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MICRO-ECONOMIC THEORIES OF FERTILITY

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This paper presents simple economic models of household behavior to clarify the normative and predictive implications of so-called economic theories of fertility. It also contains some new empirical tests of hypotheses derived from economic theories of fertility and indicates some directions for further work on the investigation of the adjustment of actual to desired family size.

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Summary and Conclusions

This paper presents economic models of household behaviour to clarify the normative and predictive implications of so-called economic theories of fertility. Three models are studied. The first two, of the simple type, on which benefit-cost analyses of population programs are usually based, assume that the welfare function of the household is dependent only on the consumption level and independent of the family size. One of the models considers only consumption level of parents while the other includes also the consumption level of children. Both models are subject to the financial constraint that the consumption level is equal to the earnings of parents and children. The conclusion in both of these models is that family size will increase to the point in which the marginal net benefit of a child is equal or very close to zero. The evidence suggests that for developed countries, at least, this prediction is not correct. A more general model in which the welfare function is not dependent only on the consumption level, but also on family size and which is more consistent with observed behaviour does not yield computable cost-benefit criteria.

The paper also contains some new empirical tests of hypotheses derived from economic theories of fertility, based on the existence of economic discrimination between populations. The discussion is based on a study of the impact on fertility of race discrimination in the United States. Finally, the paper indicates some directions for further investigation of the adjustment of actual to desired family size.
MICRO ECONOMIC THEORIES OF FERTILITY

As the recent survey by Professor Warren Robinson illustrates, micro-economic theories of fertility have developed extensively along two converging paths. The one has had a purpose mainly explanatory and predictive. It has brought household fertility decisions into the conceptual framework of household resource allocation, by extending the range of conventional consumer economics to include the acquisition of children. It emphasizes the rationality of household fertility decisions, by the explicit assumption that desired family size is determined in the maximisation of household welfare subject to a constraint on potential household earnings and the less explicit assumption that actual family size approximates closely to that desired. Household welfare is assumed dependent not only on parental consumption patterns and those of the children, but also on the number of children in the family. Family size is recognized to affect potential household earnings, both through the direct contribution of the children's labor services and through possible substitution of non-market labor services for labor market activity by one or both parents. The goal of this theoretic approach has been to derive from the model hypotheses about the influence of economic variables and parameters on optimal family size, as a prelude to empirical testing and estimation. The approach has directed attention toward costs of education, women's labor force participation and potential labor earnings, the marginal productivity of labor in agriculture, and other economic variables as determinants of fertility differentials.

The other path has been normative in its orientation. Starting from a focus on the household, but using mostly aggregative data, this approach has attempted to measure economic costs and benefits to a population from specified patterns of birth limitation. Benefits are interpreted as the release of resources from fulfillment of the consumption demands of additional children for present or future consumption by other members of the community. Costs are interpreted as the loss of the additional output which the labor services of additional children would be expected to contribute. Net benefits are then interpreted as the economic pay-off to policies affecting fertility levels, such as official family planning programs. Both approaches have been marxinalist in spirit, foregoing attempts to encompass all the interactions between demographic and economic variables in favor of theoretical approximation more readily applied empirically, and satisfactory for small changes in fertility. This distinguishes them from the growing body of aggregative growth models incorporating demographic variables, which are not to be discussed in this paper.

The main purpose of what follows is to clarify the welfare and behavioral implications of these types of micro-economic fertility models. This is attempted through a simple formal exposition which emphasizes structural differences in the theories and their consequences. It is shown that the simplicity of the fertility models underlying the benefit-cost approach entails assumptions which are empirically suspect, while the more general fertility models have few behavioral or welfare implications. Some empirical evidence on the validity of the models is also introduced.
The simplest economic model of fertility, and the one most widely used for benefit-cost calculations, asserts that the "costs" of children, essentially the resources expended on children's consumption activities, are set by the norms and conventions of the household's socio-economic reference group; and, that while meeting these "costs", the parents will determine ideal family size to maximise their own consumption possibilities, taking into consideration the effect of children on potential household income obtained through their own and the children's earnings. This model has the obvious problem that the determination of children's consumption standards is largely at loose end without some further specification of the factors influencing reference group norms and conventions. However, it is a familiar and convenient point of departure.

In presenting this and other fertility models, two simplifying assumptions are made. The first is that household face an external market for some form of asset whether real (e.g., land) or financial. If the household is a price taker on this market, it can shift consumption activities in time at a constant rate, and consumption streams can be represented in terms of annual equivalents or discounted values without explicit time reference. The second is that within the household, children share equally. Therefore, their consumption can be presented by a consumption level per child times the number of children.

The following notation will be used throughout:

- **U** = the utility index or welfare indicator of the household;
- **P** = the consumption level of the parents;
- **C** = the consumption level per child for all children;
- **k** = the number of children planned by the household;
f(k;a) = the earnings of the parents, expressed as a function of the number of children; and other parameters (a)
g(k;b) = the total earnings of all children, expressed as a function of the number of children and other parameters (b)

In this notation, this first utility model can be expressed as

1) \[ U = U(P) = \text{maximised, subject to} \]
2) \[ P + kC = f(k) - g(k) \]

More, the barred variable C indicates that the child's consumption level is regarded as a "cost" determined outside the model. By substitution into \( U \), and maximisation with respect to \( k \) the necessary condition for equilibrium is derived:

3) \[ \frac{dU}{dk} = (f' + g' - \bar{c}) = 0 \] for \( k = k^* \), the optimal family size.

