ECONOMIC GROWTH CENTER

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New Haven, Connecticut 06520

CENTER DISCUSSION PAPER NO. 604

FERTILITY IN RURAL SUDAN:

THE EFFECT OF LANDHOLDING AND CHILD MORTALITY

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July 1990

Notes: This research was supported by The Rockefeller Foundation.

Center Discussion Papers are preliminary materials circulated to stimulate discussion and critical comments.

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ABSTRACT

This paper analyzes the response of fertility to child mortality and landholding of the agricultural household in rural Sudan. The micro-economic framework of fertility behavior is used as a basis for the analysis of a demand function for children. Because child mortality is more likely to be correlated with both the biological and behavioral determinants of fertility, Two Stage Least Squares are used to estimate the parameters of the demand equation for children. Ordinary Least Squares estimates are also presented. Two equations are estimated using the method of Two Stage Least Squares. In one equation the cross-sectional mortality rate is used as an instrumental variable for child deaths. In the other a regional health variable is used to identify the demand function. The results indicate that fertility responds positively to child mortality and that the replacement response to child deaths is less than unity which indicates that a given percentage decline in child mortality is expected to be partially offset by a reduction in fertility. Also fertility responds positively and inelastically to cultivated land. The effect of some other socio-economic variables on the demand for births is also discussed.

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1. INTRODUCTION

The purpose of this paper is to investigate the extent of the effect of access to land and child mortality on fertility in rural Sudan. Knowledge of the first effect is important because the agricultural development policy in the Sudan has been characterized by an emphasis on the expansion and improvement of cultivable land. This has been achieved mainly by investment in irrigation and that has led to considerable increase in the level of employment and income of the rural population. Regarding child mortality, the evidence from many low-income countries indicates a positive relationship between mortality and fertility.[1] Child mortality is very high in Sudan where for the whole country it is estimated at a rate of .18 and it equals .19 for the rural areas[2] (Rizgalla, 1987). Nonetheless, the extent to which child mortality influences farm household fertility has not been assessed in Sudan.

The relationship between access to land and fertility has been treated from two different dimensions in the literature. One is access to land use and the other is access to ownership. The empirical findings reveal that land use as measured by size of operational holding is positively and significantly related to fertility, whereas access to ownership exhibits a negative connection (see for example Rosenzweig and Evenson (1977), Stokes *et al.* (1983) and Schutjer *et al.* (1990)). It has been hypothesized that the former relationship represent price and income effects because families with large areas of land could use additional areas of land more profitably and thus confront a lower cost of children. The underlying assumption here is that the income effect of a lower cost of children on the demand for the latter is positive (thus ruling out inferiority) and reinforces the unambiguous price effect that induces an increase in the demand. Regarding the second effect, it could be argued that land ownership substitutes for children as a source of parental security in old age and contributes to lower fertility. However this effect could be reflecting the effect of schooling, hence high cost of children, and female education by landowners on the number of children. Rosenzweig and Evenson (1977) found that land inequality is positively and significantly related to school enrollment rates of children. Schutjer *et al.* (1980) conclude that the total effect of land ownership was to reduce fertility through its influence on female education. Studies in many areas of rural Sudan reveal that children contribute substantially to their families by directly engaging in farm

I am grateful for the many helpful suggestions of T. Paul Schultz and Robert E. Evenson.

production from an early age of their life, or by sending remittances when they are employed in the urban areas. Indeed farming and nomadic households in rural Sudan have relied mainly on their own family labor where that of their children constituted a large part (Galal eldin, 1977).

It has been hypothesized that fertility responds to mortality in two different ways: a replacement *ex post* and an expectation *ex ante* or hoarding response (Ben-Porath, 1980; Lee and Schultz, 1982). Assuming that the birth and death of a child is predictable and that there is no biological constraints on the supply of children, the first response arises as parents tend to offset the death of a child in order to attain a certain number of surviving children. When uncertainty regarding mortality and biological constraints on life time production are important, the occurrence of a death or the expectation that such a death might occur would induce parents to adopt a hoarding strategy to attain their goal of a given number of surviving children. In this cross-section analysis, it is presumed that child mortality is a random variable and hence the effect of the latter on fertility measures a replacement response. From the point of view of development policy that may impact on child mortality, it is imperative to know the rate at which parents tend to replace their children.

