IMPACTS OF SOME SOCIO-DEMOGRAPHIC CHARACTERISTICS ON FERTILITY IN URBAN ADDIS ABABA

[OLS AND TOBIT ANALYSIS]

BY

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CONTENTS

Abstract

Individual household fertility has been modeled in various ways in the literature. In many empirical studies of fertility, the number of children ever born is modeled as a function of social, economical and demographic variables such as wife's education, husband's education, age at first marriage, child mortality ...etc. and the method most commonly used is regression with OLS method of estimation. There are also other studies that apply Maximum Likelihood Tobit Model. In our case, i.e. for the analysis on fertility data of urban Addis Ababa both models are adopted and may contribute to this body of research.

The results of the analysis evidenced that:
i) The three demographic variables - age at first marriage, desired number of children and child mortality gave the expected results. That is, age at first marriage has a negative but insignificant effect, while child mortality and desired number of children have marked highly significant positive effect on fertility.
ii) Virtually, consistent negative relationship was found between wife's education and fertility.
iii) Wife's work status and husband education have shown no consistent and insignificant relationship with fertility.

Finally, based on the findings, it is suggested that policies aimed at increasing women education, reducing child mortality and limiting desired number of family size are useful for decreasing fertility .

I. Introduction

Fertility is a complex demographic process responsible for the maintenance of society (Agyei, 1988). The fertility of a given population is influenced by a number of factors. Various studies in Sub-Saharan African and other developing countries have placed emphasis on the role of demographic, socio-economic and cultural factors in determining differences in fertility behavior between populations and within a population and also the impacts of these factors on fertility. Few of the factors are education, work status, child mortality, desired number of children, and age at marriage.

The educational attainment of parents has consistently been shown to be an important factor in explaining variations in levels of fertility (UN, 1983; UN, 1984). The relationship generally noted in surveys of Sub-Saharan African countries and other parts of the world has been an inverse one and groups with high educational attainment (of either husband or wife) have lower fertility than low educational groups (World Bank, 1990; UN, 1983). Within this overall tendency, however, many variations and even counter trends have been recorded.

It may be hypothesized that fertility and women's work can have a substantial relationship. Results of the world fertility survey indicate that, in general married women who work outside their home have fewer children than those who do not. Those who work for non-familial employers have the lowest fertility followed by women employed by their family and those who are self-employed, and non-employed women have the highest fertility (UN, 1984).

High levels of child mortality are thought to encourage parents to have a large number of children. Results of studies carried out by the United Nations from 1974 -1978(UN, 1984) suggest that higher infant and child mortality support higher fertility.

By taking into account the above observations about developing countries in Africa as well as in other parts of the world, this paper attempts to examine the effects of some selected factors that influence fertility for the case of Urban Addis Ababa. Accordingly, the main inquiries to be addressed are:

- the relationship between women's education level and fertility, and husband's education level and fertility
- the relationship between women's work status and fertility
- the effect of demographic characteristics such as child mortality, desired number of children and age at marriage on fertility
- the combined effect of the above factors on fertility and

- identifying those factors that affect fertility more

This thesis is organized in six sections. Section II presents the objectives of the research; Section III outlines the statistical methods adopted for the analysis; Section IV includes literature review; Section V provides the results of the analysis and finally in Section VI conclusions and recommendations are given. Some additional details are also presented in the Appendices.

II. Objectives

We have already mentioned some of the important determinants of fertility. Some of the factors which affect fertility are social, religious and demographic. The purpose of this work is, therefore, to examine the effects of some of these factors on fertility for the case of Urban Addis Ababa. Hence the specific objectives of this research project are:

- to examine the relationship between the explanatory variables mentioned in the next section and the dependent variable(number of children ever born)
- to identify the variable(s) that describe the relation more
- to study fertility differentials among different groups (demographic and social), and
- finally to give some conclusions and recommendations based on the findings.

III. Data and Methodology

3.1. Data

The data to be analyzed are from the 1995 Addis Ababa Fertility Survey conducted by CSA. The data were collected from women of child bearing ages, that is 15 to 49 years. The sample selection was done by a two-stage stratified sampling plan. Woredas were treated as strata and at the first stage Enumeration Areas (EAs) are selected by probability-proportional-to-number of households. At the second stage households were selected systematically from a fresh list of households that are needed for the enquiries.

For the purpose of the study, only currently married fecund women (at the time of the survey) are considered.

3.2. Variables of interest

The variables to be considered in the study are :

1. *Children Ever Born (CEB)*

The number of CEB is the number of live births the respondent had up to the date of the survey. The choice of this variable is based on its closeness to the concept of individual fertility. In most fertility surveys this information is obtained through a direct question on total number of live births.

2. *Number of dead children*

3. *Desired number of children*

Desired number of children has typically been measured through survey questions about how many children respondents want. The two major types of questions are:

i. How many children would a woman want if she gets married again? This may be called "starting over" measures or simply ideal family size.

ii. How many additional children a woman would want to have? The response to this question when combined with number of living children provides what will be called the "desired family size" measure.

Our data, therefore, provide the desired family size.

4. *Age at first marriage*

Age at first marriage is the age at which a woman enters her first union.

5. *Wife's level of Education*

This measure represents the highest level of school attended. Consequently, the standard classification covered five categories (illiterate, primary, junior secondary, senior secondary and higher level). However, in this study the four categories (illiterate, primary, secondary and above secondary school) are used.

6. *Wife's work status*

The work status of a woman is classified into two categories (Working outside home and Not Working).

7. *Husband's level of education*

The construction of this variable is identical to that of wife's level of Education.

The independent variables (2 - 7 above) for the analysis are selected by considering partly the evident strength of their relationship to fertility level observed in previous comparable studies and partly on practical grounds of data availability.

Note that religion was one of the variables of interest. But the distribution of the selected women by religion shows that 85.3% are Orthodox Christian, 8.5% are Moslems, 4.8% are Protestants, 1% are Catholics and the remaining 0.3% are others. From this it can be seen that one religion, namely Orthodox, is dominant, and for this reason we excluded religion as an explanatory variable.

3.3. Statistical Method

3.3.1. Classical Multiple Linear Regression Model

One of the models used in this study for the analysis is the Multiple Linear Regression Model. It is one of the most widely used statistical tools that provides a simple method for establishing a functional relationship among variables (Chatterjee and Price, 1977).

For our case, the model regresses number of children ever born to each woman on a set of independent variables that are mentioned earlier and it is given by

$$y_j = \beta_0 + \beta_1 x_{j1} + \beta_2 x_{j2} + \beta_3 x_{j3} + \beta_4 x_{j4} + \beta_5 x_{j5} + \beta_6 x_{j6} + \epsilon_j$$

$$j = 1,2, \ldots, n$$

where:	y_j	number of CEB(dependent variable)
	β_0	intercept
	β_k	are coefficients (k = 1,...,6)
	x_{j1}	number of dead children
	x_{j2}	desired number of children
	x_{j3}	woman's age at marriage

x_{j4} woman's education level [four groups]

x_{j5} woman's work status [two groups]

x_{j6} husband's education level [four groups]

ϵ_j the error terms

The estimation technique used for the above model is the ordinary least squares estimation technique. In order to draw statistical conclusions based on ordinary least squares estimates the following assumptions must hold.

1. ϵ_j's are random quantities that are independent, identically distributed with mean zero and constant variance σ^2 and
2. ϵ_j's are uncorrelated with the regressors.

The variables education status and work status are re-coded and defined as follows.

1. Education is a categorical variable both for wife and husband and define three dummy variables for each to represent the four categories.

Hence for the wife's and husband's education, we have

EW_{j1} = 1 if the jth respondent (wife) is in the primary category

= 0 otherwise

EW_{j2} = 1 if the jth respondent (wife) is in the secondary category

= 0 otherwise

EW_{j3} = 1 if the j^{th} respondent (wife) is in the above secondary category

= 0 otherwise

EH_{j1} = 1 if the j^{th} husband is in the primary category

= 0 otherwise

EH_{j2} = 1 if the j^{th} husband is in the secondary category

= 0 otherwise

EH_{j3} = 1 if the j^{th} husband is in the above secondary category

= 0 otherwise

2. Work status of the wife is also a categorical variable and we require only one dummy variable to distinguish the two categories.