The rational household's ideal family size will be such that the last child's contribution to household income just covers his consumption plus any loss in parental earnings associated with child-rearing activities. Since children are not infinitely divisible, a more appropriate version of this condition is that for family sizes above the optimal, these net costs are positive; for sizes below the optimum, they are negative.

Since the marginal utility of parental consumption is by assumption always positive, the possibility that a welfare maximum can be obtained is assured by the condition that

4) \[ \frac{d^2U}{dk^2} = U''(f'' + g'') < 0 \text{ or } (f'' + g'') < 0. \]

which states, in effect, that as family size increases, additional children result in successively smaller increments to total household income, taking into account the negative influence of family size on parental earnings.
The association between the necessary condition (3) for the household's optimal family size and the benefit-cost criterion based on the net economic costs of children is easily discerned, if one makes the assumption that social welfare is based on individual household welfare, in the sense that the social good is increased by any change which puts any set of households into preferred positions with no households made worse off. Then, ignoring possible externalities in consumption or family size, \( \frac{dU}{dk} \) greater than zero for any set of households would signal a possible increase in social and private welfare by an increase in family sizes. Since (3) indicates that this condition is equivalent to the net economic benefits of additional children being positive, this benefit-cost criterion serves as a social welfare indicator.

But, if social policy is to be based on the preferences of individual households, the representation of household behavior contained in the underlying fertility model should be adequately realistic. This can be ascertained by testing empirically the behavioral implications of the model. Foremost among these is the prediction that for the family size equal to the ideal family size, the net economic costs of the last child will be approximately zero. Evidence strongly suggests that for the developed countries, at the least, this prediction is not even roughly correct. A recent study prepared for the Commission on Population Growth and the American Future estimates that it costs the average family $80,000 to $150,000 to raise two children and send them through college. The net economic costs of additional children are probably significantly positive at all parities, due to the lengthy period of dependency, the high opportunity costs of child care for women able to find market employment, and the limited financial contributions from children to parents after the formation of the second-generational nuclear family.
Other behavioral implications of the model can be brought out by supposing a shift in the children's earnings function \( g(k;v) \), caused by a movement in some parameter \( b \) which reduces potential earnings at all parities. This might represent for example, an extension of compulsory education or a shift in the economic structure away from sectors which provide employment opportunities for young people. The first implication of the model is that, by assumption, any impact of such a shift on household consumption will fall entirely on parental consumption. The short-run children's propensity to consume out of household income is assumed to be approximately zero. Despite the scarcity of data on the intra-familial distribution of expenditures, casual empiricism again casts considerable doubt on the realism of this assumption.

Also implicit in the model is the definite prediction that optimal family size would be lower for lower values of potential child earnings. This plausible statement is verified by considering the derivative of the equilibrium condition (3) with respect to the shift parameter \( b \):

\[
\frac{\partial k}{\partial b} + (g') \frac{\partial k}{\partial b} + g'' = 0, \quad \text{or}
\]

\[
\frac{\partial k}{\partial b} = - \frac{g''}{g'} (f'' + g'')^{-1} < 0 \quad \text{for} \quad \frac{g''}{g'} < 0
\]

From the assumption that the household is maximizing its welfare, it follows directly that a shift which reduces potential earnings of an additional child will also reduce ideal family size. Similarly, a shift which increases the loss of parental earnings income through additional child-bearing definitely is associated with smaller ideal family size.
The unrealistic assumption that definite "costs" can be assigned to the maintenance of children, in any sense independently of household choice in the allocation of income among family members, is unnecessary to the central features of the benefit-cost approach. The validity of this welfare indicator does not depend on such an assumption. Households may be assumed to determine children's consumption levels as they deem best, according to their own preferences. The validity of the benefit-cost criterion depends only on the critical assumption that family size itself is a matter of indifference to the household except for its bearing on household earnings and total consumption possibilities.

To clarify this point, it is sufficient to formulate the fertility model as follows:

7) \[ U = U(P; C) = \text{maximum, subject to} \]
8) \[ P + kC = f(k;a) + g(k;b) \]

Here, the level of consumption per child is considered to be a decision of the household and not determined in some ways by outside influences. The applicability of the benefit-cost criterion under these assumptions is demonstrated by substitution of (8) into (7) and recognition that

9) \[ \frac{dU}{dk} = U_p (g' + f' - C), \] indicating that an increase in family size increases private welfare so long as the net economic benefits are positive.

The main behavioral implications of this model can be best indicated by a standard maximization of the Lagrangean expression

10) \[ L = U(P; C) + \lambda (P + kC - f - g) \]

which leads to the equilibrium conditions

11) \[ U_p + \lambda = 0 \]
12) $U_C + k\lambda = 0$, which imply

13) $U_P = U_C/k$, where $U_P$ and $U_C$ are marginal utilities,

14) $C - f' - g' = 0$, and

finally, the budgetary constraint on the household, (8).

