A list of Working Papers on
the last pages

No. 130, 1984

FERTILITY AND THE OPPORTUNITIES OF CHILDREN: EVIDENCE ON QUANTITY-QUALITY INTERACTIONS IN SWEDEN

by

Bertil Holmlund

Paper presented at the Nordic Demographic Meeting, Paimio, Finland, June 1984.

September, 1984

1 INTRODUCTION

Several psychological studies show a pronounced relationship between family size and the children's mental capacity, as revealed by various ability tests. From two-children families and upwards, the association is typically negative. Only-children appear to fall somewhat outside the general pattern and perform less well than those in two-children families. (See Walldén (1982) for a survey of sibling research in psychology and sociology.)

The relationship between mental capacity and number of siblings has been given several different interpretations. For example, the relationship may be due to parent differences that are correlated with family size. Essentially this argument is one of omitted variable bias. Another interpretation presumes a casual link between family size and mental development among children. High fertility families have, on average, less resources in terms of goods and time to devote to their children. A third interpretation focuses on the importance of birth order. Several studies indicate an inverse association between birth order and mental capacity. High fertility families will produce more children of high birth order and therefore more children with lower mental capacity; as a consequence, average child capacity may fall.

The economic approach to fertility of Becker and Lewis (1973) provides an optimization framework for understanding the relationship between quantity and "quality" of children. The basic idea is that household welfare depends on, inter alia, the number of children as well as various utility-affecting characteristics of the children, such as their intellectual and emotional development and ultimately their educational attainment and earnings power as adults.

Quantity-quality models typically involve non-linear budget constraints. It turns out that important "interaction effects" between quantity and quality may follow as a consequence. This is due to a crucial property of such models - the endogeneity of shadow prices for quantity and quality, respectively. The shadow price of quantity is proportional to the level of quality and the shadow price of quality is proportional to quantity. An initial disturbance that induces a decrease in quantity will also lead to a decrease in the shadow price of quality and therefore to a further substitution away from quantity towards quality. Substitution responses will be magnified by this quantity-quality interaction.

Several significant policy issues are related to the nature of the tradeoff between the number and quality of children. One issue concerns the mechanisms whereby inequality across generations is transmitted and perpetuated. For example, if low-income parents are more likely to have many children they will also be more likely to invest less in each of those children, since a large number will be associated with a higher shadow price of quality. Those who grew up with many siblings will therefore be equipped with less "endowment" from their parents and will probably receive less education and earnings as teenagers and adults. A "vicious circle" whereby intergenerational inequality is perpetuated is conceivable.

The quantity-quality tradeoff has also relevance for population policy. Child subsidies that induce an increase in fertility will also raise the shadow price of child quality - and a further substitution away from quality may occur. To the extent that it is desirable to influence current trends in fertility, one should certainly not ignore possible quantity-quality interactions that various policy measures may produce.

In this paper we explore the role of the family size and other family background characteristics for Swedish children's educational achievements as adults. We start, in Section 2, with a brief exposition of the quantity-quality fertility model and use this framework as a guide for specification of equations for parents' fertility demand as well as children's educational attainment. Some econometric issues are discussed in Section 3 and the empirical analysis is given in Section 4. A summarizing discussion concludes the paper.

2 ANALYTICAL FRAMEWORK

Consider a family acting as a single decision unit and attempting to maximize a well-behaved utility function

$$U = U(N,Q,C) \tag{1}$$

where N is the number of children, Q is the (average) quality per child and C is consumption of a composite commodity. Child quality represents a flow of services that provide direct utility to the household and is produced by each family by the use of time and market goods.

The utility function is maximized subject to a full income constraint

$$I = PNQ + P_N N + P_Q Q + P_C C \tag{2}$$

where I is full income, P is the price per unit of quality, P_C is the price of the composite commodity and P_N and P_Q are fixed prices related to quantity and quality. P_N "includes the time, expenditure, discomfort, and risk spent in pregnancy and delivery, governmental child allowances (a negative cost), and all other psychic and monetary expenditures on children that are largely independent of quality". (Becker, 1981, p. 107.) P_Q is associated with expenditures on children that are unrelated to the number of children because of joint consumption.

The first-order conditions resulting from utility maximization are

$$U_N = \lambda(PQ + P_N) = \lambda\pi_N \tag{3}$$

$$U_Q = \lambda(PN + P_Q) = \lambda\pi_Q \qquad (4)$$

$$U_C = \lambda P_C \qquad (5)$$

where λ is the marginal utility of full income and π_N and π_Q are shadow prices of quantity and quality, respectively. An important point to note is that the shadow price of quantity depends on the level of quality and that the shadow price of quality depends on the level of quantity. This provides a basis for interaction effects as discussed in some detail by Becker (1981). For example, lower costs of contraceptives are likely to reduce the number of children, but may also have indirect effects through a lower shadow price of quality, leading to an increased demand for quality and a further decrease in the number of children.

Unlike conventional prices, these shadow prices are endogeneous and determined by the parameters of the problem, i.e., the price vector and full income. Eqs. (2) - (5) can be solved for the optimal values of the choice variables as functions of these parameters.

Some properties of this framework are best conveyed by ignoring the composite commodity and focusing on a 2-good quantity-quality model. It is straightforward to show that the level curve for the budget constraint will be convex to the origin in the quality-quantity space; the curvature of this constraint increases as P increases. Internal equilibrium requires that the curvature of the indifference curve exceeds the curvature of the budget curve. The magnitude of the substitution effect will be affected by the degree of the nonlinearity of the budget constraint (i.e., the level of P).