$Work_{j1}$ = 1 if the j^{th} respondent is working

= 0 otherwise

Accordingly, in terms of the dummy variables described above, the regression model is rewritten as

$$y_j = \beta_0 + \beta_1 x_{j1} + \beta_2 x_{j2} + \beta_3 x_{j3} + \gamma_1 EW_{j1} + \gamma_2 EW_{j2} + \gamma_3 EW_{j3} + \delta_1 Work_{j1} + \eta_1 EH_{j1} + \eta_2 EH_{j2} + \eta_3 EH_{j3} + \epsilon_j$$

3.3.2. The Tobit (*censored regression*) Model

Tobit Model refers to a censored regression model in which the range of the dependent variable is constrained in some way. In economics, such a model was first suggested in a pioneering work by Tobin (1958). Tobin called his model a model of limited dependent variables. The original model and its generalization are known popularly among economists as Tobit model, a phrase coined by Goldberger (as cited in Maddala, 1983) because of similarities to probit models. The model is also known as *censored regression model*. A model is called *censored* if the dependent variable is not observed outside the specified range (Amemiya, 1985).

Suppose y* is the true demand for children (which can be positive or negative) and y is the observed number of children ever born, which can take the value zero or positive integers. The Tobit Model takes into account the fact that negative values of y* are not observed, but it still assumes that y is a continuous variable in the nonnegative range.

Then the Tobit Model is given by

$$y = y^* \quad \text{if } y^* \geq 0$$
$$= 0 \quad \text{otherwise} \qquad (1)$$

where

$$y^* = X\beta + \epsilon$$

Assumptions:

$$\epsilon \sim N(0, \sigma^2 I)$$

$$E(\epsilon) = 0$$

$$E(\epsilon_i, \epsilon_j) = \sigma^2 \qquad i=j$$
$$= 0 \qquad i \neq j$$

$$E(y^*) = X\beta$$

where

β is $(k+1)\times 1$ vector of unknown parameters (including the intercept)

X is $n\times(k+1)$ matrix of known constants (the given exogenous variables) with vector x'_i in the i^{th} row

Tobit coefficients are estimated using the *maximum likelihood method* (Amemiya 1973, 1985 ; Maddala 1983).

For the model considered in (1), let n_0 be the number of observations for which $y^* < 0$ and n_1 the number of observations for which $y^* \geq 0$. Also, without any loss of generality, assume that the n_1 nonnegative observations for y^* occur first. For convenience, we define the following

$$F_i = F(x'_i\beta, \sigma^2) = \int_{-\infty}^{x'_i\beta} \frac{1}{\sigma(2\pi)^{\frac{1}{2}}} e^{-\frac{t^2}{2\sigma^2}} dt \tag{2}$$

$$f_i = f(x'_i\beta, \sigma^2) = \frac{1}{\sigma(2\pi)^{\frac{1}{2}}} e^{-(\frac{1}{2\sigma^2})(x'_i\beta)^2} \tag{3}$$

$$\Phi_i = F_i = \int_{-\infty}^{\frac{x'_i\beta}{\sigma}} \frac{1}{(2\pi)^{\frac{1}{2}}} e^{-\frac{t^2}{2}} dt \tag{4}$$

$$\phi_i = \sigma f_i = \frac{1}{(2\pi)^{\frac{1}{2}}} e^{-\frac{(x'_i\beta)^2}{2\sigma^2}} \tag{5}$$

In the above expressions ϕ_i and Φ_i are the standard normal density and distribution functions respectively evaluated at $x'_i\beta/\sigma$.

Notations:

$$\gamma_i = \frac{\phi_i}{1-\Phi_i} \qquad (6)$$

$Y_1 = (y_1, y_2, \ldots, y_{n_1})'$ is a $n_1 \times 1$ vector of n_1 nonnegative observations on y*

$X_1 = (x_1, x_2, \ldots, x_{n_1})'$ is a $n_1 \times k$ matrix of values of x_i for nonnegative y*

$X_0 = (x_{n_1+1}, \ldots, x_n)'$ is a $n_0 \times k$ matrix of values of x_i for negative y*

$\gamma_0 = (\gamma_{n_1+1}, \ldots, \gamma_n)'$ is a $n_0 \times 1$ vector of values of γ_i for $y^* < 0$

(7)

For $y^*_i < 0$

$$\text{prob}\ (y^*_i < 0) = 1 - F_i$$

For $y^*_i \geq 0$, we have

$$Prob(y^*_i \geq 0) \cdot f(y_i / y^*_i \geq 0) = \frac{1}{(2\pi\sigma^2)^{\frac{1}{2}}} e^{-(\frac{1}{2\sigma^2})(y_i - x'_i\beta)^2}$$

Hence, the likelihood function is

$$L = \prod_0 (1-F_i) \prod_1 \frac{1}{(2\pi\sigma^2)^{\frac{1}{2}}} e^{-(\frac{1}{2\sigma^2})(y_i - x'_i\beta)^2}$$

where the first product is over the n_0 observations for $y^*_i < 0$ and the second product is over n_1 observations for which $y^*_i \geq 0$.

The log-likelihood is

$$Log(L) = \sum_{0} \log(1-F_i) + \sum_{1} \log\left(\frac{1}{(2\pi\sigma^2)^{\frac{1}{2}}}\right) - \sum_{1}\left(\frac{1}{2\sigma^2}\right)(y_i - x'_i\beta)^2 \tag{8}$$

The following expressions are used to obtain the first and second derivatives of Log L with respect to β and σ^2.

$$\frac{\partial F_i}{\partial \beta} = f_i x_i$$

$$\frac{\partial F_i}{\partial \sigma^2} = -\frac{1}{2\sigma^2} x'_i \beta f_i$$

$$\frac{\partial f_i}{\partial \beta} = -\frac{1}{2\sigma^2} x'_i \beta f_i x_i$$

$$\frac{\partial f_i}{\partial \sigma^2} = \frac{(x'_i\beta)^2 - \sigma^2}{2\sigma^2} f_i \tag{9}$$

Using these, we get the first-order conditions for maximum as

$$\frac{\partial Log(L)}{\partial\beta}=-\sum_{0}\frac{f_i x_i}{1-F_i}+\frac{1}{\sigma^2}\sum_{1}(y_i-x'_i\beta)x_i=0 \tag{10}$$

$$\frac{\partial Log(L)}{\partial\sigma^2}=\frac{1}{2\sigma^2}\sum_{0}\frac{x'_i\beta f_i}{1-F_i}-\frac{n_1}{2\sigma^2}+\frac{1}{2\sigma^4}\sum_{1}(y_i-x'_i\beta)^2=0 \tag{11}$$

Note: These equations are non linear so the solutions can be found iteratively.

Pre-multiplying (10) by $\beta'/2\sigma^2$ and adding the result to (11) and using the notations in (7) we get

$$\sigma^2=\frac{1}{n_1}\sum_{1}(y_i-x'_i\beta)y_i=\frac{Y'_1(Y_1-X_1\beta)}{n_1} \tag{12}$$

Also, after multiplying by σ, equation (10) can be written as

$$-X_0Y_0+\frac{1}{\sigma}X'_1(Y_1-X_1\beta)=0 \tag{13}$$

or

$$\beta=(X_1'X_1)^{-1}X_1'Y_1-\sigma\ (X_1'X_1)^{-1}X'_0\ Y_0 \tag{14}$$

$$=\hat{\beta}_{LS}-\sigma(X'_1X_1)^{-1}X'_0Y_0 \tag{15}$$

where $\hat{\beta}_{LS}$ is the least-squares estimator for β obtained from the n_1 nonnegative observations on y*.

Equation (15) shows the relationship between the maximum likelihood estimator for β and the least-squares estimator obtained from the nonnegative observations on y*.

An iteration method for obtaining the maximum likelihood estimates of β and σ^2 using equation (15) is suggested. The method suggested is the following (see Maddala, 1983, p.154).

Step 1 *Compute* $\hat{\beta}_{LS}$ *and* $(X_1'X_1)^{-1}X'_0$.

Step 2 *Choose a value of* β, *say* $\beta^{(1)}$ *and compute* σ^2 *from (12). Let* $\sigma^{(1)}$ *denote the square root of this value of* σ^2.

Step 3 *Compute the vector* γ_0 *using* $\beta^{(1)}$ *and* $\sigma^{(1)}$. *Denote this by* $\gamma_0^{(1)}$.