The rest of this paper is as follows. Section 2 offers some of the theoretical considerations relating to the demand for children and in Section 3 the data, estimating problems and methods are discussed. In Section 4 we present the empirical results. A conclusion and some of the implications of the exercise are found in Section 5.

2. THEORETICAL CONSIDERATIONS

In the household production model, the number of children is represented as a demand function of the wife's and husband's wage rate, non-labor income and prices. Since children are wife's time intensive, the theory predicts that an increase in the wife's wage would have an inverse repercussion on the demand for children given that the substitution effect dominates the income effect. The effect of an increase in husband's wage rate cannot be signed *a priori* and hence either a positive or negataive effect is expected. In the context of high income countries the price variables were found to explain a large proportion of variation in fertility. Because of the difficulty of measuring the wage variables, particularly for women who are not in the labor force, education is taken as a proxy for the wage rate. Empirical studies have found that the regression coefficient on women's education tends to be negative as expected and significant, while the regression coefficient on men's education coefficient is smaller in absolute magnitude and generally less significant statistically (Schultz, 1973).

In the low-income countries, particularly in rural areas, other factors need to be stressed in explaining variation in fertility. Caldwell (1982) argues that large family size is economically justified given the social structure of inter-generational wealth transfer flows from children to parents. Caldwell thus recognizes the importance of the economic contribution of children in these societies. Rosenzweig and Evenson (1977) postulate a neoclassical household model in a rural low-income country in which utility is defined over the number of children Z_n, education of children Z_e, leisure Z_ℓ and a composite commodity Z_s. The model implies a reduced-form demand equation of the form:

$$Z_n = f(W_f, W_m, W_c, L, P_{xn}) \tag{1}$$

where W_f and W_m are the wife's and husband's wage rate, respectively, W_c is the wage rate for children, L is a vector of agricultural inputs which are positively associated with the marginal pecuniary contribution of children, e.g. land, and P_{xn} is the price of child input x. The partial derivatives $\frac{\partial Z}{\partial W_i}$ can be signed under certain assumptions. Assuming that Z_e, Z_ℓ are substitutes for Z_n and Z_e, Z_ℓ are complements then (i) if children are mother's time intensive goods it can be shown that $\frac{\partial Z_n}{dW_f} < 0$, i.e. an increase in the value of time of mother reduces the demand for children, (ii) an exogenous increase in the husband's wage rate is expected to increase fertility given that father's time intensity in rearing of children is lower than that on other commodities produced by the household and (iii) an increase in child wage rate is expected to encourage increases in family size since it decreases the shadow price of children, i.e. $\frac{\partial Z_n}{dW_c} > 0$. If markets for child labor are imperfect, W_c may not reflect the true marginal productivity of child labor and sometimes might not be observed because of absence of such monetized markets. Under such conditions the marginal contribution of children $\tilde{W}$ would be determined by the vector of the family agricultural inputs L, such that $\tilde{W}_c = \psi(L)$, $\psi' > 0$ and thus $\frac{\partial Z_n}{\partial L} > 0$.

To this list of variables child mortality is added as a factor influencing fertility through its effects on the number of surviving children. Mortality increases the expected cost per survivor and hence influences the demand for survivors; it affects the derived demand for births by increasing the number of births required to attain a given number of survivors. Under the assumption that the cost of a survivor is inversely proportional to survival rate, the behavioral demand for births with respect to child mortality can be shown to increase if the elasticity of demand for survivors is less than unity (Schultz, 1976).