We noted that the shadow price of quality was an increasing function of the number of children. It would be tempting, therefore, to expect that an income-compensated increase in the fixed cost per child - which unambiguously decreases the number of children - also would induce an increase in the demand for child quality through a lower shadow price of quality. This conclusion, however, is not warranted in quantity-quality models involving more than 2 goods, e.g., the 3-good model outlined above.[1] Although the signs of the cross-substitution effects between quantity and quality are ambiguous, the presence of non-linear budget constraints will make negative signs "less likely". A positive cross-substitution effect in the linear case is increased in magnitude by the quantity-quality interaction through the budget constraint. In fact, the cross-substitution effect in the non-linear case may be positive even if quality and quantity are complements in the linear case.

The Becker-Lewis approach to child quality is perhaps best viewed as relevant for parental investments in "younger" children. Investment decisions concerning older children, for example on higher education, may be regarded as taken by the children themselves, <u>conditional</u> on inherited "ability" and available financial and other resources. Ability, in turn, is determined by endowed genetic components as well as parental investments in child quality.

Consider the following relations explaining the demand for quantity and quality of children,

$$N = X\beta + \varepsilon_1 \tag{6}$$

$$Q = X\gamma + \varepsilon_2 \tag{7}$$

where X is a vector of variables capturing variations in prices and income and ε_1 and ε_2 are stochastic errors.

Parental investments in child quality will contribute to the children's intellectual development. Assume that the children's educational attainment (ED) is determined, in part, by "ability" as reflected in parental expenditures on child quality,

$$ED = Z\Theta + \tau_1 N + \tau_2 Q + \varepsilon_3 \tag{8}$$

where Z is a vector including variables affecting costs and returns to education. Note that the number of children enter as argument in (8) - in addition to quality. One important reason is that more children mean that less financial resources will be available for each child; schooling costs are likely to be an increasing function of the number of siblings.

3 ECONOMETRIC ISSUES

Eqs. (6) - (8) could be estimated consistently by ordinary least squares - if all relevant variables were observable and if the stochastic errors were uncorrelated across equations. Unfortunately, child quality is not observed at all and variations in prices are only possible to detect through proxy variables. There is, furthermore, little reason to expect $E(\varepsilon_1\varepsilon_2) = 0$; in fact, the quantity-quality hypothesis suggests $E(\varepsilon_1\varepsilon_2) < 0$. If quantity and quality are substitutes, we expect that "excess fertility" (large ε_1-values) are associated with lower than average quality. The stochastic errors capture, among other things, variations in contraceptive failures as well as differences in fecundity. Unwanted births, or involuntary infecundity, will induce quality responses through the effects on the shadow price of quality.

As noted, Q is not observed whereas its determinants included in the X-vector are (at least through proxy variables). Substitute, therefore, Eq. (7) into Eq. (8), to obtain a "quasi-reduced form",

$$ED = Z\Theta + \tau_1 N + \tau_2 X\gamma + \varepsilon_3^* \qquad (9)$$

where $\varepsilon_3^* = \varepsilon_3 + \tau_2\varepsilon_2$. Assume that $E(\varepsilon_1\varepsilon_3) = E(\varepsilon_2\varepsilon_3) = 0$ but $E(\varepsilon_1\varepsilon_2) < 0$ because of quantity-quality interaction. OLS-estimation of (9) yields

$$\text{plim}(\hat{\tau}_1) = \tau_1 + \frac{E(\varepsilon_3^*\varepsilon_1)}{E(\varepsilon_1^2)} = \tau_1 + \frac{\tau_2 E(\varepsilon_1\varepsilon_2)}{E(\varepsilon_1^2)} \qquad (10)$$

and the estimate of the sibling coefficient will be downward biased because of unobserved quantity-quality interaction through the stochastic errors (assuming $\tau_2 > 0$). Eq. (9) is not easily estimated by using instrumental variables. The candidate instruments are variables in the X-vector, but they are already included in the estimating equation; obviously, identification is not achieved in this case.

The quantity-quality error covariance is not directly estimable, but its sign can be determined if specific assumptions about the value of τ_1 are imposed. We estimate, therefore, a reduced form equation for educational attainment,

$$ED = Z\Theta + \tau_1 X\beta + \tau_2 X\gamma + \varepsilon_3^{**} \tag{11}$$

where $\varepsilon_3^{**} = \varepsilon_3 + \tau_1\varepsilon_1 + \tau_2\varepsilon_2$. We have

$$E(\varepsilon_1\varepsilon_3^{**}) = \tau_1 E(\varepsilon_1^2) + \tau_2 E(\varepsilon_1\varepsilon_2) \tag{12}$$

or

$$\tau_2 E(\varepsilon_1\varepsilon_2) = E(\varepsilon_1\varepsilon_3^{**}) - \tau_1 E(\varepsilon_1^2) \tag{13}$$

An estimate of the sign of (13) - conditional on τ_1 - is obtained via estimated covariances and variances, i.e., $E(\hat{\varepsilon}_1\hat{\varepsilon}_3^{**})$ and $E(\hat{\varepsilon}_1^2)$. The τ_1-coefficient is negative by assumption; hence, the last term in (13) is positive, and a necessary, although not sufficient, condition for an estimated negative quantity-quality covariance is that $E(\hat{\varepsilon}_1\hat{\varepsilon}_3^{**}) < 0$. We know that $E(\hat{\tau}_1)$ will have a negative bias, which in turn produces an upward bias in the estimated quantity-quality covariance. Although no formal test is offered, we can conclude that an estimated non-positive sign of (13) indicates a negative sign of $E(\varepsilon_1\varepsilon_2)$.

Our empirical analysis will include estimations of equations for fertility demand and educational attainment. The latter is estimated in two forms, corresponding to Eqs. (9) and (11) above. We can thereby provide evidence on the sign of the quantity-quality error covariance. By estimating Eq. (9), a fertility coefficient is obtained that reflects the sibling effect (τ_1) as well as the effect arising from negative error covariances.

4 EMPIRICAL ANALYSIS

4.1 Variables and Data

The data analyzed are from the Swedish Level of Living Surveys of 1974. We will explore the determinants of educational attainment among the respondents and the determinants of fertility among the respondents' parents. The sample was restricted to those (i) whose parents were Swedish citizens at date of birth, (ii) who had no serious health problem among family members during their childhood, and (iii) who were brought up in a family with both biological parents.

