intensity of child services, the latter effect will be negative
and may thus wholly or partly offset the positive production sub-
stitution effect. The net influence of a change in female wage

rates on the derived demand for expenditures on child quality will
thus depend on the magnitude of the consumption and production
elasticities. Increases in the wage rates of women could result
in both increased expenditures per child and a decline in the demand
for child quality.

The education of the wife, to the extent that formal schooling
increases the productivity of her time in home production, would
be negatively correlated with the per-unit amount of goods used in the
production of child services -- more productive time would be
substituted for goods. Since the household productivity effect
of education also results in a positive association between the
level of time-intensive child quality and schooling, the net effect
of the educational attainment of women on the derived demand for
total child expenditures is also ambiguous. Higher levels of schooling
of women could thus be associated with higher quality children
but less expenditures per child.

C. Summary

Before proceeding to the next section, in which measures of
fertility, male and female child quality, and expenditures on children
are regressed on proxies for the household production variables
implicated in the preceding analysis, it may be useful to review
some of the empirical "predictions" derived from the theoretical
framework:

1) Female should dominate male variables in all the regression

equations, that is the educational attainment and wage variables

pertaining to the wife should exert more influence on the three

measures of child investment than do those pertaining to the husband.

2) The partial correlations between the female wage rate

and fertility and male and female quality are most likely to be

negative if women specialize in child investment; the wage effects

on the sex-specific quality measures may differ if either preferences

[tastes] for male and female child quality differ or their production

characteristics ("technologies") are dissimilar.

3) The influence of female education on fertility depends

on the relative strengths of the contraceptive knowledge and home

productivity effects of schooling. If the schooling of the wife

and the knowledge of efficient birth control techniques are posi-

tively associated, then female education will have a negative

impact on the birth rate and a positive effect on quality per

child. If schooling increases the productivity of the wife's time

in home production, then female educational attainment should be

positively correlated with both fertility and child quality. If

both education effects are operative, the female schooling

coefficient in the fertility regression equation should be al-

gerbraically less then its counterpart in the child quality regressions.

4) The relation between the wife's wage and the derived demand

for total expenditures per child may be positive even if the demand

for quality per child declines with increases in the wife's price

of time, if there is strong substitution of goods for time in the household production of child services.

5) Compulsory schooling laws, if they succeed in riasing child quality above the levels otherwise desired by parents, should have a negative influence on family size and may also be an institutional, or non-household, source of bias with respect to sex-specific child investment if they are enforced in a discriminatory manner.

II. Empirical Analysis

a) The Data and the Dependent Variables

The preceding framework implied that family size, male and female child quality intensity, and the aggregated goods used as inputs in child quality production are all dimensions of child investment jointly related to the variables pertaining to the parental decision-makers.[20] Thus, to test the implications of the model, empirical counter-parts to these theoretical constructs are used in four separate ordinary least squares regression equations corresponding to the four child investment measures. An important advantage of considering a number of aspects of child investment simultaneously is that another dimension is added to the test of the model -- the consistency of the signs of the variable coefficients across equations.[21]

The unit of observation used in all equations is the state and all data pertain to urban residents[22] as defined in the 1960 Census of Population. While the household production model of child investment has been formulated in terms of an individual family, the model is tested on aggregate data because aggregate samples have two important advantages over data consisting of individual observations.[23]

1) The price of time of women in individual families is often unknown
and endogenously related to the proxies for child investment because
many women, at a given point in time, are not in the labor market;
the existence of separate labor markets in urban areas between
states provides estimates of female wage rates and thus the average
opportunity cost of time for women in each state. 2) Variation
in tastes, high among individual families, is considerably attenuated
when aggregate population averages are utilized. This phenomenon
is important because among individual families, preferences for
child services influence labor force participation and thus the
relevant opportunity costs of child investment.[24]

Of the four dependent variables representing different aspects
of child investment, that used in the fertility regression is the
number of children ever born per 1,000 urban married women aged
35-44 (CEB). This age-cohort was chosen because these women are
likely to have completed their childbearing and thus the fertility
measure corresponds closely to the lifetime child quantity variable
in the model. Measures of the completed fertility of older cohorts
were not used because the effects of mortality on these surviving
women might produce biases in the estimated regression coefficients.