Briefly restated, households will expand family size up to that number beyond which additional children impose net economic costs, in the sense of reductions in total household consumption possibilities. Total household earnings will be at a maximum. Households will divide these earnings between parental and child consumption in the best way possible, according to the preferences of the household decision makers. Therefore, the implication remains that at the ideal family size, the net economic costs of children should be approximately zero.

This fertility model suggests that the fertility decision can be regarded as a two-stage process, in which the household first decides its desired family size so as to maximise total household income; then distributes household income to maintain the most desired pattern of parental and child consumption. This two-stage representation make it plausible that any change in the environment which increases the total contribution of children to household income should increase desired family size. This implication can be demonstrated by establishing the sign of $\frac{dk}{dF}$, through differentiation of the equilibrium conditions (8), (ii), (12) and (14), and solution of the resulting linear equations. Differentiation with respect to the parameter $b$, representing a shift in the relationship between children's total contribution to household income and the number of children in the family, results in the following equations:
The standard technique of comparative statics analysis involves the solution of these equations for \( \frac{dk}{db} \) by application of Cramer's Rule, and then investigation of the direction of this response. The first step is to note that the determinant of the system of equations, formed from the matrix of coefficients on the left-hand side of (15)-(18) must be negative, from the second-order conditions that the extreme value is a maximum. Expansion of the numerator of the expression derived by Cramer's Rule yields:

\[
\frac{dk}{db} = \left( \frac{-1}{D} \right) \lambda \frac{3g'}{db} + k = 1
\]

In this expression, \( D \) is the determinant of the system of equations. The second-order conditions also imply that the first determinant of the numerator, a bordered principal minor of \( D \), is positive. By assumption, the potential earnings of the last child are affected in the same direction as those of the others by the assumed shift in the earnings function, so \( \frac{3g'}{db} \) is positive. Finally, \( \lambda \) equals \(-U_P\) and is therefore negative. Consequently, the first term on the left must be positive, in view of the sign of \( D \). The second term can be reduced to \( \left( \frac{-1}{D} \right) \left( \lambda (U_P k - U_{CP}) \right) \),
because at equilibrium the net economic costs \((C-f'-g')\) must be nil. This whole expression is also definitely positive. Therefore, according to this less restrictive theory of fertility underlying the benefit cost approach, optimal family size is still expected to respond positively to a shift in the household's environment which increases the potential earnings of children; or, by very similar reasoning, a shift which reduces the loss in parental earnings occasioned by additional children.

In summary, the benefit-cost approach to population policy is implicitly based on the premise that society is indifferent to the size of the population per se. If social policy is held to reflect the preferences of constituent households, it implies the further premise that family size per se is a matter of indifference to the household, and is determined simply to maximise household consumption possibilities. However, this further assumption carries the implication that at the desired family size, the net economic costs of additional children will be approximately zero, an implication which seems rather widely contradicted by available evidence. Most studies, both of the benefit-cost variety and of a more micro-economic origin, seem to indicate that the net economic costs are significant, even at parities below that considered ideal by the majority of households. Consequently, one must conclude either that the underlying representations of household fertility decisions and the social welfare indicator derived from it are unrealistic, or that households, even in the more modernised communities, do not have fertility under effective control. These conclusions emerge more clearly from the following discussion of a more general micro-economic theory of fertility decisions.
This model is more general in that it admits the possibility that the size of the family is of direct concern to the household; that parents have definite preferences about the number of children they will have, independently of the economic consequences of family size. Optimal family size is determined jointly by psychological and economic considerations.

This generalisation, although obvious and clearly warranted, has a marked effect on the normative and predictive implications of the theory. The resulting theory no longer yields simple, or simplistic, social welfare criteria; nor does it yield unambiguous predictions. In becoming more realistic, the theory becomes more equivocal.

Mathematically, the generalisation is expressed simply by the reformulation of the household welfare function to read

\[ U = U(P; C; K) \]

which indicates that the household welfare is affected by the number of children in the family as well as their consumption standards and those of the parents. Consumption is constrained by household earnings, as in (8). This formulation at once suggests the inadequacy of the benefit cost approach as a comprehensive indicator of social welfare in population policy. If social policy is founded on household preferences (and externalities are absent), the expression

\[ \frac{dU}{dK} = U_p(f' + g' - C) + U_k \]

indicates that a reduction in family size would not necessarily increase welfare, even if net economic savings would result. The last factor, \( U_k \),
the direct effect of a change in family size on household welfare, could more than offset the value of such savings. Since the benefit-cost approach does not take into consideration this intrinsic, or psychological, preference of the household concerning the size of the family, it omits what is likely to be an important determinant of household behavior, and social welfare. Put another way, this more general model of fertility states that households are not necessarily made better off in their own estimation, by policy interventions which discourage fertility, even if they are thereby made economically better off. Also, of course, the model implies that should \( U_k \), the marginal utility to the household of an additional child, be negative, (because an additional child would conflict with family size norms, more valued activities, or would imperil maternal health) then a policy intervention to discourage fertility would not necessarily reduce welfare even if the family's economic status were thereby undermined.