The three dependent variables of interest are number of children (N), years of schooling (S) and level of education (EL_j, $j = 1, ..., 7$). The assumption is that years of schooling and educational level have partly separate effects on wage rates. For example, a higher level of education at a given number of years of schooling will on average yield a higher return to market work.

For obvious reasons, the sample is such that only parents with at least one child are included. This restriction may lead to problems of estimating the fertility equation if self-selection into voluntary childlessness is important. We doubt that this is the case during the periods under investigation (primarily the last decades of the 19th and the first half of the 20th century).

The educational levels are represented by a number of dummy variables:

EL_1 = basic compulsory six or seven year education (folkskola)

EL_2 = vocational education for at least one year in addition to EL_1

EL_3 = junior high school (realexamen, grundskola, högre folkskola, flickskola, folkhögskola)

EL_4 = vocational education for at least one year in addition to EL_3

EL_5 = high school (studentexamen)

EL_6 = vocational education for at least one year in addition to EL_5

EL_7 = university degree.

A conceivable procedure is to estimate separate equations for years of schooling and level of education. The latter variable, however, is represented by 7 binary variables, which at least makes the estimation problem non-trivial. We have adhered to a simpler approach and formed a new composite variable for educational level. This is derived from an estimated earnings function, which makes the natural logarithm of the wage rate a function of, inter alia, years of schooling, level of education, years of work experience and work experience squared, i.e.,

$$\ell n\ W_i = \alpha_0 + \alpha_1 S_i + \sum_{j=2}^{7} \alpha_j EL_{ij} + \alpha_8 EXP_i +$$

$$\alpha_9 EXPSQ_i + u_i \qquad (14)$$

where W_i is the ith individual's wage rate, S_i is years of schooling, EL_{ij} is education level j, EXP_i is years of work experience, $EXPSQ_i$ is work experience squared and u_i is a stochastic error. The maintained hypothesis is that $E(\varepsilon_3^* u) = 0$.[2]

The estimated wage equation can be used to compute the expected wage at labor market entry for each individual. This is given as

$$\ell n\ \hat{W}_{0i} = \hat{\alpha}_0 + \hat{\alpha}_1 S_i + \sum_{j=2}^{7} \hat{\alpha}_j EL_{ij} \qquad (15)$$

Turning next to the exogenous variables affecting fertility and educational attainment, we have used age (a cohort variable), sex, and dummies for father's education, mother's education, father's occupation and type of location. The reference group has six or seven years of education. The other education levels are as follows:

(i) education level 1 - vocational high school;
(ii) education level 2 - junior high school (realskola);
(iii) education level 3 - high school or higher education.

As is seen, information on parents' education is less detailed than information on education among the children.

Type of locality measures the degree of urbanization of the place in which the individual grew up (countryside, small community, small town, moderately large town, or large city). The type of locality variables are related to fixed costs per child for several reasons. First, food and housing have been cheaper in the countryside, (presumably also for non-farmers). Secondly, most likely there have been substantial differences in contraceptive costs between different type of localities. With increasing accessibility of inexpensive contraceptive technology, the net cost of having an extra child has increased. The hypothesis is that the net cost of contraceptives has been lower in big cities than in the countryside.

Type of locality may also be a candidate variable in the Z-vector, thereby having an effect on educational attainment independent of its effect on parental investment in quantity and quality of children. Variations in costs of education are to a large extent related to the accessibility of education within a given distance. Educational investments will seldom require simultaneous migration decisions for persons in big cities - but quite often so for individuals in the countryside. The latter are thereby facing higher pecuniary as well as psychic costs of education.

The parents' education and father's occupation capture the family's economic resources (full income). Education is also a proxy for the value of time, which is of crucial importance for time use and fertility decisions. For example, women with higher education are likely to spend more time in the labor market at the expense of time-intensive child care activities.

4.2 Estimation

Table 1 shows the estimated earnings function. In addition to education and work experience we have included controls for marital status, sex and living in a big city. An important issue is whether the various family background characteristics have effects on wage rates in addition to their effects on education. We tried to detect such influences by including parents' education, father's occupation, etc., in the wage equation. In almost all cases the estimated coefficients for background characteristics were insignificant and small. Our tentative conclusion, therefore, is that family background effects on earnings inequality are transmitted primarily through educational achievement.[3]

We can note that the coefficient for years of schooling is somewhat smaller than what is commonly found in basic earnings functions without education levels included. The average wage rate for a person with a university degree (EL_7) - and three years of studies at the university - is around 30 percent higher than the wage rate for a person with high school (EL_5).

The estimated educational coefficients are used to predict wage rates at labor market entry according to Eq. (15). However, we run separate regressions for the "years-variable" ($\hat{\alpha}_1 S$) and the "level-variable" ($\Sigma\hat{\alpha}_j EL_j$). The analysis is here restricted to individuals who are at least 30 years old in order to avoid problems with a censored dependent variable; in other words, we prefer a sample that essentially includes those who have completed their basic formal education. The re-

Table 1 **The estimated earnings function**
Dependent variable: ℓn (1974 wage).
(t-ratios in parentheses)

	(1)	(2)
Constant	6.995 (164.4)	7.004 (156.3)
Married	0.039 (2.505)	0.039 (2.504)
Woman	-0.199 (-14.65)	-0.199 (-14.56)
Big city	0.052 (3.585)	0.051 (3.522)
Experience	0.024 (12.73)	0.024 (12.72)
$(\text{Experience})^2/1000$	-0.397 (-10.51)	-0.396 (-10.46)
Schooling	0.023 (4.882)	0.022 (4.821)
EL_2	0.074 (3.239)	0.074 (3.211)
EL_3	0.055 (2.027)	0.053 (1.945)
EL_4	0.115 (3.950)	0.114 (3.900)
EL_5	0.169 (4.026)	0.167 (3.968)
EL_6	0.225 (4.854)	0.224 (4.825)
EL_7	0.359 (6.576)	0.359 (6.572)
Number of children	-	-0.002 (-0.663)
R^2	0.379	0.379
Sample size	1719	1719

Note: The sample includes workers reported as employed in the Level of Living Survey of 1974 and who participated also in the 1968-survey (irrespective of labor force status in 1968). The wage rate is earnings per hour in Swedish Öre.

sults are displayed in Table 2. Male-female differences in educational achievements are controlled for by an intercept dummy. As is clear from estimates given in an Appendix, there is no marked sex-differences with respect to the slope coefficients.