The sex-specific child quality variables, Q_M and Q_F , are measured by the school enrollment rates of male and female urban teen-agers aged 15-18 (ENRM, ENRF) [25] The theory of human capital investment [26] suggests that those parents who desire high quality children will invest more in them at every stage of the child's life cycle, at home and in school; thus children's schooling and the household investment in children should be positively correlated. To the extent that schooling and time-intensive household child investment are substitutes, however, the coefficients of the wife's wage variables will be biased upwards.

Aggregate current state public school expenditures per pupil in average daily attendance in urban districts (EXP) is the proxy used to represent the goods input in the production of child quality.[27] It is assumed that families are able to influence the level of these

expenditures on education through either the political process
or migration. The omission of private school expenditures from
this educational expenditure measure may bias towards zero all
the estimated coefficients of the variables in the expenditure
regression equations if public school expenditures understate
total expenditures on schooling more for high then for low ex-
penditure-demand states.

    b. Independent Variables

    The measure of the opportunity cost of time for women aged
35-44 used in all the regressions   (FW) is the average wage of
all women in that age group who worked-- their annual income divided
by an estimate of the number of weeks worked during the year.
This computed wage is preferable to annual female earnings because
time spent in the labor force and thus total female income will
be negatively correlated with child investment,since such activity
is time intensive. Thus a negative correlation between female
earnings and child investment variables would not represent the
effect of the wife's price of time on fertility or child quality
but the influence of tastes for children on earnings. The wage
coefficient may, however, be biased downward because women with
higher preferences for child services would tend to have less labor
force experience, and thus less human capital, for given levels of
schooling, then other women. The "depreciation" of the market
skills of these women while specializing in home production[28] could

also produce a negative correlation between female wage rates and measures of child investment even in the absence of the substitution effects predicted by the household production model. To the extent that aggregation reduces the variety in tastes, however, this latter consideration is unimportant-- taste dispersion between states is much less strong than between individuals.

The male price of time (MW) is constructed in the same manner as the female variable. The parental education measures (EDF, EDM) are the number of years of schooling completed by males and females aged 35-44. These wage and schooling variables represent the basic household production parameters which are used in each equation.

Infant mortality (IM) is also entered in all the regressions to capture the effect of child survival probability on number of births and on child quality. While the sign of the coefficient of this variable in the fertility equation is ambiguous-- decreases in infant mortality both increase the demand for surviving children (if infant deaths are costly) and decrease the number of births needed to attain any given family size, increases in the likelihood that children will survive and become adults should raise the amount of resources invested in them.

To assess the differential strength of compulsory schooling laws on sex-specific teen-age school enrollment or child quality; and thus on family size, the minimum lawful school-leaving age for each state (EDLAW) is entered in all regressions. Edwards (1970) found that these laws had differential effects on teen-age male and female school enrollment

rates, being more effective in boosting the rates of teen-age males.

The proportion of urban non-whites aged 35-44 (NONW) is included to test if, ceteris paribus, whites and non-whites differ with respect to their child investment behavior. Conlisk (1969) found that non-whites have significantly lower enrollment rates than whites and McMahon (1970), Gustman and Pidot (1973) and DeTray (1973) concluded that non-whites also spend less per child for educational purposes; all these results, however, were obtained from equations whose specifications differ from those used here.

In addition to these variables, which are included in all four regression equations, the urban unemployment rate for the age groups 15-24 (U) and the wage rate of the non-agricultural unskilled (OPW) were entered in the enrollment equations to control for the opportunity costs of schooling. It would be expected that, for given desired levels of child quality, enrollment rates of teen-agers would be higher in those states where teen-age unemployment was high, since the probability of getting work in those states would be small, and where the relevant opportunity wages available were low.