Step 4 *Compute* β *from equation (15) using* $\sigma^{(1)}$ *and* $\gamma_0^{(1)}$. *Denote this value by* $\beta''^{(1)}$.

Let $\beta^{(2)} = \beta^{(1)} + \lambda(\beta''^{(1)} - \beta^{(1)})$ $(0<\lambda\leq 1)$, *where* λ *is just a damping factor used in procedures of this sort.*

Step 5 *Using* $\beta^{(2)}$ *go to Step 2 and repeat the process until the iterations converge.*

$$\frac{\partial^2 Log(L)}{\partial\sigma^2\partial\beta} = -\sum b_i x_i$$

$$\frac{\partial^2 Log(L)}{\partial\beta\partial\beta'} = -\sum a_i x_i x'_i$$

$$\frac{\partial^2 Log(L)}{\partial(\sigma^2)^2} = -\sum c_i \qquad (16)$$

In the above three equations

$$a_i = -\frac{1}{\sigma^2}\left(z_i\phi_i - \frac{\phi_i^2}{1-\Phi_i} - \Phi_i\right)$$

$$b_i = \frac{1}{2\sigma^3}\left(z_i^2\phi_i + \phi_i - \frac{z_i\phi_i^2}{1-\Phi_i}\right)$$

$$c_i = -\frac{1}{4\sigma^4}\left(z_i^3\phi_i + z_i\phi_i - \frac{z_i^2\phi_i^2}{1-\Phi_i} - 2\Phi_i\right) \qquad (17)$$

and the summations run over all n observations.

In (17) $z_i = x'_i\beta/\sigma$, ϕ_i and Φ_i as defined earlier are the density function and distribution function of the standard normal variate evaluated at z_i.

The asymptotic covariance matrix of the estimates of (β,σ^2) is the inverse of the matrix

$$V = \begin{bmatrix} \sum a_i x_i x'_i & \sum b_i x_i \\ \sum b_i x'_i & \sum c_i \end{bmatrix} \qquad (18)$$

The hypotheses about the relationship of y to one or more of the independent variables in the matrix of regressors X may be tested by the likelihood-ratio-method(Tobin, 1958). Consider for example the hypothesis $H_0{:}\beta_1=0$. The difference between the logarithm of the likelihood evaluated with the solutions under the constraint of this hypothesis and the logarithm maximized without the constraint is the test statistic. This test statistic is approximately distributed as chi-square with 1 degree of freedom for large samples. Similarly, other hypotheses about subsets of the β's can be tested(see Appendix I). In some studies the t - ratios are also used for similar purposes.

Note:

Although the Tobit model takes the censoring of the dependent variable into consideration, the results are sensitive to the assumptions of homoscedasticity and normality of the errors. Violation of any of these assumptions produces inconsistent estimates (Maddala, 1983).

IV. Literature Review

In most of the studies regression analysis (using OLS method of estimation) was applied to examine the effects of socio-demographic characteristics on fertility. In very few studies Tobit model was applied. In this respect, an attempt is made to summarize literature about these methods and give some image regarding the impacts of selected characteristics on fertility.

4.1. Child Mortality and Fertility

Child mortality can affect fertility in three ways. First, there is a biological effect, exercised through the cutting off of lactation and the consequent shortening of birth interval to the following child. Secondly, there may be a replacement effect, when women try to replace a child that died. Thirdly, an unconscious protection or insurance effect may operate whereby women have more children in areas of high mortality because they expect that one or more of their children will die.

Studies by the United Nations from 1974 - 1978 showed that child mortality and fertility have strong positive correlation. That is, lower fertility generally have relatively low child and infant mortality or vice versa (UN, 1984).

A recent study, in Cote d'Ivoire and Ghana by World Bank (see Benefo and Schulz, 1994), indicated also that the reduction of five children deaths could lead to a decrease in fertility of one birth.

4.2 Age at First Marriage and Fertility

Although a women could in principle bear children throughout her reproductive life, from the age of about 15-49, this is rarely the case, because her overall exposure to child bearing is limited to the total amount of time during which she is actually cohabiting or in union. Therefore, the total time spent in unions for all women depends on the age at first marriage (Bongaarts, Frank and Lesthaeghe, 1984). With this in mind, it is assumed that an increase in the age at marriage reduces the length of exposure to the risk of pregnancy and consequently reduce cumulative fertility.

On the other hand, socio-economic development, particularly improvement in women's education, provision of increased employment opportunities for women and raising their status can contribute to higher age at marriage. World Fertility Survey data, show, however, that postponement of marriage by a few years in many developing societies where age at marriage is very low has little reduction effect on fertility. It appears that in most countries only where age at marriage is raised substantially above the level of around age 21 is associated with lower fertility. Even above that age the impact of higher age at marriage is not always clear. Women who marry late tend to be better educated, have a higher social status and practice contraception to a great extent than women marrying younger. Their pattern of lower fertility may, therefore, be due to these factors rather than to their somewhat shorter period of exposure to risk of conception(birth) (UN, 1984).

The study in rural Sierra Leone (using OLS technique of estimation) by Bailey and Serow (1991) showed that age at marriage behaved as generally expected on fertility.

A case study of one Kebele in Addis Ababa by Alemseghed(1989), showed that the difference in the average number of CEB between those who married at ages below 15 and 15-19 was quite small and those who married at ages 20 and above had substantially lower fertility than the former two groups. Therefore, although the magnitude is small it is consistent with the expectation.

4.3. Desired Family Size and Fertility

Desired family size is closely related to the investment motives of parents, that is raising children in the expectation that they will provide their parents with physical and economic support in old age. Thus desired family size is expected to have a positive effect on the number of children ever born.

For example, the study by Bailey and Serow (1991) showed the expected results, that is, desired family size has a positive effect on the number of children ever born.

4.4. Education and Fertility

It is useful to survey the specific connections between education and fertility. These links are arranged, firstly, according to whether their effects are direct, indirect or joint (UN, 1983). Direct effects are immediate influences of education in changing attitudes, values and beliefs towards a small family norm. On the other hand, several indirect effects of education upon fertility have been hypothesized:

- education acts to delay entry to marital union
- education facilitates the acquisition of information related to family planning
- education also creates aspirations for upward social mobility and accumulation of wealth

- education enhances the likelihood of outside female employment
- education increases husband-wife communication
- education leads to reduction in infant and childhood mortality

All of the above indirect effects are hypothesized to lower fertility levels. Finally, some joint effects have also been singled out as "modernization" (urbanization and industrialization) is theorized to influence fertility through , or jointly with, education.

Several studies have been conducted both in Africa and other parts of the world to examine the relationship between education and fertility.

OLS results of a comparative analysis of world fertility survey data for twenty-two developing countries discerned an overall negative impact of education upon cumulative fertility except in two countries, Kenya and Indonesia, in which they do not follow this trend (UN, 1983).

Another study by Ainsworth, Beegle and Nyamete (1995), revealed that in fourteen Sub-Saharan African countries(using OLS techniques of estimation of regression coefficients) increased schooling (education) is generally associated with lower fertility. In Tanzania, Uganda, Burundi, Mali, Niger, Togo and

Senegal the relationship showed slight decreases in fertility with increased education.

Furthermore, the study showed that female primary education is associated with lower cumulative fertility in half of the fourteen countries. In these cases, women with some or complete primary education have 0.17 to 0.30 fewer number of CEB than those with no education. In six other countries, women with primary education did not have a significantly different cumulative fertility than women with no education (Cameroon, Zambia, Ghana, Ondo State in Nigeria, Togo and Mali). Contrary to this, the study showed that, in Burundi women with elementary education have significant higher fertility than uneducated women.

This same study disclosed women's secondary education is associated with lower fertility in all of the fourteen countries and had a greater effect than primary education. Secondary education is associated with a reduction of number of children ever born by 0.3 to 0.7 children compared to women with no education. In eleven of the fourteen countries, women with secondary education have had 1.2 to 1.6 fewer children than women with no education. It was also observed that husbands education has no significant relation with fertility in about one-third of the countries.

In a socio-economic determinants of fertility study in Cote d'Ivoire using OLS and Tobit maximum likelihood method of estimation (Ainsworth, 1989) it was observed that women with secondary education had substantially lower fertility than those with no education. The relationship for primary education is less clear that not until age 30 does primary schooling seem to have a negative impact on fertility.