It should be emphasized that the family background characteristics we have used are rather rough measures of parental resources. Parents' education, for example, are represented by crude dummy variables where the highest level includes high school (gymnasium) and university education. Nevertheless, the explanatory variables appear to account for a substantial part of the variation in educational attainment.

Of primary interest is the coefficient for the number of children. There is no obvious functional form; it turned out that a logarithmic term produced a somewhat better fit than a linear function, which might reflect economies of scale in child care. As is seen, the fertility variable is highly significant and with the expected negative sign. It appears as if children's educational attainment is decreasing, at a decreasing rate, with the number of siblings in the family. The partial wage effect at $N = 2$ is 1 percent. Table 3 gives a more detailed picture of the implications of the estimates. It turns out that individuals from five-children families receive 2 percent lower entry wages than persons from two-children families.

Among other results, it can be noted that children's education is strongly influenced by parents' education and father's occupation. The

Table 2 The determinants of educational attainment, ("quasi-reduced form")

(t-ratios in parentheses)

	Equation for years of schooling ($\hat{\alpha}_1 S$) (1)	level of education ($\Sigma\hat{\alpha}_j EL_j$) (2)	Total effect (1)+(2) (3)	Change in years of schooling (4)
Constant	0.256 (47.46)	0.110 (16.63)		
Age	-0.001 (-15.55)	-0.001 (-11.19)	-0.002	-0.062
Woman	-0.008 (-3.747)	0.014 (-5.083)	-0.022	-0.0374
ℓn (Number of children)	-0.010 (-5.363)	-0.011 (-4.752)	-0.021	-0.459
<u>Parents' education:</u>				
Educ.level 1, father	0.020 (4.310)	0.022 (3.814)	0.042	0.895
Educ.level 2, father	0.042 (7.429)	0.052 (7.492)	0.094	1.850
Educ.level 3, father	0.042 (5.416)	0.047 (4.945)	0.089	1.869
Educ.level 1, mother	0.017 (2.539)	0.018 (2.152)	0.035	0.768
Educ.level 2, mother	0.050 (8.537)	0.054 (7.537)	0.104	2.204
Educ.level 3, mother	0.062 (6.393)	0.078 (6.494)	0.140	2.769
<u>Father's occupation:</u>				
Unskilled blue-collar worker	-0.004 (-1.194)	-0.007 (-1.536)	-0.011	-0.191
Skilled blue-collar worker	0.005 (1.466)	0.002 (0.399)	0.007	0.232
Lower level white-collar worker	0.025 (5.680)	0.025 (4.505)	0.050	1.128
Upper level white-collar worker	0.049 (5.616)	0.064 (5.192)	0.113	2.197

Table 2 (cont.)

	(1)	(2)	(3)	(4)
Self-employed, no employees	0.001 (0.151)	-0.006 (-0.870)	-0.005	0.037
Self-employed, with employees	0.035 (7.058)	0.031 (5.109)	0.066	1.536
Type of locality during childhood:				
Small community	0.005 (1.658)	0.007 (1.817)	0.012	0.242
Small town	0.004 (0.774)	0.003 (0.463)	0.007	0.178
Middle sized town	0.025 (6.495)	0.019 (4.063)	0.044	1.124
Big city	0.025 (5.515)	0.016 (2.864)	0.041	1.090
R^2	0.423	0.348		
Sample size	2425	2425		

Note: The reference groups are: parents' education - compulsory six- or seven-year school (folkskola); father's occupation - farmer or blue-collar worker with small farm; type of locality - countryside.

Table 3 Fertility and children's education

Number of children	Change in ℓn entry wage rate	Change in years of schooling
1	0	0
2	-0.015	-0.32
3	-0.023	-0.50
4	-0.029	-0.64
5	-0.034	-0.74
6	-0.038	-0.82
7	-0.041	-0.89
8	-0.044	-0.95
9	-0.046	-1.01
10	-0.048	-1.06

estimates imply, for example, that children of more highly educated parents (education level 3) and with a father in an upper level white-collar occupation, receive 37 percent higher wage rates than children from an unskilled blue-collar worker family where the parents only have six or seven years of schooling.

We next turn to estimates of reduced form equations for fertility and educational attainment, with the latter concept represented by the composite variable for years of schooling and level of education (i.e. $\ln \hat{W}_{0i}$). As before, the sample is restricted to individuals who are at least 30 years old. The results are displayed in Table 4. Again, the choice of functional form is somewhat arbitrary. The exponential fertility function has the advantage of constraining the predicted number of children to positive values. A comparison of goodness of fit revealed that the two functional forms - linear and exponential - performed just about as well (in terms of accounting for the variation in the number of children).