C. The Results

Table IV reports on the results of the four child investment regressions; Tables II and III define the symbols and provide the sources of the variables used.

In general, the household production parameters, together with the selected control variables, account for over 50% of the interstate variation in each of the four measures of child investment and the signs and statistical significance of the coeffecients are consistent with the implications derived from the formal model of part I. The most striking characteristic of the set of equations is the dominance of female over male variables. In all cases but one, the schooling and wage coefficients pertaining to males are not significantly different from zero, while all of the coefficients of the household production parameters pertaining to women at least approach statistical significance. Thus, the results confirm the notion that it is women who supply the most time to child investment in the home.

a. Child Quantity- Fertility

The significant negative effect of the female wage on family size is consistent with the assumption that child services require more of the wife's time per unit of output than other commodities produced in the household. High levels of the wife's education are also associated with lower fertility, a result which seems to support the hypothesis that female schooling and contraceptive efficiency are positively correlated. The recent decline in birth rates can thus be attributed to increases in both female educational attainment, which would shrink discrepencies between desired and actual fertility, and female wage rates, which would lead to a decline in the desired number of children, who require relatively large amounts of more expensive female time.

While the wage of the husband has no effect on fertility, because of the small participation of the husband in household production and the relatively even distribution of his time among consumption activities in the household, male schooling levels are positively, but weakly, correlated with family size. Increases in the educational attainment of both males and females by 10% **results** in a net reduction in fertility of 7.5%; the negative female education effect dominates the positive influence of male schooling.

The negative and significant coefficient for NONW seems to indicate that, for given levels of parental education and wage rates, urban non-whites bear less children than urban whites. The effect of the compulsory schooling laws on family size, while in the predicted negative direction, is not significantly different from zero. The reason for the lack of influence of these laws on fertility may be their failure to raise school enrollment rates, and thus child quality, by significant amounts.

b. Male and Female Child Quality- Sex-specific School Enrollment Rates

Female wages are also negatively and significantly correlated with the child quality variables, indicating that rises in the wages of women will lower the demand for the quality of children because of the wife's time intensity of child investment. The observed upward trend in school enrollment rates, is due to the much stronger positive (approaching significance) influence of the schooling level of women. The relatively strong positive effect of female educational attainment (EDF) may be due to the negative impact of female schooling on the quantity of children, as was found in

the CEB regression, which would raise desired levels of quality
per child, the positive effect of schooling on the productivity
of the wife's time on household production, which would lower the
cost of time-intensive child investment more than other com-
modities, and/or a positive correlation between schooling and
tastes for high quality children. Because of the strength of
the positive education effect, increases in schooling and earnings
of women would, on net, thus result in an increase in the demand
for child quality.

The rise in both male and female teen-age enrollment rates from
1960 to 1970, depicted in Table I, can thus be explained by the
influence of rises in the schooling of female parents. The
higher level of male and the greater increse in female school
enrollment rates during this period can also be accounted for by
the results obtained. Only two variables in the male and female
quality equations have significantly different coefficients-- the
female wage (FW) and the compulsory schooling law variable (EDLAW).
Ceteris paribus, compulsory schooling laws appear to affect only
male teen-age school enrollment; the coefficient of this variable
is positive and approaches significance in the male enrollment
equation, but is not significantly different from zero in the female
child quality regression. Thus the impact of compulsory schooling
legislation may account somewhat for the higher level of the male
school enrollment rate.

That the negative influence of the wife's wage rate on female

school enrollment is significantly less strong than its effect on

male school enrollment is supportive of the hypothesis that male

and female children are treated differently in the home. It will

be recalled that the model formulated in part I predicts just such

a result for the female wage under the assumption of the greater

time intensity of male than female child quality; the desired level

of male child quality will increase less than that of female child

quality because male children   require more of the wife's time

per unit of quality produced. Alternatively, of course, the pre-

dicted changes in the levels of male and female child quality may

reflect a correlation between preferences for sex-specific levels

of child quality and female earnings.