One problem which arises from the inclusion of child mortality among the right hand determinants of fertility is whether this variable can be considered as an exogenous variable. The possibility that fertility and child mortality are jointly determined cannot be ruled out as the latter might be influenced by the same factors that affect the number of children, e.g. education of mother, agricultural productivity. However, the causation from fertility to child mortality could be attributed to some biological factors, which is unfortunately not possible to estimate in this paper. For instance, it is argued that a woman who is highly fertile might have shorter-than-average interval between births, other things being equal, which would contribute to early weaning of her children and consequently lead to higher child mortality. Because of this interdependence between fertility and mortality, in order to estimate the fertility equation one should look for an identifying variable that is highly correlated with mortality but does not affect fertility directly. The choice of such variable and method of estimation will be discussed in the next section.

3. DATA, EMPIRICAL SPECIFICATION AND ESTIMATION

Data for the paper are drawn from a random sample of 599 rural agricultural households. The sample covered 26 villages whose population is engaged in production of cash crops (cotton, groundnuts) and staple food crop (sorghum) in Elsuki Scheme.[3] For the analysis of fertility only 523 households were used. The rest were dropped because either the records had some missing variables or fertility and child mortality were reported inconsistently. We also had to exclude women with no births.[4]

In explaining variation of fertility (C) in the sample, other variables beside land cultivated (L1) and child deaths (D) are included among the independent variables. We include the amount of land owned but not cultivated by the household (L2) because of irrigation difficulty, particularly at the tail-ends of the main irrigation canal. We presume that the knowledge that these areas might be cultivated in the future induces a wealth effect in the behavioral demand for children. In order to control for the biological productive supply of the woman, age (A) and age squared (A2) are introduced in the regression. No schooling is observed for the head's wife in the sample, though in most cases some of the children were enrolled or had some years of education. Only the years of schooling of the husband (E) are observed. However we would not interpret the coefficient on husband's schooling as reflecting only that the effect of husband's earnings or value of time on fertility (though educated farmers might be more productive than uneducated ones). Rather we think that more educated farmers demand schooling for their children thereby raising the cost of children and reducing their demand for a large family. Households who are immigrants to the irrigation scheme's area from the indigenous population are distinguished because it is hypothesized that the farmer's fixed endowment of resources (in terms of availability of services, location and wealth) is smaller for the immigrant. A dummy variable (I) which takes the value of one for immigrant and zero otherwise is introduced in the regression analysis for this purpose. The demand equation for fertility which we propose to estimate would therefore take the following form:

$$C_i = a + b_1(A_i) + b_2(A_i2) + b_3(L_i1) + b_4(L_i2) + b_5(E_i) + b_6(I_i) + b_7(D_i) + u_i \,. \qquad (2)$$

Because of simultaneous determination of fertility and child mortality, the error term u and D will be correlated and Ordinary Least Squares (OLS) estimates of b will be biased and inconsistent. Olsen (1980) has shown that OLS estimates of the replacement rate can be corrected for bias under different assumptions regarding the mortality rate.[5] If the variation in the child mortality rate, D/C, across women is assumed to be random and independent of u, Two-Stage Least Squares (TSLS) estimates of (2) can be obtained that are consistent by using the mortality rate as an instrument, since this instrument is highly correlated with child deaths and uncorrelated with u (Olsen, 1980). We will also consider as an identifying restriction a regional dummy variable (R) which we think captures the effect of community-level services of the provision of health facilities and clean water sources. Thus, R takes the value of one if an observation comes from an area where these services are provided and zero otherwise. Regression of child deaths, D, on the rest of the explanatory variables of (2) and R has shown that child mortality is negatively and significantly related to R.[6]

In the simple framework in (2), the response of fertility to child mortality will not be complete, i.e. $0 < b_7 < 1$. So a given percentage decline in child mortality is expected to be partially offset by a reduction in fertility. However, if quality of children is introduced in the optimization process of the household, and if quality is a substitute for quality, then it is possible for a given percentage decline in mortality to lead to a larger decline in quality in order for parents to make more investment in the quality of their offsprings, i.e. $b_7 > 1$. More generally a mortality decline should lead to smaller reductions in quantity when increases in quality per child are more difficult or costly to achieve (O'Hara, 1975).