The sign of the estimated error covariance is of interest for the quantity-quality interaction hypothesis. We find a <u>negative</u> error covariance $E(\hat{\varepsilon}_1\hat{\varepsilon}_3^{**})$ that can be used to compute an estimate of the sign of the quantity-quality error covariance. We have

$$\hat{\tau}_2 E(\hat{\varepsilon}_1\hat{\varepsilon}_2) = E(\hat{\varepsilon}_1\hat{\varepsilon}_3^{**}) - \hat{\tau}_1 E(\hat{\varepsilon}_1^2) \tag{16}$$

which corresponds to Eq. (13) above. Our estimates are: $E(\hat{\varepsilon}_1\hat{\varepsilon}_3^{**}) = -0.0073$, $\hat{\tau}_1 = -0.021$ and $E(\hat{\varepsilon}_1^2) =$

Table 4 **The determinants of fertility and children's educational attainment (reduced form)**
(t-ratios in parentheses)

	Number of children (1)	ℓn (Number of children) (2)	ℓn wage rate at labor market entry (3)
Constant	2.305 (10.26)	0.798 (14.84)	7.344 (663.2)
Age	0.057 (15.05)	0.014 (15.15)	-0.003 (-15.96)
Woman	-	-	-0.023 (-4.771)
<u>Parents' education:</u>			
Educ.level 1, father	-0.582 (-2.817)	-0.116 (-2.349)	0.045 (4.463)
Educ.level 2, father	-0.391 (-1.575)	-0.100 (-1.693)	0.095 (7.963)
Educ.level 3, father	0.236 (0.688)	0.086 (1.043)	0.087 (5.268)
Educ.level 1, mother	-0.664 (-2.208)	-0.186 (-2.577)	0.039 (2.704)
Educ.level 2, mother	0.007 (0.029)	0.059 (0.966)	0.102 (8.226)
Educ.level 3, mother	-0.451 (-1.046)	-0.086 (-0.831)	0.142 (6.812)
<u>Father's occupation:</u>			
Unskilled blue-collar worker	-0.191 (-1.201)	-0.057 (-1.502)	-0.010 (-1.281)
Skilled blue-collar worker	-0.508 (-3.232)	-0.134 (-3.568)	0.010 (1.299)
Lower level white-collar worker	-0.764 (-3.882)	-0.227 (-4.819)	0.055 (5.785)
Upper level white-collar worker	-0.884 (-2.269)	-0.199 (-2.138)	0.118 (6.256)

Table 4 (cont.)

	(1)	(2)	(3)
Self-employed, no employees	-0.552 (-2.245)	-0.161 (-2.730)	-0.002 (-0.136)
Self-employed, with employees	-0.743 (-3.434)	-0.183 (-3.527)	0.069 (6.631)
Type of locality during childhood:			
Small community	-0.375 (-2.581)	-0.092 (-2.643)	0.015 (2.105)
Small town	-0.497 (-2.169)	-0.112 (-2.045)	0.009 (0.848)
Middle sized town	-0.798 (-4.654)	-0.201 (-4.896)	0.049 (5.927)
Big city	-1.200 (-6.158)	-0.331 (-7.096)	0.047 (5.028)
R^2	0.169	0.179 (0.163)*	0.397
Sample size	2425	2425	2425

Note: The reference categories are the same as in Table 2. R^2 in parentheses in column (2) measures explained variation in the number of children and is computed as:

$$R^{*2} = 1 - \frac{\Sigma[N - \exp(\widehat{\ell nN})]^2}{\Sigma(N-\bar{N})^2}$$

0.339. Hence, the estimated quantity-quality error covariance is negative $(\hat{\tau}_2 E(\hat{\varepsilon}_1 \hat{\varepsilon}_2) = -0.0002)$. Given the downward bias of $E(\hat{\tau}_1)$, this result does indeed corroborate the conjecture of a negative sign of the correlation between the "true" errors. This can be interpreted as an additional piece of evidence in favor of the quantity-quality interaction hypothesis, given that errors in the fertility equation to a large extent are due to "exogeneous" events (contraceptive failures, infecundity etc.).

A few comments are in order regarding the fertility equation. The type of locality variables have coefficients that indicate a clear effect of urbanization on fertility; families in the countryside have on average (at least) one child more than families in big cities. This pattern is consistent with the relative price hypothesis suggested above. There is also some evidence for an inverse correlation between fertility and the father's occupational position, indicating a negative relationship between income and the demand for the number of children. Of course, the occupational dummies are very crude proxies for income, and interpretations of the results should be made cautiously.[4]

4.3 Other Issues: Birth Order, Spacing and Structural Shifts

An inverse correlation between birth order and the children's mental achievement shows up in many psychological studies. An interpretation in terms of life cycle changes in the production of child quality is conceivable and has been put forward by, e.g., Razin (1980). The basic idea is that the well-being of a child is closely related to the amount of time allocated to it by its parents. The lower the birth order of a child, the longer he or she receives benefits from child rearing.

The birth order isssue is related to the question of spacing of children. If child quality is an increasing function of parental time in child care, we would expect that longer birth intervals will improve child quality. We have used one variable to explore this possibility, the distance (in years) to the closest sibling.

Table 5 displays results of testing for effects of several variables capturing sibling position. Birth order as well as only child have coefficients with negative signs but they are always close to zero and far from significant. Interestingly, the spacing variable has a significant positive coefficient, holding total number of children constant. Siblings born six years apart appear to receive a schooling advantage that corresponds to a wage premium of 2 percent, compared to siblings born only one year apart. The coefficient for the number of children increases somewhat (in absolute value) when the spacing variable is included.

Table 5 **Effects of Birth Order and Spacing on Children's Educational Attainment**

Dependent variable: ℓn wage rate at labor market entry

	(1)	(2)	(3)	(4)	(5)
ℓn (Number of children)	-0.021 (-4.004)	-0.024 (-4.494)	-0.023 (-3.456)	-0.028 (-5.025)	-0.027 (-2.944)
Birth order	-0.00034 (-0.220)		-0.00010 (-0.065)		-0.00012 (-0.074)
Only child		-0.0066 (-0.602)	-0.0064 (-0.564)	-0.0079 (-0.726)	-0.0077 (-0.681)
Distance to closest sibling (years)				0.0045 (2.411)	0.0045 (2.411)

Note: Additional regressors are those given in Table 4 above.