Using chi-square contingency coefficients, Alemseghed (1989) found that cumulative fertility (number of children ever born) of women was lower for the formal education group than that of the illiterates for the age groups 15-19 and 35-39. However, it was higher for the age groups 25-29, 30-34 and 40-44. Further, his study disclosed that the number of CEB for the age group 20-24 did not change with education.

4.5 Women Work and Fertility

In general, it is postulated that married women who work outside their home have a smaller number of children than those who do not.

Cochran and Farid (1989) found the highest fertility among those not working women in Sub- Saharan Africa, Asia and Latin America.

In the same study, looking at individual countries, however, Cochran and Farid found enormous variation from this pattern. Only in the Sudan is highest fertility associated with women who do not work and the lowest found among those occupationally working.

As they noted in their study, this diverse pattern arises because of small fertility differences by work status in Sub-Saharan Africa, that is, 0.33 of a child to 0.5 a child. This compares with 1.32 to 1.80 in North Africa, 0.70 to 1.50 in Middle East, 1.10 to 1.50 in Latin America. Again Sub-Saharan Africa is closer to Asia which has differences of 0.60 to 0.80. They found also the differentials are smaller in Sub-Saharan Africa than elsewhere.

Alemseghed (1989), indicated that except for the age group 20-24 fertility was lower for the working group of women than that of women in the not working group including the age group 45-49 (complete fertility).

V. Results of the Analysis

5.1 Summary statistics

Table 5.1.1 Average Number of CEB and Standard Error by Education Status of Ever Married Women

Education Status	No. of Observation	Mean CEB	S.E.	Percentage (%)
Illiterate	189	5.180	0.219	26.92
Elementary	213	4.601	0.195	30.34
Secondary	242	2.653	0.128	34.47
Above Secondary	58	2.534	0.263	8.26
Total	702	3.915	0.106	100.00

The average number of CEB by status of education of women is presented in Table 5.1.1. The average decreases as level of education increases. The average number of CEB is 5.180, 4.601, 2.653 and 2.534 for the education group illiterate, elementary, secondary and above secondary respectively.

Table 5.1.2. Average Number of CEB and Standard Error by Working Status of Ever Married Women

Working Status	No. of Observation	Mean CEB	S.E.	Percentage (%)
Working	297	3.818	0.151	42.31
Not Working	405	3.985	0.147	57.69
Total	702	3.915	0.106	100.00

Table 5.1.2 presents the relationship of average number of CEB and women work status. The average number of children for women who are working outside their home is 3.818 while women not working is 3.985. This shows that women who are not working have an average of 0.167 children more than that of working women.

Table 5.1.3. Average Number of CEB and Standard Error by Education Status of the Husband

Education Status	No. of Observation	Mean CEB	S.E.	Percentage (%)
Illiterate	63	5.111	0.410	8.97
Elementary	210	5.000	0.212	29.91
Secondary	303	3.300	0.136	43.16
Above Secondary	126	2.984	0.201	17.95
Total	702	3.915	0.106	100.00

With regard to husbands education, the average number of CEB decreases as the level of education increases and, therefore, a similar relationship is observed as that of women's education status. However, in some studies education of husband is considered as a proxy to income and it is hypothesized that as education of the husband increases fertility increases, that is they are positively correlated (Sarma, 1985).

Table 5.1.4 below provides the means and the standard deviations of the dependent and independent variables.

Table 5.1.4 Means/Proportions and Standard Deviations of the dependent and independent variables

Variables	All Observations		Five observations removed	
	Mean/ Proportion	SE	Mean/ Proportion	SE
Number of CEB	3.915	2.804	3.931	2.806
Age at marriage	17.319	4.899	17.329	4.906
Number of dead children	0.440	0.840	0.442	0.842
Desired number of children	4.449	2.217	4.407	2.162
Woman Education Level				
Elementary	0.303	0.460	0.303	0.460
Secondary	0.345	0.476	0.346	0.476
Secondary plus	0.083	0.276	0.082	0.274
Woman Work Status				
Working outside home	0.423	0.494	0.423	0.494
Husband Education Level				
Elementary	0.299	0.458	0.300	0.459
Secondary	0.432	0.496	0.430	0.495
Secondary plus	0.179	0.384	0.179	0.384
n	702		697	

5.2 Estimation Results[1]

5.2.1 Introduction

i) OLS Estimates

Prior to presenting the results, we should investigate the pattern of residuals to check for model specification (additivity of the model) to be able to directly interpret the coefficients of the dummy variables. Hence, to observe the pattern, we plot the residuals against a new categorical variable that takes a separate value for each of the thirty two combinations** (four woman education levels, two working status and four husband education levels). The graph for each of the groups as depicted in Figure 1 looks acceptable and indicates that the given model explains the relationship adequately. In other words, the effects of education and work status on fertility determination are additive. However, as seen from the graph, five observations are suspected as outliers and the situation could be improved if these observations are deleted.

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[1] The results are produced using SPSS for the regression and LOTUS for the iteration in the Tobit Model.

** See appendix II-1

An F-value which is equal to 264.51 also indicates that the regression equation is significant.

One of the model assumptions is homogeneity of error variances. Nonetheless, it is not a simple matter to detect (investigate) heteroscedasticity in a multiple regression situation. The plot of residuals against the fitted values of the response variable can serve as a first step. However, the plot does not clearly identify the source of the problem and, this was encountered in our case. Hence, a more plausible way to investigate heteroscedasticity in multiple regression is by clustering observations according to prior, natural and meaningful associations (Chatterjee and Price, 1977). Consequently, we can consider the thirty-two wife-husband education and work status groups in a similar manner as mentioned above. Hence, Figure 1 depicts nonconstant variance. As indicated earlier, it is clear from the plot that five observations are separated from the other observations and these are perhaps the cause for heterogeneity. In this regard, the regression coefficients are re-estimated by deleting these five observations. The estimates do not show any dramatic change but the re-drawn plot (Figure 2) of residuals against education-work status groups shows that the distribution of the errors is roughly evenly distributed about zero. This behavior implies that the model given explains adequately the relationship and no serious heteroscedasticity is detected. As a result the assumptions of the error terms are justified in the model without five observations.

There are also some other techniques to test the existence of heteroscedasticity. Among these the likelihood ratio test is recommended for large sample (see Maddala,1992, pp. 201-214). The procedure of the test is the following. Divide the residuals (estimated from the OLS regression) into k groups with n_i observations in the i^{th} group ($\Sigma n_i = n$). Estimate the error variances in each group by s_i^2. Let the estimates of the error variance from the entire sample be s^2 :

Let

$$h = \prod_{i=1}^{k} \frac{S_i^{n_i}}{S^n}$$

then -2log h has a $\chi2_{(k-1)}$ distribution.

If we reject the hypothesis of existence of heteroscedasticity (i.e. -2log $h >$ $\chi2_{(k-1)}$), there are significant differences between the error variances. Consequently, the above test was conducted for all observations and heteroscedasticity was detected. In similar manner the test was carried out after deleting the five outlying observations and no heteroscedasticity was noticed (see Appendix II-2). Hence, the visual investigation and decisions made based on the plots are supported by the test.

On the other hand, the assumption of the normality of the error terms can be justified for large samples on the basis of asymptotic theory (central limit theorem). Moreover, it is assumed that the errors are uncorrelated.

The variance inflation factors (VIF's) are also presented in Table 5.2.1 and no serious multicollinearity is detected. In practice VIF's exceeding 10 indicate that the associated regression coefficients are poorly estimated because of multicollinearity (Montgomery and Peck, 1992, p. 317).