The other coefficients obtained in the school enrollment

equations indicate that whites and non-whites do not differ in their

demand for child quality and that low levels of infant mortality

are associated with high levels of quality investment in children.

The latter result is consistent with the hypothesis that parents

are more willing to invest in children the higher the probability

of their survival to adulthood.

The positive effect of the unemployment rate on school enrollment,

reflecting the influence of the probability of obtaining employment

alternative to schooling, is consistent with expectations, but the

positive coefficient of the opportunity wage variable is contrary

to the direction of influence predicted and is a puzzle.[29]

c. Inputs to Child Quality-- School Expenditures

The EXP equation represents the derived demand for one type of input used in child investment. The positive and significant effect of the wife's wage on school expenditures thus appears to reflect the strength of the substitution effect in the production of child quality-- increases in the price of time of women lead to the substitution of purchased goods for time, per unit of child quality produced, which more than offsets the weak negative relation between women's wages and the demand for the level of child quality. The insignificance of the female education coefficient may be due to the strong offsetting influence of the positive consumption effect of the wife's education, as evident in the child quality regressions. Increases in the schooling of women both strongly increase the demand for the level of child quality and, given the positive effect of education on the productivity of time in the home, induce substitution away from goods to more productive time in the production of each unit of child quality. The level and input substitution effects of female schooling, of opposite sign and, perhaps, of equal strength, thus may offset each other.

That the coefficients of the male wage and schooling variables in the EXP regression are not significantly different from zero, however, is further evidence of the small amount of time supplied by the husband to household child investment since the effects

of these variables on the level of child quality were also insignificant. Increases in schooling expenditures per pupil may thus be attributed to the substitution of wive's household child investment time for goods as women's wages have risen.

Conclusion

The principal general conclusions that can be made on the basis of the foregoing theoretical and empirical analysis are that the levels and movements in family size, male and female enrollment rates, and per-pupil school expenditures are the joint manifestations of child investment decisions made within the family; that it is the set of parameters associated with the wife's time, principally her wage and education,which dominate these decisions, and that some differential investment in children with respect to sex occurs within the household. A continuation of the upward trends in the education and wage rates of women should result in further declines in fertility, continued increases in school enrollment rates, but at a faster pace for female than for male teen-agers, and a continued rise in educational expenditures because of the time-intensity of household child services production.

These conclusions and the results on which they are based must remain tentative, however, because the male-female allocation of time between household production activities and the division of labor between home and market work may change in the future so that women may cease to be dominant in household child investment. In addition, the evidence of child investment differences between

male and female children requires further exploration, particularly
as regards whether those differences can be attributed to tech-
nological factors in child quality production or are the result of
the preferences of the parents, and if the latter, to what extent
they are rational parental responses to sex differentials in the
rates of return to child quality that derive from the economic
structure of society.

Table I: Urban Teen Age School Enrollment Rates,

Male and Females Aged 15-18

	1960	1970	% Change
Male	.7586	.8436	11.0
Female	.6979	.8023	17.5

_____

Sources: U.S. Bureau of the Census, Census of Population 1960, PC (1)
2D - 52D, Table 103

_____. Census of Population 1970,

"Special Report-- School Enrollment."

Table II: Variable Used in Child Investment Regressions
Urban Population

Symbol   Definition

Dependent Variables

   CEB   Children ever born per 1000 maried women aged 35-44

   ENRM   School enrollment rate of males aged 15-18

   ENRF   School enrollment rate of females aged 15-18

   EXP   Total current public school expenditures per
                pupil attending school in urban districts

Independent Variables

   FW   Weekly income of women aged 35-44

   MW   Weekly income of males aged 35-44

   EDF   Median years of schooling of women aged 35-44

   EDM   Median years of schooling of males aged 35-44

   EDLAW   Minimum state lawful school - leaving age

   IM   Infant mortality rate in urban areas, average
                annual infant births per 1000 births for
                1950-59

   NONW   Percent of urban population aged 35-44 non-white

   AGE   Median age of non-agricultural employed males

   U   Unemployment rate of urban population aged
                15-24

   DPW   Wage rate of non-agricultural unskilled workers,
                average for 1950-59.