We have also explored possible structural shifts in the equation for educational attainment. The question is whether education among younger cohorts is less dependent on family background characteristics, which would be the case if social mobility has increased over time. We divided the sample in two categories: "middle-aged" individuals of age 30-49 and "older" persons of age 50 or more, and run separate regressions for the two sub-samples, checked for (dis)similarities in the estimated coefficients and tested for changes in the coefficients. Results for the sub-sample regressions are given in the Appendix. The coefficients on background variables did not show marked changes in any unambiguous direction. In fact, no single coefficient on parents' education, father's occupation or type of locality was significantly different, at conventional levels, across the two cohort groups. The fertility coefficient was virtually the same.

The data set contains some information on labor force behavior among the respondents' mothers. We appended two dummies to the equation for (total) educational attainment representing (i) market work during most years of the respondent's childhood, or (ii) market work during shorter periods. The first variable had a <u>positive</u> coefficient with a t-ratio at 2.0, whereas the second variable had a negative but insignificant coefficient. The fertility coefficient remained basically unchanged when the labor force participation variables were included.

4.4 Other Evidence

Several U.S. studies on earnings and education have included number of siblings as a family background variable. One example is Datcher (1981), who explores race/sex differences in the effects of background on education and earnings. Her education analysis includes a schooling equation similar to our specification: years of education is explained by father's education, mother's education, father's occupation, type of location during childhood and number of siblings. The sibling-coefficients have negative signs in 7 out of 8 investigated subgroups. For whites, the mean value of the estimated coefficients is -0.18, which is not far away from our estimates on Swedish data; the results given in Table 2 implies $\partial S/\partial N = -0.15$ for $N = 3$.

Datcher tests for family background effects in the earnings equation, holding education (and work experience) constant. Most background coefficients are insignificant. A basic conclusion is the "the effects of background on earnings operate principally through influencing years of schooling. Direct impacts independent of education and other market-valued characteristics have declined over time and now appear to be relatively small for all groups" (Datcher, 1981, p. 388).

Other analysts have attempted to estimate educational production functions. Kenny (1980) focuses on the determinants of cognitive skills among twelfth grade U.S. males in 1960. Students were given a long questionnaire and a battery of tests. The results implied that the number of siblings as well as birth order had a significant and negative impact on test scores.

Another approach involves analyses of expenditures on children. Birdsall (1980) explores data from a family budget study in for major cities of Colombia. The data set includes detailed information on various expenditures by the household, for example, the amount of spending on the children's education. The results (based on OLS- as well as TSLS-estimations) reveal a negative effect of number of children on per-child spending on education.

Leibowitz (1972) reports an investigation of the returns to home investments. A schooling equation is estimated that essentially corresponds to Eq. (8) above; Leibowitz explains years of schooling by parental characteristics, number of siblings and IQ-measures. It turns out that education is negatively related to number of siblings, holding IQ and family background variables constant.

Hill and Stafford (1984) specify and estimate a structural equations model with fertility, child quality and lifetime labor supply as endogeneous variables. A variable capturing the "importance for care of children under age five by the child's mother" was used as proxy for quality. The estimates provided some support for the quantity-quality trade off hypothesis; the fertility variable was estimated with a negative sign in the structural quality equation and the estimated covariance between number of children and care per child was negative.

Lindert (1977) attempts to remove the influence of omitted variables that may be a problem in studies based on cross-sections of individuals from different families; unobserved parental attributes may be correlated with sibling position (family size, birth order and spacing) and omitted variable bias will follow as a consequence. Lindert's study uses information on intrafamily sibling differences in achievement; by this technique it is possible to estimate the importance of birth order and spacing, but not the effect related to completed family size per se. Lindert also uses information from time-use surveys to calculate an index of parental time inputs into children in various sibling positions. The time input index turns out to be a significant determinant of intrafamily schooling differences.

5 CONCLUDING REMARKS

This study is an attempt to quantify the relationship between family size and children's educational achievement in Sweden, using the economic quantity-quality approach to fertility as a guide for the empirical analysis. Other theoretical approaches are, of course, conceivable, including those with less emphasis on purposeful actions on part of the parents. A larger family size is likely to involve a strain on parents' resources irrespective of whether they actually plan for a utility maximizing quantity-quality tradeoff.

The empirical analysis does indeed reveal that a greater number of siblings reduces the schooling level for each child. The estimated coefficients are "small" but highly significant. In fact, the coefficients are fairly close to estimates produced on U.S. data sets. We also provided some support for the "spacing hypothesis"; it appears as if longer birth intervals lead to higher educational attainment among the children. Contrary to several other studies, we found no support for the idea that family size effects primarily capture the importance of birth order.

Our analysis has focused on the children's educational attainment and ignored other welfare measures. Although higher education is associated with higher wage rates, it is likely that family background characteristics - including family size - will be less important for the dispersion in lifetime earnings than for the dispersion in wages at a point in time. For example, persons with higher education will spend fewer years in the labor force. On the other hand, there are presumably also various non-pecuniary benefits from investments in education which will strengthen the basic "cost of sibling" hypothesis.

NOTES

[1] The comparative static properties of quantity-quality models have been investigated by Rosenzweig and Wolpin (1980) as well as Edlefsen (1981).

[2] It might be argued that unobserved ability in the earnings equation will produce an upward bias in the schooling coefficients. Several studies have investigated the importance of this "ability bias" by including scores on IQ-tests as additional regressors in earnings functions. The results are somewhat mixed, but most authors appear to conclude that the "ability bias" is small. (See, Griliches (1977) for a discussion and further references.)

[3] Blomquist (1979) has estimated an earnings function on Swedish data including several family background characteristics as regressors in addition to schooling, educational levels and work experience. Using a somewhat different sample and specification than ours he finds some significant direct family background effects on wage rates.