The more important predictive hypotheses implied by this more general formulation can be indicated by the standard comparative statics treatment. Maximisation of (18) subject to the household budget constraint (8) results in the following equations describing the optimal family size and distribution of household consumption:

\[
22) \quad U_p + \lambda = \mu;
\]

\[
23) \quad u_k + k\lambda = 0; \text{ which together mean that}
\]

\[
24) \quad U_C = kU_p; \text{ also}
\]

\[
25) \quad U_k = U_p(0-f'-g'); \text{ and,}
\]

\[
(8) \quad C_p + kC = f(k;a) + g(k;b)
\]
As in the simpler model, household consumption is distributed between parents and children so that, according to the preferences of household decision makers, the best allocation is achieved. However, family size is planned not to maximise household earnings, but so that the marginal cost of the last desired parity, in terms of the marginal utility of the parental consumption foregone as a consequence of the last parity, is just offset by the subjective valuation of the last child itself.

Since an addition to parental consumption is assumed to be always desired, this condition has the potentially interesting implication that, should the economic value of an additional child to the household be positive, additional children will be desired until that family size is attained at which further births in themselves are held in such strong aversion that the economic benefits are offset. On the other hand, if in the community under discussion, the economic costs of additional children at parities near the actual median are quite high, the theory predicts that, apart from economic considerations, households will be found strongly to desire additional children for their own sakes. Since there are probably wide differences among communities in the net economic benefits or costs of children, in terms of parental consumption, there is perhaps scope for empirical testing of this prediction through survey methods. The main methodological challenge would be to isolate economic from other motivations in the determination of desired family size. Nonetheless, it might be expected, for example, that in multiple response answers to questions on the reasons for not wanting more children, there would be in communities with low economic costs or economic benefits to child-raising a greater frequency of answers having to do with health constraints, social norms, personal and interpersonal factors, and other non-economic reasons.
The fertility model suggests that in communities in which the economic costs of children are high, these should be cited as the main reason for not wanting additional children, with a low frequency of responses indicating a non-economic aversion to further births.

Unfortunately, it can be shown that this is about the only potentially interesting implication of the more general fertility theory. All else is ambiguous. Interest in the micro-economic theory of fertility centers on its relevance to the formulation of population policies, which operate for the most part through the household budget constraint.

Consequently, of greatest interest is the response of optimum family size to shifts in the functions relating parental and child earnings to family size, in equation (8) above. It was demonstrated earlier that the simpler model yielded the definite prediction that a shift which reduced the potential economic contribution of children to household income, either directly or through their effect on parental earnings, would reduce desired family size. The same procedure can be applied to the present model. Differentiation of the equilibrium conditions (22), (23) and (25) and (8) with respect to the shift parameter results in the following system of equations:

\[
\begin{align*}
26) \quad & (U_{pp}) \frac{df}{db} + (U_{pc}) \frac{dc}{db} + (U_{pk}) \frac{dk}{db} + \frac{d\lambda}{db} = 0 \\
27) \quad & (U_{c'p}) \frac{dp}{db} + (U_{c'} \frac{dC}{db} + (U_{c'k} - U_{c'p}) \frac{dk}{db} + k \frac{d\lambda}{db} = 0 \\
28) \quad & (U_{k'p}) \frac{dp}{db} + (U_{k'c'} - U_{k'p}) \frac{dc}{db} + (U_{kk} + U_p(f'' + g'')) \frac{dk}{db} + (C-f'-g') \frac{d\lambda}{db} = -U_{p3b} \\
29) \quad & \frac{dp}{db} + k \frac{dc}{db} + (C-f'-g') \frac{dk}{db} = 1
\end{align*}
\]
This system of linear equations can be solved for the family size response, $\frac{dk}{db}$. The determinant of the matrix of coefficients on the left-hand side of this system, denoted $D$ as before, must again be negative from the second-order conditions for a constrained maximum. The solution can be expanded as follows:

\[
\frac{dk}{db} = \frac{-1}{D} \begin{vmatrix} U_{PP} & U_{PC} & 1 \\ U_{CP} & U_{CC} & k \\ U_{KP} (U_{KC} - U_{P}) (C - f' - g') & - U_{P} \frac{\partial g'}{\partial b} & 1 \\ \end{vmatrix} - \frac{U_{P}}{D} \frac{\partial g'}{\partial b} \begin{vmatrix} U_{PP} & U_{PC} \\ U_{CP} & U_{CC} \\ \end{vmatrix} k
\]

The second determinant on the right is positive, also from the second-order conditions. $\frac{\partial g'}{\partial b}$ is expected to be positive, like $\frac{\partial g}{\partial b}$. Therefore, the second expression is always positive.