   C   Constant term.

Number of observations = 47; Rhode Island, Alaska, Hawaii excluded.

Table III: Sources of Variables

Children ever born: U.S. Bureau of the Census, <u>Census of Population 1960</u>,
     PC(1) 2D-52D; Table 113.

Enrollment rates:_____; Tables 101 and 102.

School expenditures: U.S. Office of Education, <u>Biennial Survey of Education</u>
     <u>in the United States, 1964-56</u>, "Statistics of Local School Systems--
     Staff, Pupils, and Finances;" Chapter 3, Section IV; Table 0 for
     38 states; Chapter 3, Section III; Table 3 and 4 for 6 states
     having country-unit systems, groups I and II.

Weekly wages: U.S. Bureau of the Census, <u>Census of Population 1960</u>,
     PC(1) 2D-52D; Median income, Table 134; Weeks worked computed
     from Table 118.

Schooling: _____; Table 103.

Compulsory schooling law: U.S. Office of Education, Circular Number 793,
     <u>State Law on Compulsory Attendance</u>.

Infant mortality: U.S. Bureau of the Census, <u>Vital Statistics</u>, "National
     Summaries," 1950-59.

Proportion non-white: U.S. Bureau of the Census, <u>Census of Population</u>
     <u>1960</u>, PC(1) 2D-52D; Table 103.

Age:_____ ; Table 187.

Unemployment rate:_____; Table 176.

Opportunity wage: U.S. Department of Labor, <u>Statistical Yearbook, 1960</u>.

Table IV: Regression Results

(t-values in parentheses)

Dependent Variables

Independent Variables	CEB	ENRM	ENRF	EXP
FW	-5.865 (1.66)*	-.01092 (3.07)*	-.00421 (2.149)*	3.07015 (3.46)*
MW	3.259 (0.63)	.00127 (0.14)	.00024 (0.05)	.22782 (0.16)
EDF	-495.3 (1.84)*	.30837 (1.28)*	.23979 (1.34)*	-19.7702 (0.25)
EDM	337.8 (1.63)*	-.01299 (0.05)	.00022 (0.00)	21.9366 (0.37)
EDLAW	-3.613 (0.92)	.01399 (1.33)*	-.002373 (0.47)	-2.70668 (1.06)
IM	-20.78 (1.95)*	-.02204 (2.14)*	-.01221 (2.16)*	-1.4937 (0.58)
NONW	-14.94 (2.25)*	-.00170 (0.30)	.00164 (0.53)	.138555 (0.10)
AGE	-84.52 (3.64)*	-.04134 (1.46)*	-.01348 (0.86)	-1.23294 (0.179)
U		.03529 (1.65)*	.01406 (1.19)	
OPW		.52233 (1.69)*	.27810 (1.64)*	
C	.9434 (4.74)	.08982 (0.04)	-.65804 (0.58)	
R^2	.5323	.6471	.6323	.6455

* Significant at 10 percent level with a one-tailed test.

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Footnotes

[1] Malkiel and Malkiel (1973) and Mincer and Polachek (1973) are the most recent examples.

[2] Becker (1960) was the first to consider the demand for the quantity and quality of children in the context of the family. More recently, Willis (1973), Becker and Lewis (1973), and DeTray (1973) have developed models of child investment. In none of these studies is a distinction made between male and female quality.

[3] DeTray is an exception. His empirical analysis, however, contains serious flaws. See note 27.