[4] Bernhardt (1972) studies fertility behavior among Swedish couples who married in the mid 1950s. The relationship between fertility and family income (recorded in 1967) is found to be negative, except at the top end of the scale. A somewhat different picture emerges when fertility is related to husband's income. The relationship then appears "to be more U-shaped, with families in the highest income group having almost the same average family size as those with the lowest incomes." (Berhardt, 1972, p. 178.)

APPENDIX

Table A1 **The determinants of educational attainment among different groups**
Dependent variable: Predicted ℓn wage rate at labor market entry
(t-ratios in parentheses)

	Men	Women	Age 30-49	Age 50-
Constant	7.359 (404.3)	7.341 (554.8)	7.453 (240.8)	7.270 (316.2)
Age	-0.003 (-8.798)	-0.002 (-11.40)	-0.005 (-6.571)	-0.001 (-3.503)
Woman	-	-	-0.028 (-3.329)	-0.018 (-3.419)
ℓn (Number of children)	-0.019 (-2.892)	-0.023 (-4.813)	-0.023 (-3.227)	-0.019 (-4.192)
<u>Parents' education:</u>				
Educ.level 1, father	0.048 (2.982)	0.035 (3.000)	0.035 (2.114)	0.040 (3.520)
Educ.level 2, father	0.105 (5.687)	0.073 (4.941)	0.098 (5.421)	0.077 (4.905)
Educ.level 3, father	0.078 (2.542)	0.090 (5.170)	0.081 (2.971)	0.087 (4.349)
Educ.level 1, mother	0.062 (2.586)	0.007 (0.400)	0.015 (0.660)	0.066 (3.572)
Educ.level 2, mother	0.106 (4.951)	0.102 (7.472)	0.107 (5.954)	0.095 (5.372)
Educ.level 3, mother	0.124 (3.615)	0.156 (6.561)	0.104 (3.193)	0.179 (6.955)

Table A1 (cont.)

	Men	Women	Age 30-49	Age 50-
Father's occupation:				
Unskilled blue-collar worker	-0.002 (-0.201)	-0.019 (-2.132)	-0.021 (-1.523)	-0.004 (-0.538)
Skilled blue-collar worker	0.013 (1.096)	0.001 (0.144)	-0.002 (-0.173)	0.012 (1.490)
Lower level white-collar worker	0.046 (3.036)	0.059 (5.183)	0.047 (2.800)	0.055 (5.246)
Upper level white-collar worker	0.155 (4.792)	0.080 (3.844)	0.116 (3.535)	0.118 (5.608)
Self-employed, no employees	-0.004 (-0.190)	-0.008 (-0.605)	-0.028 (-1.350)	0.014 (1.053)
Self-employed, with employees	0.054 (3.235)	0.080 (6.443)	0.056 (3.172)	0.078 (6.517)
Type of locality during childhood:				
Small community	0.014 (1.256)	0.011 (1.396)	0.021 (1.670)	0.004 (0.563)
Small town	0.018 (1.010)	-0.001 (-0.096)	0.033 (1.616)	-0.009 (-0.797)
Middle sized town	0.054 (3.860)	0.032 (3.443)	0.056 (4.121)	0.027 (2.661)
Big city	0.049 (3.175)	0.033 (2.953)	0.034 (2.132)	0.048 (4.426)
R^2	0.365	0.475	0.338	0.389
Sample size	1225	1200	1104	1321

Note: The reference categories are the same as in Table 2.

REFERENCES

Becker, G.S. (1981), A Treatise on the Family, Massachusetts, Cambridge: Harvard University Press.

Becker, G.S. and Lewis, H.G., (1973), "On the Interaction Between the Quantity and Quality of Children", Journal of Political Economy 81, 279-288.

Bernhardt, E.M., (1972), "Fertility and Economic Status - Some Recent Findings on Differentials in Sweden", Population Studies XXVI, 175-184.

Birdsall, N., (1980), "A Cost of Siblings: Child Schooling in Urban Columbia". In J.L. Simon and J. DaVanzo (eds.) Research in Population Economics 2, Connecticut, Greenwich: JAI Press.

Blomquist, N.S., (1979), "Wage Rates and Personal Characteristics", Scandinavian Journal of Economics 81, 505-520.

Datcher, L.P., (1981), "Race/Sex Differences in the Effects of Background on Achievement". In M.S. Hill, D.H. Hill and J.N. Morgan (eds.) Five Thousand American Families - Patterns of Economic Progress, IX, Ann Arbor.

Edlefsen, L.E., (1981), "The Comparative Statics of Hedonic Price Functions and Other Nonlinear Constraints", Econometrica 49, 1501-1520.

Griliches, Z., (1977), "Estimating the Returns of Schooling: Some Econometric Problems", Econometrica 45, 1-21.

Hill, C.R. and Stafford, F.P., (1984), "Lifetime Fertility, Child Care, and Labor Supply". In F.T. Juster and F.P. Stafford (eds.) Time, Goods and Well-Being, Ann Arbor.

Kenny, L.W., (1980), "The Effects of Family and School upon Cognitive Achievement". In J.L. Simon and J. DaVanzo (eds.) Research in Population Economics 2, Connecticut, Greenwich: JAI Press.

Leibowitz, A., (1974), "Home Investments in Children", Journal of Political Economy 82, 111-131.

Lindert, P.H., (1977), "Sibling Position and Achievement", Journal of Human Resources XII, 198-219.

Razin, A., (1980), "Number, Spacing and Quality of Children: A Micro-Economic Viewpoint". In J.L. Simon and J. DaVanzo (eds.) Research in Population Economics 2, Connecticut, Greenwich: JAI Press.

Rosenzweig, M.R. and Wolpin, K.I., (1980), "Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment", Econometrica 48, 227-240.

Walldén, M., (1982), "Sibling Position and Mental Capacity", University of Stockholm, Department of Sociology, Research Report No. 20, Project Metropolitan.