The sign of the first determinant is not clear-cut, however. Expansion along the bottom row of this determinant gives a set of sufficient conditions for the determinant to be positive, which would imply $\frac{dk}{db}$ positive for all parameter values. These are:

31) $U_{KP} > 0$

32) $(U_{KC} - U_{P}) > 0$

33) $(C - f' - g') > 0$

Only with considerable effort is it possible to attach any common sense meaning to this set of conditions. They indicate primarily that in the more general theory of fertility, the response of ideal family size to changes in the economic setting cannot be determined without reference to a complex set of household preferences for parental consumption, consumption
per child, and the size of the family. There is no necessary relation between the marginal economic costs of children, defined as \((C - f' - g')\) and the response of ideal family size to a specified shift in these costs. In general, there is no reason to suppose on a priori grounds that the conditions \((31)\) through \((33)\) will be fulfilled in any household or population of households. In this sense, the broader economic theory of fertility produces few interesting empirical hypotheses.

Nonetheless, a great deal of work has been done to explore empirical regularities between fertility and socio-economic variables. With no attempt to review this literature, it can be stated that, in general, the results suggest that fertility usually varies directly with income and the economic contribution of children, ceteris paribus, and inversely with the opportunity costs of children. The following paragraphs propose a somewhat different empirical test of the micro-economic behavior of fertility, one based on the economics of discrimination. The existence of economic discrimination implies that, independently of all other factors (like education, job experience, occupation, industry, age, place of residence) which determine the marginal productivity of labor services, the characteristic on which discrimination is based will exert an independent influence on earnings. The victim of discrimination will receive a lower earned income than the beneficiary of discrimination, even after careful control of other relevant factors. If discrimination is persistent and long-standing, it will be reflected in the returns to the acquisition of human capital, which will be lower for the victim than for the beneficiary.
Furthermore, it will consequently be reflected in the potential net economic costs of children: for any given level of education, for example, the child's expected earnings would be lower; and, to achieve any particular level of expected earnings, the child would have to receive a larger investment in human capital. In fact, economic discrimination acts like a shift parameter in the household budget constraint. Other things equal, it operates to lower the expected earnings of the children of the victimised group, and to raise those of the exploiting group's children.

In the United States, the two principal characteristics on which economic discrimination is based are race and sex. With regard to race, a large body of evidence has been accumulated on the extent of economic discrimination, in just the sense of the last paragraph. Two tables from one of the most recent and sophisticated analyses give clear indications of the extent of this phenomenon. The first is derived from a multiple regression analysis of factors associated with "family poverty", defined as annual income of $3,000 or less in 1960.

The table gives the values of the independent variables used in the regression analysis, separately for whites and non-whites, under the heading "characteristics". The last column was derived by weighting these values by the regression coefficients relating the variables to the national incidence of poverty, and estimating thereby the contribution of each to the differential incidence of poverty among whites and non-whites. It shows

that "most (82 per cent) of the difference between the incidence of white
and Negro poverty is explained by the handicaps of being a Negro and of
having a low education level". The second table is based on a regression
analysis associating income levels for males with the major elements of
human capital formation: formal education and years of on-the-job
experience. It shows, for the southern and for other regions, that for
non-whites the economic returns to both formal and informal education are
lower than for whites. Moreover, it shows that outside the southern
region, "blacks could have the same amounts of education and experience
as whites and have the same income elasticities with respect to education
and experience, but still earn lower incomes due to smaller shift co-
2/efficients".

Table 1: CONTRIBUTION OF EACH VARIABLE IN
POVERTY MODEL TO DIFFERENCE BETWEEN WHITE AND NON-WHITE
POVERTY, 1960 (IN PERCENTAGES)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Characteristics</th>
<th>Sources of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White</td>
<td>Non-White</td>
</tr>
<tr>
<td>Families living on farms</td>
<td>7.5</td>
<td>6.6</td>
</tr>
<tr>
<td>Families headed by non-white</td>
<td>0.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Families with no one working</td>
<td>10.5</td>
<td>12.9</td>
</tr>
<tr>
<td>Family heads with less than eight years of schooling</td>
<td>19.2</td>
<td>48.5</td>
</tr>
<tr>
<td>Population aged 16 and over working 50-52 weeks per year</td>
<td>35.5</td>
<td>28.9</td>
</tr>
<tr>
<td>Index of industrial structure</td>
<td>98.8</td>
<td>97.8</td>
</tr>
<tr>
<td>Incidence of poverty,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Projected</td>
<td>18.6</td>
<td>48.0</td>
</tr>
<tr>
<td>Actual</td>
<td>18.6</td>
<td>47.8</td>
</tr>
</tbody>
</table>

Source: Thumrow, Table 3.4, page 42.

1/ Thumrow, page 42.