Table 1 presents the mean and standard deviations of the variables. The mean number of births is 7.16 while the average number of children who died is 1.54 suggesting a child death rate of 0.21 which is close to the national average of child death for the country as a whole (see Rizgalla, 1987). The average age of a wife is 35.4 years. The area of land cultivated by the household is approximately 12 feddans which is lower than average ownership of about 13 feddans as shown in Table 1. The average area not cultivated due to limits on irrigation is about 1.3 feddans.

Table 1. Descriptive Statistics

Variable	Mean (Standard Deviation)	Minimum	Maximum
Children Ever-born	7.161 (3.109)	1.000	17.00
Age of Woman	35.38 (10.21)	18.00	65.00
Age Squared	1356. (795.8)	324.0	4225.
Owned Land	12.96 (7.181)	10.00	80.00
Cultivated Land	11.91 (6.831)	.0000	70.00
Non-cultivated Land	1.281 (3.001)	.0000	20.00
Husband's Education	1.541 (2.203)	.0000	12.00
Child Deaths	1.541 (1.692)	.0000	8.000
Child Mortality Rate	.1813 (.1829)	.0000	1.000
Immigration Dummy	.3308 (.4709)	.0000	1.000
Regional Health Dummy	.5009 (.5005)	.0000	1.000

5. EMPIRICAL RESULTS

Both OLS and TSLS estimates of the fertility equation are presented in Table 2. Two equations are estimated using OLS, in which mortality is measured by the number of child deaths in (1) and by the mortality rate in (2). Two equations are estimated by TSLS, in which the instruments for child mortality are all the exogenous variables in equation (2) and in equation (4) the regional health and sanitation dummy (R) is also added to the list of instruments.

Table 2. Regression Results: Dependent Variable Children Ever-Born

Explanatory Variable	Ordinary Least Square (OLS) (1)	(2)	Two Stage Least Square (TSLS) (3)	(4)
Age of Woman	.5739 (10.75)[a]	.705 (11.19)[a]	.627 (11.39)[a]	.633 (4.37)[a]
Age Squared	-.00623 (-9.30)[a]	-.00759 (-9.74)[a]	-.00678 (-9.76)[a]	-.00712 (-4.74)[a]
Cultivated Land	.0761 (6.34)[a]	.0851 (5.93)[a]	.0786 (6.38)[a]	.0803 (5.57)[a]
Non-cultivated Land	.0501 (1.84)[b]	.0442 (1.36)[c]	.0473 (1.69)[b]	.0454 (1.51)[c]
Immigration Dummy	-1.125 (-5.97)[a]	-1.0413 (-4.59)[a]	-1.000 (-5.16)[a]	-.916 (-2.38)[a]
Husband Education	-.0349 (-.87)	-.0303 (-.63)	-.0249 (-.61)	-.0182 (-.36)
Child Deaths	1.000 (19.61)[a]	--	.734 (12.42)[a]	.556 (.80)
Mortality Rate	--	5.826 (10.65)[a]	--	--
Constant	-6.713 (-6.80)	-9.238 (-7.93)[a]	-7.604 (-7.48)[a]	-8.199 (-3.21)[a]
$\bar{R}^2$	.66	.51		
F(7,515)	144	78	106	78
Sample Size	523	523	523	532

Notes: Figures in parentheses are the t-statistics.

[a]Coefficient statistically significant at 1% level.
[b]Coefficient statistically significant at 10% level.
[c]Coefficient statistically significant at 20% level.

The regression results indicate that most of the variables are significantly related to fertility and explain more than 50% of its variation. Years of education of the husband does not seem to have a significant effect on fertility. However the negative sign could mean that educated fathers might spend more on the education of their children and hence would demand smaller family size. That this effect is not significant is expected in view of the fact that educational attainment of the fathers are very low in the sample. Child mortality and wife's age seem to be the most significant factors influencing fertility. As can be noted from the table the instrumental variable estimate of the replacement effect in equation (2) is lower than the OLS estimate of equation (1). In fact when child deaths are instrumented using R (the health and sanitation dummy) the result as shown in equation (4) indicate that though child deaths induces women to bear more children, the influence is not statistically significant. This might be due to the fact that the health facility variable R influences child deaths marginally.