[4] In real terms, current expenditures per pupil in average daily attendance in public elementary and secondary schools rose from 525 dollars in 1959-1960 to 889 dollars in 1969-1970. Source: Office of Education, U.S. Department of Health, Education and Welfare, Digest of Educational Statistics 1972, Table 77.

[5] For simplicity it will be assumed that $0 < f < 1$.

[6] The linear homogeneity of the household production functions has been assumed.

[7] This assumption is not unrealistic. In 1960, of the women 30-45 years of age who were not currently in the labor force, over 85% had previous work experience.

[8]See Willis (1973) for a detailed discussion of why efficient household production requires the equality of the value of the marginal product of the wife's time in the production of each household commodity with her market wage.

[9]Michael (1973) provides evidence that the schooling of women is positively correlated with the efficiency of the contraceptive technique chosen.

[10]See May and Heer (1968) and Ben-Porath and Welch (1972).

[11]In the aggregate population, the larger families would be those with relatively more girls; large f families would thus dominate large (1-f) families, raising f above 1-f.

[12]For a rigorous analysis of this point see Becker and Lewis (1973).

[13]All references to the effects of changes in the shadow prices in the rest of the text will assume the constancy of the real income of the family; changes in the child investment variables in response to shadow price variations will thus be "compensated" effects.

[14]The definition of parent's "time-value share", which will also be referred to as "earnings share" or "time-value intensity" is:

$$\frac{t_{ij}w_i}{\pi_j} \quad , \text{ where } i = W,H, \quad j = S, C_F, C_M$$

[15]In general, $E_{a,b} = \dfrac{\delta a}{\delta b} \cdot \dfrac{b}{a}$ where a = one of the commodities, b = one of the household production parameters or prices.

[16] While second-order conditions for the maximization of utility imply that increases in the π_M or π_F decrease the demand for male and female child services, and that <u>both</u> the quality and quantity elasticities cannot be positive, either $E_{N_{F(M)}, \pi_{F(M)}}$, or $E_{Q_{F(M)}, \pi_{F(M)}}$, may be greater than zero. The model thus does not predict how changes in the demand for child services are distributed between the quantity and quality of children.

[17] See Smith (1972).

[18] This particular kind of home productivity effect of education is thus neutral between commodities but non-neutral between production inputs; the marginal productivities of the goods inputs are assumed to be unaffected by the wife's schooling.

[19] Thus, if the time spent by the husband in the household production of child services is small, changes in his price of time would have only a negligible effect on the demand for child investment market goods.

[20] In particular, the analysis implies that family size would only have an independent influence on quality per child to the extent that parents did not have significant control over fertility. When the family size variable was included in the child quality equations its coefficient did not attain significance.

[21] For example, while it is theoretically possible for the female wage coefficient to be positive in either the fertility or child quality regressions, a positive wage coefficient in both equations would represent a contradiction of one prediction of the model.

[22]The child investment behavior of farm families is significantly different from that of urban families and urban income variables are not compatible with those pertaining to the farm population. Thus, the data used here are purged of the errors-in-variables and specification error due to these occupational effects. For evidence, see Rosenzweig (1974).

[23]For a detailed discussion of the advantages (and shortcomings) of using aggregate data to estimate fertility behavior, see Cain and Weininger (1973).

[24]See Willis (1973) for a detailed analysis of this point.

[25]The enrollment rates of these age groups were chosen because the interstate variation in the rates of the school-age population below the age of 15 was negligible.

[26]See Ben-Porath (1967)

[27]DeTray tests the child quality implications of his model with a measure of quality per child that contains both school expenditures and enrollment. By combining inputs and output in one variable, he is led to the erroneous conclusion that child quality is not female time-intensive. However, the evidence obtained here (section e) for per-pupil expenditures and enrollment indicate that DeTray's result represents the net offsetting effects of the significant negative child quality and positive expenditure effects of the wife's price of time.

[28]See Mincer and Polachek (1973).

[29]One possible explanation is that these wages may be positively correlated with the returns to education.