2/ Thumrow, page 77.
Table 2: INCOME ELASTICITIES OF EDUCATION AND EXPERIENCE FOR MALES, BY COLOR AND REGION, 1960

<table>
<thead>
<tr>
<th>Color and Region</th>
<th>Years of Education</th>
<th>Years of Experience</th>
<th>Shift</th>
<th>Coeff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-5</td>
<td>0-12</td>
<td>12+</td>
<td>0-5</td>
</tr>
<tr>
<td>All white</td>
<td>0.11</td>
<td>0.72</td>
<td>1.73</td>
<td>0.20</td>
</tr>
<tr>
<td>All non-white</td>
<td>0.08</td>
<td>0.76</td>
<td>1.33</td>
<td>0.26</td>
</tr>
<tr>
<td>N. white</td>
<td>0.10</td>
<td>0.52</td>
<td>1.70</td>
<td>0.20</td>
</tr>
<tr>
<td>N. non-white</td>
<td>0.06</td>
<td>0.51</td>
<td>1.22</td>
<td>0.27</td>
</tr>
<tr>
<td>S. white</td>
<td>0.11</td>
<td>0.91</td>
<td>1.91</td>
<td>0.20</td>
</tr>
<tr>
<td>S. non-white</td>
<td>0.08</td>
<td>0.57</td>
<td>1.74</td>
<td>0.24</td>
</tr>
</tbody>
</table>

Source: Thirnow, Table 5.1, page 77.

The table indicates, for example, that for all whites, the income elasticity of educational experience (defined as the percentage increase in measured income associated with a one per cent increase in educational experience) during the first eight years of school was 0.11; for non-whites, it was 0.08.

Outside the South, both the returns to human capital formation and the base earnings levels are lower for non-whites than for whites by a considerable margin.

These data demonstrate very clearly that for non-whites as a group, the function g(k; b) is shifted substantially downwards relative to its value for whites as a group. The rational non-white household could realistically expect that, everything else equal, more expenditure would be required on education and training to ensure the children any specified consumption standard. In this sense, the net economic costs of children are shifted up.
It is natural, then, to examine differential fertility between whites and non-whites to see whether a residual effect can be detected, after the influence of other relevant factors are controlled. The simpler economic models of fertility predict that such a differential should exist, and that non-white fertility should be shifted downwards relative to white fertility, other things equal. The more general model does not imply such a prediction, but other empirical work based on the theory nonetheless leads to the expectation that it would be true. Of course, to attempt such a test is to plunge headlong into the middle of a long debate over the sources of differential fertility between races in America, in which one side holds that different cultural values are important intervening explanatory factors and would lead to the persistence of fertility differentials even should social and economic differences between the races disappear. In terms of the economic models discussed above, this side maintains that the household welfare functions $U(P; C; k)$ differ systematically between races in ways which are not determined by the values of the economic variables themselves. By implication, at least, the present hypothesis is closer in spirit to that of the other side, the so-called "characteristics" school of thought, which holds that fertility differentials are predominantly the consequence of differences in social and economic conditions among whites and non-white, and would very largely disappear should conditions be equalised.

A recent multivariate analysis of white and non-white fertility differentials in a paper by David F. Sly sheds a good deal of light on these questions. He conducted three-way analysis of variance on data
relating fertility to race, region, educational attainment, occupation, and income. In each, race and region were included along with one of the socio-economic variables, so that the direct effects of each variable on fertility and also the interaction effects of race with region, education, income or occupation could be estimated. Analysis of variance was performed for all regions together, then for all the regions other than the South.

The results indicate the part of the observed variance which can be associated with each of the independent variables, and to interaction between each pair of them, along with appropriate tests of statistical significance. In the abbreviated tables presented below, only the degree of freedom, values of the F-statistic, and significance levels are reported. For all regions together, the results for the analysis of variance including the income variable were not reported in the original paper.

Table 3: ANALYSIS OF VARIANCE INCLUDING RACE, REGION, AND EDUCATION FOR ALL REGIONS TOGETHER

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>F-Statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>1</td>
<td>6.716</td>
<td>.05</td>
</tr>
<tr>
<td>Education</td>
<td>3</td>
<td>87.824</td>
<td>.001</td>
</tr>
<tr>
<td>Region</td>
<td>3</td>
<td>24.203</td>
<td>.001</td>
</tr>
<tr>
<td>Race - Education</td>
<td>3</td>
<td>7.921</td>
<td>.01</td>
</tr>
<tr>
<td>Race - Region</td>
<td>3</td>
<td>9.059</td>
<td>.01</td>
</tr>
<tr>
<td>Education - Region</td>
<td>9</td>
<td>4.706</td>
<td>.05</td>
</tr>
<tr>
<td>Error</td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Sly, Table 6, Page 45.
### Table 4: Analysis of Variance Including Race, Region, and Husband's Occupation, For All Regions Together

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>F-Statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>1</td>
<td>3.356</td>
<td>-</td>
</tr>
<tr>
<td>Occupation</td>
<td>9</td>
<td>30.070</td>
<td>.001</td>
</tr>
<tr>
<td>Region</td>
<td>3</td>
<td>12.941</td>
<td>.001</td>
</tr>
<tr>
<td>Race - Occupation</td>
<td>9</td>
<td>1.914</td>
<td>-</td>
</tr>
<tr>
<td>Race - Region</td>
<td>3</td>
<td>5.212</td>
<td>.01</td>
</tr>
<tr>
<td>Occupation - Region</td>
<td>27</td>
<td>1.482</td>
<td>-</td>
</tr>
<tr>
<td>Error</td>
<td>27</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Silv, Table 7, page 455.