Table 5.2.1 Variance Inflation Factor (VIF)

Variable	VIF	
	All Observations	Five observations Deleted
Age at marriage	1.465	1.461
Number of dead children	1.173	1.177
Desired number of children	1.177	1.186
Woman Education Level		
Elementary	1.582	1.581
Secondary	2.279	2.283
Secondary plus	1.991	2.000
Woman Work Status		
Working outside home	1.088	1.086
Husband Education Level		
Elementary	3.152	3.137
Secondary	3.992	3.968
Secondary plus	3.520	3.527

Figure 1. Plot of Standardized Residuals against Groups(OLS)
(All Observations)

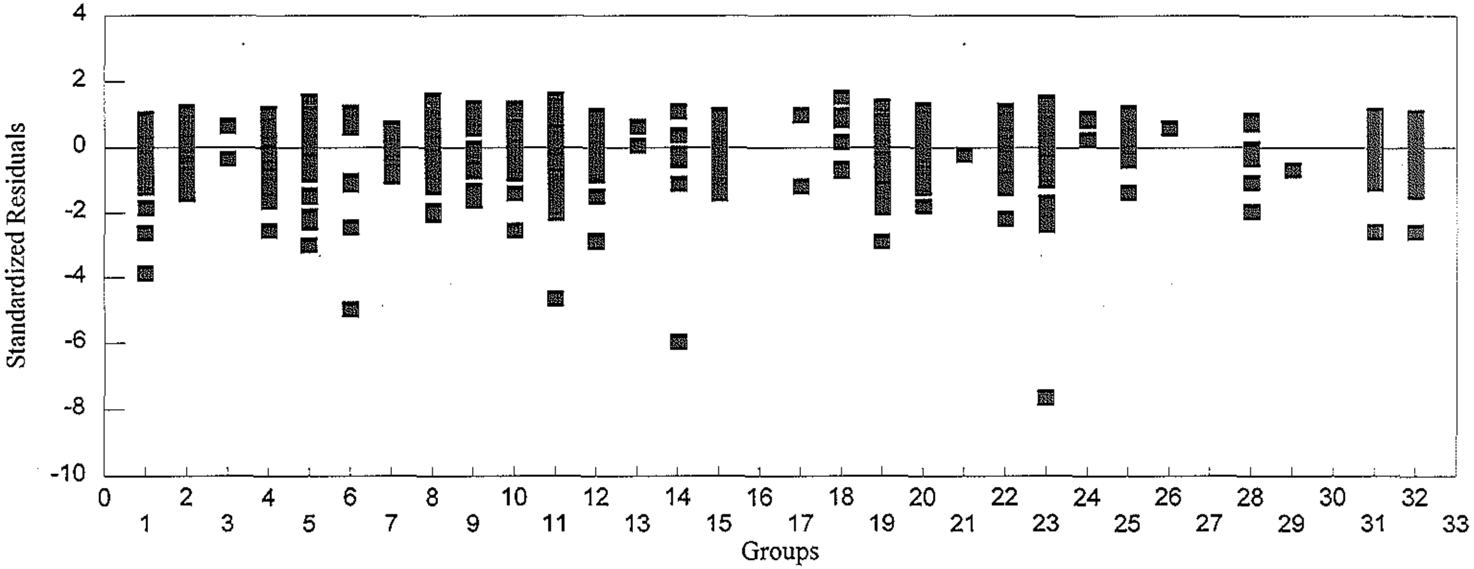
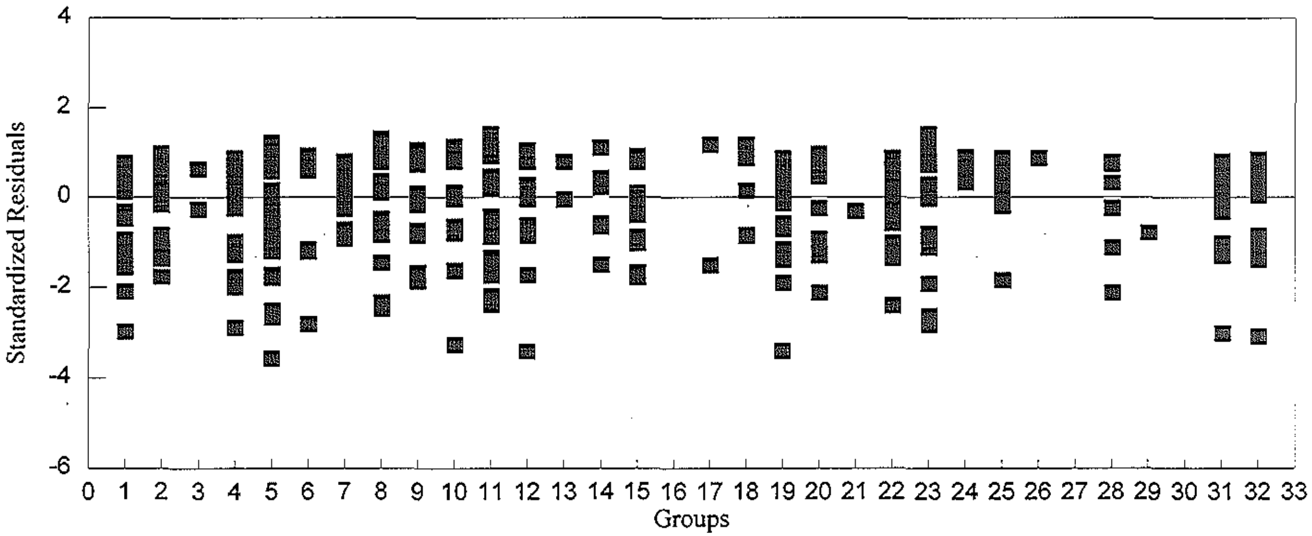


Figure 2. Plot of Standardized Residuals agianst Groups(OLS)
(Five Observations Deleted)



ii) Tobit MLE

Nelson (1981) derived a general test of the standard assumptions (homoscedasticity and normality) against a general misspecified alternative in the Tobit regression model. Computational ease and freedom from specification of a specific alternative hypothesis are the major merits of the test.

The test Nelson derived is based on the asymptotic specification test derived by Hausman (1978). Let $\hat{w}_0$ and $\hat{w}_1$ be two estimators of the parameter vector **w** of dimension k such that under the null hypothesis they are both consistent and asymptotically normal, with asymptotic covariance matrices u_0 and u_1. Also, let $\hat{w}_0$ be asymptotically efficient, so that the matrix u_1-u_0 is nonnegative definite. Then $\sqrt{n}(\hat{w}_1-\hat{w}_0)$ is asymptotically normal with covariance matrix u_1-u_0 . Letting $\hat{u}_1$ and $\hat{u}_0$ be consistent estimates of u_1 and u_0 respectively, Hausman constructed the test statistics $n(\hat{w}_1 - \hat{w}_0)'(\hat{u}_1 - \hat{u}_0)^{-1}(\hat{w}_1 - \hat{w}_0)$, which, he argued, is asymptotically χ^2 with k degrees of freedom.

To implement this test, Nelson constructed two estimators: the MLE and the method of moments (MOM) estimator. Both are consistent under the null hypothesis, and the former is efficient. Under the alternative hypothesis, the MOM estimator is consistent, but the MLE is not. The details of the test are as follows. We consider the usual Tobit model given by (1) on page 12.

Let ϕ be an n-vector with $\phi_i=\phi(x'_i\beta/\sigma)$ as the ith element. Φ is an $n\times n$ diagonal matrix $\Phi_i=\Phi(x'_i\beta/\sigma)$ as the ith diagonal element. The other notations are as described before.

As shown on page 44

$$E(y_i)=(x'_i\beta)\Phi_i+\sigma\phi_i$$

$$E(y_i^2)=(x'_i\beta)^2\Phi_i+\sigma^2\Phi_i+(x'_i\beta)\sigma\phi_i \qquad \text{(i)}$$

Hence,

$$E_{xy}=E((1/n)X'Y)=(1/n)(X'\Phi X\beta+\sigma X'\phi) \qquad \text{(ii)}$$

and variance of ((1/n)X'Y) is

$u_1=(1/n)(X'u_yX)$ where u_y is an $n\times n$ diagonal matrix with diagonal elements $E(y_i^2)-[E(y_i)]^2$, as defined in (i) (iii)

The MOM estimator is ((1/n)X'Y). The corresponding efficient estimator the MLE obtained by evaluating (ii) at the MLE of β and σ and the covariance matrix u_0 is given by

$$(1/n^2)[X'\Phi X\beta \quad X'\phi]'Q\,[X'\Phi X\beta \quad X'\phi] \qquad \text{(iv)}$$

where Q is variance-covariance matrix of the MLE of (β,σ^2) given on page 20 (V^{-1}).

The test statistic is

$$m = n((1/n)X'Y - \hat{E}_{xy})'(\hat{u}_1 - \hat{u}_0)^{-1}((1/n)X'Y - \hat{E}_{xy})$$

where $\hat{u}_1$ and $\hat{u}_0$ are (iii) and (iv) evaluated at the MLE of β and σ.
This statistics follow, asymptotically, a χ^2 distribution with k degrees of freedom.