The amount of land cultivated by the household is positively and highly significantly associated with fertility but the marginal response of the latter to additional units of cultivation is small, approximately .08. This value does not take into consideration the indirect effect on fertility of cultivated land through child deaths. When this effect is taken into account, a higher value of .09 is calculated.[7] Though non-cultivated land exerts a positive effect on fertility, it does not seem to have a significant influence. The results indicate that immigrant household exhibits a lower fertility than non-immigrant ones. As we have seen the estimated equation for child deaths shows that immigrant households to the Scheme suffer from high mortality compared to non-immigrant ones. One reason for this may be the lack of health services in the areas where the immigrant population is concentrated. Other explanations which need further investigation, is the possibility of higher incidence of diseases among the immigrant groups, e.g. malaria or mal-nutrition. The cultural and social values of this group are also such that the women, unlike those of the rest of the population, contribute more to work in the fields, and therefore might lose some of their children through miscarriage because of heavy work.

Table 3. Estimated Elasticity of Fertility with Respect to Cultivated Land and Child Mortality

Explanatory Variable	Ordinary Least Square (OLS) (1)	(2)	Two Stage Least Square (TSLS) (3)	(4)
Cultivated Land	.126	.141	.129	.133
Child Mortality	.215[a]	.153	.158	.199

[a]The corrected OLS estimate of the replacement effect using Olsen correction procedure (Olsen, 1980, pp. 435-36), that is .63, gives an elasticity of .135.

Using Olsen correction method (Olsen, 1980, pp. 435-36), the biased OLS estimate of the replacement response of fertility to child mortality in equation (1), is corrected for the bias giving an estimate equal to .63.[8] Using equation (2) the replacement rate is estimated at 0.71.[9] The simultaneous equation (4) estimate of the replacement rate is .56, but not precisely estimated. Thus these results would indicate a value of the replacement rate of .56-.73.

Point elasticities of fertility with respect to landholding and child mortality are reported in Table 3 using the mean values of the sample. The elasticity of fertility with respect to cultivated land lies between .12 and .14 whereas the child death elasticity is between .12-.16. Using two-stage least squares estimates (3) the landholding elasticity implies that raising the mean cultivable land from 11.9 to 17.9 (50% increase), holding all other variables constant, would raise the mean fertility from 7.16 to 7.62. If the indirect effect of cultivated land, referred to above, is considered one arrives at an elasticity of 0.15. This implies that a 50% increase in cultivable land would raise mean fertility to 7.7. This means that the number of mean surviving children will increase from 5.2 to 6.08. The child mortality elasticity of about .16 implies that reducing mean child death from 1.54 to .77 (by about half) would reduce fertility from 7.16 to 6.28. In this case surviving children will fall from a mean of 5.62 to 5.51.

5. CONCLUSION AND POLICY IMPLICATION

The effect of landholding and child mortality on fertility of agricultural household has been estimated on the basis of a demand function for children. Because of the possibility of joint determination of fertility and child death, two-stage least squares is used to obtain consistent estimates of the coefficients. Two equations are estimated using TSLS. In one child deaths were instrumented on actual mortality rates since the latter are highly correlated with child deaths and are presumed to be independent of the error term in the cross-section analysis. The regression results indicate that women experiencing high child mortality would tend to replace those who die at a rate of .71. However, when a community health and sanitation variable is used to predict child deaths, the results show that fertility is not significantly influenced by child mortality. We attributed this to a weakness in the instrumental variable. This suggest that there is a need to try other identifying variables which are free of individual influence, e.g. control of endemic diseases like malaria.