### Table 5: Analysis of Variance Including Race, Region, and Education, Excluding the South

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Degrees of Freedom</th>
<th>F-Statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>1</td>
<td>21.829</td>
<td>.01</td>
</tr>
<tr>
<td>Education</td>
<td>3</td>
<td>43.792</td>
<td>.001</td>
</tr>
<tr>
<td>Region</td>
<td>2</td>
<td>20.120</td>
<td>.01</td>
</tr>
<tr>
<td>Race - Education</td>
<td>3</td>
<td>3.958</td>
<td>-</td>
</tr>
<tr>
<td>Race - Region</td>
<td>6</td>
<td>0.426</td>
<td>-</td>
</tr>
<tr>
<td>Education - Region</td>
<td>6</td>
<td>3.199</td>
<td>-</td>
</tr>
<tr>
<td>Error</td>
<td>27</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Silv, Table 8, p.456.
### Table 6: Analysis of Variance Including Race, Region, and Occupation, Excluding the South

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Degrees of Freedom</th>
<th>F-Statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>1</td>
<td>0.287</td>
<td>-</td>
</tr>
<tr>
<td>Occupation</td>
<td>9</td>
<td>31.774</td>
<td>.001</td>
</tr>
<tr>
<td>Region</td>
<td>2</td>
<td>10.499</td>
<td>.001</td>
</tr>
<tr>
<td>Race - Occupation</td>
<td>9</td>
<td>1.092</td>
<td>-</td>
</tr>
<tr>
<td>Race - Region</td>
<td>2</td>
<td>0.203</td>
<td>-</td>
</tr>
<tr>
<td>Region - Occupation</td>
<td>18</td>
<td>1.250</td>
<td>-</td>
</tr>
<tr>
<td>Error</td>
<td>59</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Sly, Table 9; p.456.

### Table 7: Analysis of Variance Including Race, Region, and Income Excluding the South

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Degrees of Freedom</th>
<th>F-Statistic</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Race</td>
<td>1</td>
<td>3.169</td>
<td>-</td>
</tr>
<tr>
<td>Income</td>
<td>7</td>
<td>5.054</td>
<td>.01</td>
</tr>
<tr>
<td>Region</td>
<td>2</td>
<td>25.054</td>
<td>.001</td>
</tr>
<tr>
<td>Race - Income</td>
<td>7</td>
<td>0.855</td>
<td>-</td>
</tr>
<tr>
<td>Race - Region</td>
<td>2</td>
<td>4.783</td>
<td>.05</td>
</tr>
<tr>
<td>Income - Region</td>
<td>14</td>
<td>1.542</td>
<td>-</td>
</tr>
<tr>
<td>Error</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Sly, Table 10; p.456.
Tables 5, 6 and 7, which present results of the analyses from which the Southern region was excluded, demonstrate that race has little independent explanatory power as a determinant of fertility. Moreover, race evidently interacts only weakly with region or the socio-economic variables. Only in one of the three analyses of variance is the racial variable a significant influence; and, only in one of six possible interactions between race and other variables in the three analyses of variance proved to be significantly different from zero. These results led the original researcher to the conclusion that "...if race is taken to represent minority-group status, the data then strongly suggest that when the South is eliminated from the analysis, minority-group status does not make an independent contribution to fertility, nor does the interaction of the characteristic and minority-group status. Moreover, the data gives strong support to the characteristic hypothesis. That is, education, husband's occupation, income (and region) appear to have the main effect on fertility of the factors considered when the South is eliminated from the analysis".  

When it is recalled that outside the South, the evidence of economic discrimination is obvious, Sly's results lead toward the interesting conclusion that (a) differential fertility is mainly the consequence of social and economic forces, and (b) economic discrimination which raises the net costs of children to non-white households does not result in

lower fertility among non-whites. This conclusion stands in contradiction to the predictions of the simpler economic models of fertility, and to the empirical findings based on the more general model.

Turning now to the analyses of variance which include the South, one finds in Tables 3 and 4 that race plays a stronger independent role, and interacts with the other variables, particularly if education in the socio-economic variable included in the analysis. In the analysis of variance involving income, not reported in Sly's paper, race had a significant direct effect also, but no significant interactions with other variables. Two interpretations are possible, in view of the preceding results. The first is that cultural and value differences correlated with race are important in the South, but not outside the South. The second is that race is highly correlated with an important omitted socio-economic characteristic, when the South is included. Of the two, the latter is the more plausible. The omitted characteristic is very probably urban residence, which is known to be closely associated with fertility. Non-whites are much more likely to be rural residents in the South than in the North, so that when the South is included, the results of the analysis attribute much of the urban-rural variable's effects to race.

This surmise is strengthened by the observation that urban occupation is included, the influence of race is minimised. The occupational classification includes farmers and farm workers, and so picks up more urban-rural variation than does either income or education.

Aside from this point, it is noteworthy that the direction of the association between race and fertility is contrary to that predicted by theory. The influence attributed to race in the data including the
South sets to raise non-white fertility relative to that of whites, whereas
the expected result of economic discrimination would be to lower it, other
things equal. In other words, even if there were an independent influence
of race on fertility, it would be operating in the "wrong" direction, given
the economics of discrimination and the usual interpretation of the economic
theory of fertility.