Accordingly, we attempted to test this general test and the value of the test statistic is found to be $m = 0.3011$. The corresponding $\chi^2_{0.01}(11) = 24.73$. Hence, no gross violation of the assumptions is detected. Note that if violation is detected there are some methods to handle the problem by making some alternative assumptions about departures from the standard model (see Maddala, 1983, pp.178-192).

5.2.2 Results

The estimates of the two models (OLS and Tobit) are presented in Tables 5.2.2 and 5.2.3. The first figure in each cell is the coefficient (β) for the variables in the regressions. To facilitate comparison among the two models, the coefficients on the expected value function of the Tobit model have been calculated at the sample means and are presented in brackets**. These figures could therefore be compared with the ordinary least squares coefficients.

The results in Table 5.2.3 are used for interpretation since the basic assumptions in the two models are justified. As shown in the table, the two models generated more or less similar results in terms of sign, magnitude and

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** The coefficients of the Tobit model represent $\partial y^*/\partial X$. The coefficients for E(y) are obtained as follows (Maddala, 1983):

$$E(y) = pr(y^* >= 0)\ E(y/y^* >= 0) + pr(y^* < 0).E(y/y^* < 0)$$

$$= \Phi(X\beta + \sigma\phi/\Phi) + (1 - \Phi)\cdot 0$$

$$= \Phi\cdot X\beta + \sigma\cdot\phi$$

$$\partial\ E\ (y)\ /\partial x_i = [\ \Phi + (X\beta/\sigma)\phi - (X\beta/\sigma)\phi]\cdot \beta_i$$

$$= \Phi\cdot \beta_i$$

where ϕ and Φ are the normal density and distribution function of $X\beta/\sigma$, evaluated at the mean. The i subscript denotes the explanatory variable.

significance of coefficients. This is because the number of censored observations are very small compared to the total number of observations (only 2.58%). This means that the smaller the degree of censoring the closer are the OLS and Tobit coefficients (Ainsworth, 1989). Thus, we have opted to use the simpler and easy to interpret OLS estimates.

Accordingly, age at first marriage exerts an insignificant negative effect on fertility. On the other hand, child mortality and desired number of children are the demographic variables that influence fertility positively and are highly significant.

In general, education level of women is associated negatively with fertility. The results obtained depict that an illiterate woman has about 0.1 more children than a woman with elementary education, about 0.4 more children than a woman with secondary education and about 0.3 more children than a woman with above secondary education. However, the effects of elementary education and above secondary are not significant.

The relation between work status and fertility obtained from the analysis is contrary to the hypothesis and some other studies. That is, working outside home, although insignificant, correlates positively to the number of CEB, and a woman who works outside home has about 0.1 more children than a woman who does not work outside her home.

Education level of men has shown no apparent relation to fertility. In some studies education of men is used as a proxy to income and expected to have a positive relation to fertility. Nevertheless, the result obtained here does not show this relation. Men's secondary education is negatively associated and insignificant while the other categories are positively correlated as expected but insignificant.

Table 5.2.2 Regression results for all Observations
Dependent Variable : CEB

Explanatory Variable	Coefficients	
	OLS	Tobit
Age at marriage	-0.015627 (0.011994)	-0.018689 (0.012145) [-0.018665]
Number of dead children	1.214502** (0.062589)	1.220967** (0.062524) [1.219380]
Desired number of children	0.868684** (0.023760)	0.900967** (0.024154) [0.899796]
Woman Education Level		
Elementary	-0.103075 (0.132754)	-0.067644 (0.133086) [-0.067556]
Secondary	-0.442448** (0.154114)	-0.444034** (0.155205) [-0.443457]
Secondary plus	-0.498568 (0.248695)	-0.493085 (0.250422) [-0.492444]
Woman Work Status		
Working outside home	0.094924 (0.102434)	0.140287 (0.103161) [0.140105]
Husband Education Level		
Elementary	0.093532 (0.188137)	0.136616 (0.189549) [0.136438]
Secondary	-0.273234 (0.195718)	-0.263889 (0.197277) [-0.263546]
Secondary plus	0.066804 (0.237197)	0.176801 (0.239085) [0.176571]
Constant	0.048847 (0.295044)	-0.154405 (0.299174)
R^2	0.79	
Adjusted R^2	0.79	
σ		1.2813994 (0.091436)
Log L		-1149.84
n	**702**	**702**

** Significant at $\alpha=0.01$

Table 5.2.3 Regression results for Without Five Observations
Dependent Variable : CEB

Explanatory Variable	Coefficients	
	OLS	Tobit
Age at marriage	-0.013843 (0.010480)	-0.016975 (0.010595) [-0.016972]
Number of dead children	1.176600** (0.054771)	1.182532** (0.054378) [1.182295]
Desired number of children	0.947135** (0.021427)	0.980886** (0.021698) [0.980690]
Woman Education Level		
Elementary	-0.108586 (0.116327)	-0.072163 (0.116028) [-0.072149]
Secondary	-0.418808** (0.135019)	-0.417383** (0.134794) [-0.417299]
Secondary plus	-0.328587 (0.219369)	-0.316431 (0.22004) [-0.316369]
Woman Work Status		
Working outside home	0.097923 (0.089644)	0.142373 (0.089516) [0.142345]
Husband Education Level		
Elementary	0.087222 (0.164288)	0.131648 (0.165028) [0.131622]
Secondary	-0.198197 (0.171005)	0.184734 (0.171861) [-0.174697]
Secondary plus	0.079400 (0.208081)	0.191473 (0.208745) [0.191435]
Constant	-0.315355 (0.258997)	-0.526007 (0.261705)
R^2	0.84	
Adjusted R^2	0.84	
σ		1.1109 (0.06872)
Log L		-1042.86
n	**697**	**697**

** Significant at $\alpha=0.01$

VI. Conclusions and Recommendations

This paper has endeavored to analyze the effects of some socio-demographic characteristics on fertility in Addis Ababa. The results indicate that demographic variables (age at first marriage, desired number of children and child mortality) have the same effect as expected. That is, though insignificant, age at first marriage has a negative effect while child mortality and desired number of children have highly significant positive effect on fertility. A more or less consistent relationship was found between wife's education and fertility. On the other hand, wife's work status and husband education have shown no consistent relationship with fertility and are insignificant.

Based on these findings, we suggest that policies aimed at raising women education level, reducing child mortality and limiting desired family size are important measures for decreasing fertility.

As mentioned at the early stage, the analysis is done only for Addis Ababa based on only some factors and cannot be taken as conclusive results. Hence, we further recommend similar analysis with additional exogenous variables(such as age cohorts, religion, location of residence, ethnicity, ...etc.) for other big towns in the country and for the country itself so as to provide complete and useful insights for formulating appropriate policies regarding fertility.

Finally, experimentation with two models revealed that OLS yields estimates that are similar in magnitude and significance to the expected value coefficients of the more sophisticated Tobit model. It is also verified that for small degree of censoring the OLS and Tobit models generate analogous estimates of coefficients.

APPENDIX I - Likelihood Ratio Test Results in the Tobit Model

All Observations

Hypothesis	Log L_{H0}	Log L	ln λ= Log L_{H0}-Log L	-2ln λ	$\chi_{.01}^2(1)$
H_0: $\eta_3=0$	-1150.14	-1149.84	-0.30	0.60	6.63
H_0: $\eta_2=0$	-1150.29	-1149.84	-0.45	0.90	6.63
H_0: $\eta_1=0$	-1150.12	-1149.84	-0.28	0.56	6.63
H_0: $\delta_1=0$	-1150.79	-1149.84	-0.95	1.90	6.63
H_0: $\gamma_3=0$	-1153.82	-1149.84	-3.98	7.96	6.63
H_0: $\gamma_2=0$	-1158.16	-1149.84	-8.32	16.64	6.63
H_0: $\gamma_1=0$	-1149.99	-1149.84	-0.15	0.30	6.63
H_0: $\beta_3=0$	-1151.05	-1149.84	-1.21	2.42	6.63
H_0: $\beta_2=0$	-1544.70	-1149.84	-394.86	789.72	6.63
H_0: $\beta_1=0$	-1304.79	-1149.84	-154.95	309.9	6.63