The positive impact of landholding on fertility is expected since agricultural households depend for their supply of labor to a large extent on their own family. The elasticity of fertility with respect to landholding of 0.15 indicated that raising the mean size of operational holding by 50% would raise mean fertility from 7.16 to 7.7. The elasticity with respect to child mortality, on the other hand, implied that halving the number of child deaths from 1.54 to .77 would reduce mean fertility to 6.26. Government policies designed to influence population could thus induce a decline in fertility by reducing child mortality. However, population might grow faster in the wake of the decline in child mortality, if parents continue to desire the same number of births as before the mortality decline. This need not be so if other social changes accompanied the reduction in mortality. One such change is education. As the data set which we used in this paper revealed, husband's education had an inverse effect on fertility. We attributed this negative impact to the possibility that the educated father is more likely to send his children to school which would raise the cost of their upbringing, reducing the demand for quantity. This result should, however, be treated with caution, since our sample does not allow much variation in this variable due to the lack of educated husbands. The effect of female education, on the other hand, could not be investigated due to the limitation of the data examined. This is a very important issue which needs to be pursued in the future since female education has been found in many low-income countries to have a negative impact on the demand for children. Some further work, therefore, would need to be carried out for Sudan, in order to assess the quantitative impact of female's education on the demand for children.

NOTES

1. Evidence from a number of low-income countries is provided in Schultz (1978). See also Schultz (1976) and Lee and Schultz (1988).

2. The figures refer to the number of children who died before completing the second year of life and they were calculated using the 1973 Population Census data on the number of children ever-born and surviving (see Table 6 in Rizgalla). Rizgalla also found that for the country as a whole 208 out of 1000 live births die before reaching their fifth birthday (Table 4 in Rizgalla).

3. In all public schemes like Elsuki, farmers are considered as tenants. Inheritance rights are allowed but sale, lease or mortgage of land is illegal. In practice, however, lease of land occurs and sale through forfeiting one's title to tenancy is observed.

4. Only three observations in the sample had these characteristics.

5. If the mortality rate P_i is constant across women and $\hat{r}$ is the OLS estimate of the replacement response, Olsen (1980, pp. 435-36) shows that:

$$\text{plim}(\hat{r}) = r + 1/[1 - pr][p + (1 - p)\bar{n}/\text{var}(n)]$$

where n is the number of children born and $\bar{n}$ is the mean. Assuming that the mortality rate is random and independent of n_i :

$$\text{plim}(\hat{r}) = r + 1/[\bar{p} + (1 - \bar{p})\bar{n}/\sigma_n^2] + \sigma_p^2[1 + (\bar{n}^2 - \bar{n})/\sigma_n^2]/\bar{p} .$$

6. The estimated equation of child deaths on the instrumental variables turned out as follows:

$$\underset{(-3.86)}{D = -3.238} + \underset{(4.43)}{0.199\,A} - \underset{(-3.26)}{0.00187\,A2} + \underset{(1.31)}{0.014\,L1} - \underset{(-.45)}{0.0105\,L2} + \underset{(3.36)}{.576\ I} + \underset{(0.95)}{0.0327\,E} - \underset{(-1.78)}{0.273\,R}$$

Sample size = 523, $\bar{R}^2 = .14$, $F(7,515) = 13.51$

(Figures in parentheses are t-statistics.)

7. This indirect effect arises since $C = f(A, A2, L1, L2, E, I, D)$ and $D = f(A, A2, L2, L2, I, E, R)$ and thus: $\frac{dC}{dL1} = \frac{\partial C}{\partial L1} + \frac{\partial C}{\partial C}\frac{\partial D}{\partial L1}$.

8. This is estimated under the assumption that the mortality rate P_i is random and independent of the number of children born n_i since our sample variance of child deaths was found to be over twice as large as predicted with non-random p (see Olsen, 1980, pp. 435-36).

9. If $n_i = \alpha + \gamma p_i$ where $p_i = \frac{d_i}{n_i} = \frac{\text{children dead}}{\text{number of births}}$ then the replacement rate is obtained from an OLS estimate $\hat{\gamma}$ as follows

$$\partial n/\partial d = \hat{\gamma}/[\bar{n} + \hat{\gamma}\bar{p}] ,$$

where $\bar{n}$ and $\bar{p}$ are the average values for the sample from Table 1.

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