However, since this theory in its broader form does not strictl
imply anything about the response of optimal family size to shifts in the
parameters of the budget constraint, it cannot be refuted or confirmed by
tests like the one just outlined. For example, these empirical results
could be rationalised by the argument that in the household welfare function,
numbers of children substitutes for the consumption standards of children,
or the "quality" of children in Becker's earlier phraseology. Non-whites,
facing lower returns to investment in human control than do whites,
substitute expenditures on larger numbers of children. This is to say that,
in equation (32), \( U_{kc} \) is sufficiently negative that \( \frac{dk}{ds} \) becomes negative as
well.

This empirical exercise involved data from the United States only.
It would perhaps be possible, and of some interest, to carry out a similar
investigation using data from less developed societies in which non-
competing groups of economic discrimination has existed. One obvious
possibility would be to explore whether caste in India has had an indepen
dent association with earnings, when other factors are controlled; and, whether
caste is independently associated with fertility.

1/ Gary Becker, "An Economic Theory of Fertility", NBER, Demographic and
Economic Change in Developed Countries, Princeton, 1960.
The discussion to this point has dealt only with the determination of optimal family size; and, in fact, only with the determination of optimal family size in households, since other variables affecting fertility like age at marriage are clearly outside the range of these models. However, what is of greater interest is the determination of actual family size and actual fertility. The actual is not necessarily the same as the optimal, and the economic theory of fertility is incomplete until the adjustment mechanism relating the two is specified. In other areas of economics, such as the theory of investment behaviour, somewhat analogous processes are described by means of a stock adjustment relation, in which additions to the stock (of assets, or children) are influenced by the relative magnitudes of current actual stock and the current desired stock. More specifically, it can be hypothesized in general terms that the marital fertility for a household at any particular time, \( \frac{dk}{dt} \), is determined by the size of the family at that time, \( k(t) \), relative to the size considered to be optimal at that time, \( k^*(t) \). This relationship would be expected to hold within the period limited by the age at marriage and earliest initial birth, at one extreme, and the period of deteriorating fecundity, at the other. Within this period, the stock adjustment mechanism would suggest that current marital fertility will be higher, the larger is \( k^*(t) \) relative to \( k(t) \); also, fertility will be lower, the larger is \( k(t) \) relative to \( k^*(t) \).

This is very general hypothesis. More specific hypotheses about the nature of the adjustment process are possible. For example, it is plausible that the adjustment process will be faster, the more sharply
focussed and strongly held is the household's desired family size. The smaller and desired size, \( k_s(t) \), therefore, the more rapid will be the adjustment process, since the difference between a desired size of one and two children is of greater significance than the difference between six and seven. Secondly, it is likely that the more uncertain is the attainment of any desired family size, the slower will be the adjustment process. Thus, the higher the rate of infant and child mortality, the slower would be the expected adjustment process. Thirdly, in traditional societies the adjustment mechanism is essentially one-sided, in that for \( k < k_s \), the household need only continue to practice natural marital sexual behavior. For \( k > k_s \), much more drastic behavioral modifications are required. These changes are the more drastic if pre-marital contraception is rare, which is more likely to be the case if marriage age is early. Furthermore, the required behavioral changes are the more drastic, the longer the marital period during which the household has followed pronatalist practices; i.e., the longer the period during which \( k < k_s \). For all three reasons, it is likely that the speed of response of current fertility to any gap between actual and desired family size will be slower, the larger is desired family size itself. The hypothesised relation can be written as:

\[
32) \frac{dk}{dt} = f(k - k_s; k_s), \text{ or } f\left(\frac{k}{k_s}, k_s\right)
\]

for "\( t \)" within the limits mentioned above. In empirical work one would have to find a convenient functional specification which would have the desired properties that (a) \( \frac{dk}{dt} \) would be limited to positive values,

(b) \( \frac{dk}{dt} \) would be related to the explanatory variable \( (k - k_s) \) or \( (\frac{k}{k_s}) \)
monotonically and non-linearly, with asymmetrical responses for $<k^*$ and $k>k^*$, and (c) for any relative magnitudes of $k$ and $k^*$, the response speed of $\frac{dk}{dt}$ would be inversely related to $k^*$.

With such a functional specification, it is conceivable that a three-step approach could be attempted. In the first stage, survey observations on $k^*$ for a sample population would be regressed on observable socio-economic characteristics. In the second stage, the predicted or observed values of $k^*$ would be used in (32), along with current and retrospective fertility data, to estimate the parameter(s) of the adjustment mechanism. Finally, in the third stage, the parameter(s) of the adjustment mechanism would be used as the independent variable in an empirical analysis testing their association with infant mortality, desired family size, age at marriage and other variables hypothesized to influence adjustment costs and adjustment speed (such as urban residence, access to contraceptive advice and services, educational attainment, and so on).

Such a procedure, although difficult, would lead to a fuller and more useful exploration of the major components of the economic theory of fertility.