Five Observations deleted

Hypothesis	Log L_{H0}	Log L	ln λ= Log L_{H0}-Log L	-2ln λ	$\chi_{.01}^2(k)$
H_0: $\eta_3 = \eta_2=\eta_1=0$	-1047.91	-1042.86	-5.05	10.1	11.34
H_0: $\gamma_3=0$	-1043.9	-1042.86	-1.04	2.08	6.63
H_0: $\gamma_2=0$	-1047.58	-1042.86	-4.72	9.44	6.63
H_0: $\gamma_1= \delta_1= \beta_3=0$	-1045.64	-1042.86	-2.78	5.56	11.34
H_0: $\beta_2=0$	-1533.44	-1042.86	-490.58	981.16	6.63
H_0: $\beta_1=0$	-1222.76	-1042.86	-179.9	359.8	6.63

APPENDIX II-1 - Groups formed to investigate model specification and constant variance

Group	Combinations****							Count	Regression Equation
	γ_1	γ_2	γ_3	δ_1	η_1	η_2	η_3		
1	1	0	0	1	1	0	0	36	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1+\delta_1+\eta_1$
2	1	0	0	1	0	1	0	33	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1+\delta_1+\eta_2$
3	1	0	0	1	0	0	1	2	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1+\delta_1+\eta_3$
4	1	0	0	0	1	0	0	51	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1+\eta_1$
5	1	0	0	0	0	1	0	64	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1+\eta_2$
6	1	0	0	0	0	0	1	8	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1+\eta_3$
7	0	1	0	1	1	0	0	9	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2+\delta_1+\eta_1$
8	0	1	0	1	0	1	0	49	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2+\delta_1+\eta_2$
9	0	1	0	1	0	0	1	38	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2+\delta_1+\eta_3$
10	0	1	0	0	1	0	0	19	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2+\eta_1$
11	0	1	0	0	0	1	0	91	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2+\eta_2$
12	0	1	0	0	0	0	1	31	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2+\eta_3$
13	0	0	1	1	1	0	0	2	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3+\delta_1+\eta_1$
14	0	0	1	1	0	1	0	10	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3+\delta_1+\eta_2$
15	0	0	1	1	0	0	1	35	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3+\delta_1+\eta_3$
16	0	0	1	0	1	0	0	0	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3+\eta_1$
17	0	0	1	0	0	1	0	2	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3+\eta_2$
18	0	0	1	0	0	0	1	7	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3+\eta_3$
19	0	0	0	1	1	0	0	35	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\delta_1+\eta_1$
20	0	0	0	1	0	1	0	16	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\delta_1+\eta_2$
21	0	0	0	1	0	0	1	1	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\delta_1+\eta_3$
22	0	0	0	0	1	0	0	57	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\eta_1$
23	0	0	0	0	0	1	0	35	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\eta_2$
24	0	0	0	0	0	0	1	3	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\eta_3$
25	1	0	0	1	0	0	0	10	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1+\delta_1$
26	0	0	0	1	0	0	0	1	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2+\delta_1$
27	0	0	1	1	0	0	0	0	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3+\delta_1$
28	1	0	0	0	0	0	0	8	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_1$
29	0	1	0	0	0	0	0	1	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_2$
30	0	0	1	0	0	0	0	0	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\gamma_3$
31	0	0	0	1	0	0	0	17	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}+\delta_1$
32	0	0	0	0	0	0	0	26	$\beta_0+\beta_1x_{j1}+\beta_2x_{j2}+\beta_3x_{j3}$
								697	

**** Continuous variables are constant in all combinations

2. HETEROSCEDASTICITY TEST – ALL OBSERVATIONS

Group	Si	ni	Si^ni
1	1.32	37	28922.475
2	0.96	33	0.25998644
3	0.91	2	0.8281
4	1.08	51	50.6537415
5	1.28	64	7268387.24
6	2.58	9	5064.97555
7	0.7	9	0.04035361
8	1.23	49	25430.2401
9	1.02	38	2.12229879
10	1.18	19	23.2144361
11	1.43	92	1.954E+14
12	1.29	31	2680.9025
13	0.52	2	0.2704
14	2.5	11	23841.8579
15	0.9	35	0.02503156
17	1.98	2	3.9204
18	1.2	7	3.5831808
19	1.07	35	10.6765815
20	1.16	16	10.7480042
22	0.9	57	0.00246503
23	2.13	36	6.632E+11
24	0.46	3	0.097336
25	0.88	10	0.27850098
28	1.27	8	6.76752342
31	1.12	17	6.86604089
32	1.07	26	5.80735292
21,26,29	0.84	3	0.592704
		702	

Maddala, G.S. 1992, Introduction to Econometrics, 2nd ed., Macmillan p.c., pp. 201–214, New York.
HETEROSCEDASTICITY TEST

If the number of observations is large the Likelihood ratio test is recommended. That is, divide the residuals(estimated from the OLS regression) in to K groups with ni observations in each group. Estimate the error variances in each group and take the standard errors (Si). Let the square root of the error variance from the entire sample be S. Then if we define h = $\prod^{k}$ Si ^ ni / S ^ n and −2 ln h has a Chi−Square distribution with K−1 d.f.
If −2 ln h > Chi−Square with K−1 d.f. there is significans differences between error variances. See the following.

S = 1.28

$\prod^{k}$ Si^ni= 5.67E+53
S ^n= 1.83E+75
$\prod^{k}$ Si^ni / S ^ n = h = 3.11E−22

−2 ln h= 99.046959

Chi−Square with 26 d.f.= 45.63
(extracted by interpolation, i.e. approximate value)

Which implies that the error variances are NOT the same (Heteroscedasticity exists).

3. HETEROSCEDASTICITY TEST : FIVE OBSERVATIONS DELETED

Group	Si	ni	Si^ni
1	1.04	36	4.10393255
2	0.95	33	0.18402591
3	0.71	2	0.5041
4	1.04	51	7.39095068
5	1.28	64	7268387.24
6	1.53	8	30.0283484
7	0.75	9	0.07508469
8	1.25	49	56051.9386
9	1.01	38	1.45952724
10	1.53	19	3229.5141
11	1.32	91	9.381E+10
12	1.3	31	3405.99434
13	0.67	2	0.4489
14	0.95	10	0.59873694
15	0.91	35	0.03685095
17	2.13	2	4.5369
18	1.04	7	1.31593178
19	1.02	35	1.99988955
20	1.11	16	5.31089433
22	0.85	57	0.00009482
23	1.26	35	3258.13503
24	0.32	3	0.032768
25	0.9	10	0.34867844
28	1.17	8	3.51145328
31	1.11	17	5.89509271
32	1.06	26	4.54938296
21,26,29	0.96	3	0.884736
		697	

S = 1.12

Π Si^ni= 7.19E+29
S ^n= 2.02E+34
Π Si^ni / S ^ n = h = 0.0000356

−2 ln h= 20.485021

Chi−Square with 26 d.f.= 45.63
(extracted by interpolation, i.e. approximate value)

Which implies that the error variances are the same (No Heteroscedasticity).

APPENDIX III

Remark: The iteration results are obtained using the method outlined in section 3.3.2.