WORKING PAPERS (Missing numbers indicate publication elsewhere)

1976

1. Corporate and Personal Taxation and the Growing Firm
by Ulf Jakobsson

8. Estimation and Analysis with a WDI Production Function
by Göran Eriksson, Ulf Jakobsson and Leif Jansson

1977

15. Pay Differentials between Government and Private Sector Employees in Sweden
by Siv Gustafsson

1980

25. On Unexplained Price Differences
by Bo Axell

34. Imperfect Information Equilibrium, Existence, Configuration and Stability
by Bo Axell

1981

36. Energi, stabilitet och tillväxt i svensk ekonomi (Energy, Stability and Growth in the Swedish Economy)
by Bengt-Christer Ysander

38. Utiliy in Local Government Budgeting
by Bengt-Christer Ysander

40. Wage Earners Funds and Rational Expectations
by Bo Axell

42. The Structure of the ISAC Model
by Leif Jansson, Tomas Nordström and Bengt-Christer Ysander

43. An Econometric Model of Local Government and Budgeting
by Bengt-Christer Ysander

44. Local Authorities, Economic Stability and the Efficiency of Fiscal Policy
by Tomas Nordström and Bengt-Christer Ysander

45. Growth, Exit and Entry of Firms
by Göran Eriksson

56. Central Control of the Local Government Sector in Sweden
by Richard Murray

59. Longitudinal Lessons from the Panel Study of Income Dynamics
by Greg J. Duncan and James N. Morgan

1982

61. Var står den nationalekonomiska centralteorin idag?
av Bo Axell

63. General Search Market Equilibrium
by James W. Albrecht and Bo Axell
General Equilibrium without an Auctioneer
by James W. Albrecht, Bo Axell and Harald Lang

64. The Structure and Working of the ISAC Model
by Leif Jansson, Thomas Nordström and Bengt-Christer Ysander

65. Comparative Advantage and Development Policy Twenty Years Later
by Anne O. Krueger

67. Computable Multi-Country Models of Production and Trade
by James M. Henderson

69. Relative Competitiveness of Foreign Subsidiary Operations of a Multinational Company 1962-77
by Anders Grufman

71. Technology, Pricing and Investment in Telecommunications
by Tomas Pousette

72. The Micro Initialization of MOSES
by James W Albrecht and Thomas Lindberg

75. The MOSES Manual
by Fredrik Bergholm

76. Differential Patterns of Unemployment in Sweden
by Linda Leighton and Siv Gustafsson

77. Household Market and a Nonmarket Activities (HUS)
- A Pilot Study
by Anders Klevmarken

1983

79. Energy Prices, Industrial Structure and Choice of Technology; An International Comparison with Special Emphasis on the Cement Industry
by Bo Carlsson

81. ELIAS - A Model of Multisectoral Economic Growth in a Small Open Economy
by Lars Bergman

84. Monopoly and Allocative Efficiency with Stochastic Demand
by Tomas Pousette

86. The Micro (Firm) Foundations of Industrial Policy
by Gunnar Eliasson

87. Excessive Government Spending in the U.S.: Facts and Theories
by Edward M. Gramlich

88. Control of Local Authority Expenditure - The Use of Cash Limits
by Noel Hepworth

89. Fiscal Containment and Local Government Finance in the U.K.
by Peter Jackson

90. Fiscal Limitations: An Assessment of the U.S. Experience
by Wallace E. Oates

91. Pricing and Privatization of Public Services
by George E. Peterson

94. Job Mobility and Wage Growth:
A Study of Selection Rules and Rewards
by Bertil Holmlund

96. The Machine Tool Industry - Problems and Prospects in an International Perspective
by Bo Carlsson

97. The Development and Use of Machine Tools in Historical Perspective
by Bo Carlsson

99. An Equilibrium Model of Search Unemployment
by James W. Albrecht and Bo Axell

100. Quit Behavior under Imperfect Information: Searching, Moving, Learning
by Bertil Holmlund and Harald Lang

102. Collecting Data for Micro Analysis.
Experiences from the Hus-Pilot Study
- by N. Anders Klevmarken

103. The Swedish Micro-to-Macro Model
- Idea, Design and Application
by Gunnar Eliasson

105. Estimation of Wage Gains and Welfare Gains from
Self-Selection Models
by Anders Björklund and Robert Moffitt

106. Public Policy Evaluation in Sweden
by Bengt-Christer Ysander

108. Entry, Industry Growth and the Microdynamics
of Industry Supply
by John C. Hause and Gunnar Du Rietz

112. Schumpeterian Competition in Alternative Technological
Regimes
by Sidney Winter

113. The Industrial Finance Systems; Europe, U.S. and Japan
by Tad Rybczynski

117. Micro Heterogeneity of Firms and the Stability of Industrial
Growth
by Gunnar Eliasson

118. The Initialization Process - The Moses Manual, Part 2
by Fredrik Bergholm

1984

119. Forestalling the Demise of Empirical Economics: The Role
of Microdata in Labor Economics Research
by Frank Stafford

120. Unemployment and Mental Health - Some Evidence from
Panel Data
by Anders Björklund

121. Comparative Keynesian Dynamics
by Richard H. Day

122. The Firm and Financial Markets in the Swedish
Micro-to-Macro Model (MOSES)
- Theory, Model and Verification
by Gunnar Eliasson

123. What Can Be Learned from the Chrysler Experience?
by Frank Stafford

125. Estimates of Bounds for Export Price Elasticities
in an Underidentified Simultaneous Two Equation System
by Eva Christina Horwitz

126. An Easy Fixup of the Flaw in Lucas' "Neutrality of Money"
by Harald Lang

127. Comment on Feldstein and Poterba's "Unemployment Insurance and Reservation Wages"
by Harald Lang

128. Information Criterion and Estimation of Misspecified Qualitative Choice Models
by David Brownstone

129. Organisation och styrsystem i ett modernt storföretag
av Gunnar Eliasson

130. Fertility and the Opportunities of Children: Evidence on Quantity-Quality Interactions in Sweden
by Bertil Holmlund