1. All observations

Esimates of Coefficients

Iteration Step

	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Constant	−0.083	−0.1141	−0.1318	−0.1417	−0.1472	−0.1504	−0.1522	−0.1532	−0.1537	−0.154	−0.1541	−0.1543	−0.1543	−0.1544	−0.1544	−0.1544	−0.1544	−0.1544	−0.1544	−0.1544	−0.1544	−0.1544	−0.15441
Secondary plus husband	0.1482	0.16088	0.16799	0.17193	0.17412	0.17537	0.17604	0.17644	0.17663	0.17674	0.1768	0.17683	0.17685	0.17687	0.17687	0.17688	0.17688	0.17688	0.17688	0.17688	0.17688	0.17688	0.176881
Deisred no. of children	0.8917	0.89576	0.89804	0.89932	0.90004	0.90045	0.90068	0.90081	0.90088	0.90092	0.90094	0.90095	0.90096	0.90096	0.90096	0.90096	0.90097	0.90097	0.90097	0.90097	0.90097	0.90097	0.900967
Working outside	0.1317	0.13549	0.13761	0.13879	0.13944	0.13982	0.14002	0.14014	0.1402	0.14024	0.14026	0.14027	0.14028	0.14028	0.14028	0.14029	0.14029	0.14029	0.14029	0.14029	0.14029	0.14029	0.140287
Elementary woman	−0.082	−0.0757	−0.0722	−0.0702	−0.0691	−0.0684	−0.0681	−0.0679	−0.0678	−0.0677	−0.0677	−0.0677	−0.0677	−0.0677	−0.0676	−0.0676	−0.0676	−0.0676	−0.0676	−0.0676	−0.0676	−0.0676	−0.06764
No. of dead children	1.2176	1.21908	1.21991	1.22038	1.22064	1.22079	1.22087	1.22091	1.22094	1.22095	1.22096	1.22096	1.22096	1.22097	1.22097	1.22097	1.22097	1.22097	1.22097	1.22097	1.22097	1.22097	1.220967
Elementary husband	0.1225	0.12886	0.13238	0.13429	0.13534	0.13594	0.13625	0.13643	0.1365	0.13655	0.13658	0.13659	0.1366	0.13661	0.13661	0.13661	0.13661	0.13662	0.13662	0.13662	0.13662	0.13662	0.136616
secondary plus woman	−0.506	−0.5006	−0.4973	−0.4954	−0.4944	−0.4938	−0.4934	−0.4933	−0.4932	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.4931	−0.49309
Age at marriage	−0.018	−0.0185	−0.0186	−0.0186	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.0187	−0.01869
Secondary woman	−0.451	−0.4475	−0.4459	−0.445	−0.4446	−0.4443	−0.4441	−0.4441	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.444	−0.44403
Secondary husband	−0.272	−0.268	−0.2661	−0.265	−0.2645	−0.2642	−0.264	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.2639	−0.26389
SIGMA	1.2837	1.28261	1.28208	1.28178	1.28161	1.28152	1.28146	1.28144	1.28142	1.28141	1.28141	1.2814	1.2814	1.2814	1.2814	1.2814	1.2814	1.2814	1.2814	1.2814	1.2814	1.2814	1.281399

Differences at each step

	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
		−0.0312	−0.0177	−0.0099	−0.0055	−0.0032	−0.0017	−0.001	−0.0005	−0.0003	−0.0002	−0.0001	−6E−05	−4E−05	−2E−05	−1E−05	−7E−06	−4E−06	−3E−06	−2E−06	−9E−07	−5E−07	−3.1E−07
		0.01273	0.00711	0.00394	0.00219	0.00125	0.00067	0.0004	0.00019	0.00011	0.00006	0.00003	0.00002	0.00001	6E−06	4E−06	2E−06	1E−06	7E−07	4E−07	2E−07	1E−07	8.3E−08
		0.00402	0.00227	0.00128	0.00072	0.00041	0.00023	0.00013	0.00007	0.00004	0.00002	0.00001	7E−06	4E−06	2E−06	1E−06	9E−07	5E−07	3E−07	2E−07	1E−07	6E−08	3.5E−08
		0.00378	0.00212	0.00118	0.00065	0.00037	0.0002	0.00012	0.00006	0.00004	0.00002	0.00001	6E−06	4E−06	2E−06	1E−06	7E−07	4E−07	2E−07	1E−07	8E−08	5E−08	2.6E−08
		0.00626	0.00353	0.00199	0.0011	0.00065	0.00035	0.00019	0.0001	0.00005	0.00003	0.00002	0.00001	6E−06	3E−06	2E−06	1E−06	7E−07	4E−07	2E−07	1E−07	8E−08	5.0E−08
		0.00148	0.00083	0.00047	0.00026	0.00015	0.00008	0.00005	0.00002	0.00001	7E−06	4E−06	3E−06	1E−06	9E−07	5E−07	3E−07	2E−07	1E−07	6E−08	4E−08	2E−08	1.3E−08
		0.00639	0.00352	0.00191	0.00104	0.0006	0.00031	0.00018	0.00007	0.00005	0.00003	0.00002	9E−06	5E−06	3E−06	2E−06	1E−06	5E−07	3E−07	2E−07	1E−07	6E−08	3.4E−08
		0.00587	0.00329	0.00186	0.00104	0.0006	0.00033	0.00018	0.00011	0.00003	0.00002	0.00001	7E−06	4E−06	2E−06	1E−06	7E−07	4E−07	3E−07	1E−07	8E−08	5E−08	2.9E−08
		−0.0002	−9E−05	−5E−05	−3E−05	−1E−05	−8E−06	−5E−06	−4E−06	3E−07	8E−07	5E−07	3E−07	2E−07	1E−07	9E−08	5E−08	3E−08	2E−08	1E−08	8E−09	5E−09	3.1E−09
		0.00299	0.00163	0.00089	0.00047	0.00028	0.00014	0.00008	0.00003	−1E−05	4E−06	2E−06	1E−06	4E−07	2E−07	5E−08	7E−09	−9E−09	−1E−08	−1E−08	−1E−08	−8E−09	−5.5E−09
		0.00361	0.00194	0.00102	0.00053	0.00032	0.00014	0.00009	0.00002	0.00001	9E−06	5E−06	3E−06	1E−06	8E−07	4E−07	2E−07	1E−07	6E−08	3E−08	2E−08	8E−09	3.9E−09
		−0.0011	−0.0005	−0.0003	−0.0002	−9E−05	−5E−05	−3E−05	−2E−05	−9E−06	−5E−06	−2E−06	−1E−06	−9E−07	−5E−07	−3E−07	−2E−07	−9E−08	−5E−08	−3E−08	−2E−08	−1E−08	−5.7E−09

* The figures in the first column are the least squares estimates obtained from the positive observations on Y*. As Fair suggested, if the number of negative observations on Y* are small these least squares estimates could be used as a starting value for the iteration. The number of negative observations on Y* are only 18 in our case.

Matrix V (All observations)

Constant	420.281162	76.8163668	1892.94113	179.4374825	128.6498632	187.857128	126.309322	35.4383738	7265.07232	142.7925217	179.704248	7.91758041
Secondary plus husband	76.8163668	76.8163668	296.542681	46.8431836	6.669727609	12.7814267	0	26.8661838	1614.994696	41.45361066	0	1.2352631
Desired no. of children	1892.94113	296.542681	10539 3574	762.378826	638.1207292	999.037226	633.508483	125.744179	31333 36487	539.6050895	780.601728	12.8637421
Working outside	179.437482	46.8431836	762.378826	179.4374825	50.03682896	88.7416233	49.9000306	29.8883823	3205.41296	58.13251943	65.9158847	2.69767593
Elementary woman	128.649863	6.66972761	638.120729	50.03682896	128.6498632	69.9366979	53.3504831	0	1963.041662	0	57.8409761	1.17425408
No.of dead children	187.857128	12.7814267	999.037226	88.7416233 1	69.93669788	383.913411	90.0303624	6.08854233	2853.496806	26.06223979	48.5921731	0.38021049
Elementary husband	126.309322	0	633.508483	49.90003063	53.35048305	90.0303624	126.309322	1.11038834	1995.342855	16.64204398	0	1.5196092
secondary plus woman	35.4383738	26.8661838	125.744179	29.88838229	0	6.08854233	1.11038834	35.4383738	831.1339976	0	7.4618017	0.76136293
Age at marriage	7265.07232	1614.9947	31333 3649	3205.41296	1963.041662	2853.49681	1995.34286	831.133998	13559 74039	2727.927928	3107.0462	158.442823
Secondary woman	142.792522	41.4536107	539.60509	58.13251943	0	26.0622398	16.642044	0	2727.927928	142.7925217	83.5841862	4.65920255
Secondary husband	179.704248	0	780.601728	65.91588469	57.84097611	48.5921731	0	7.4618017	3107.046195	83.5841862	179.704248	4.37378252
VARIANCE	7.91758041	1.2352631	12.8637421	2.697675929	1.174254078	0.38021049	1.5196092	0.76136293	158.4428234	4.659202546	4.37378252	120.064473

Variance covarianc matrix (Inverse of V)

Constant	$\boxed{0.08950509}$	−0.0198079	−0.0036458	−0.0052844	−0.00733783	−0.0038577	−0.0233642	0.00832985	−0.00251255	−0.002226	−0.02418	−0.0005794
Secondary plus husband	−0.0198079	$\boxed{0.05716177}$	−0.0003659	−0.00018485	−0.00596611	0.00205015	0.03010049	−0.023109	−0.00033495	−0.01392312	0.0360515	0.00024791
Desired no. of children	−0.0036458	−0.0003659	$\boxed{0.00058337}$	0.000190928	0.000139143	−0.0001655	−0.000267	0.000455	0.000056251	0.000584616	−0.0002238	0.00008829
Working outside	−0.0052844	−0.0001848	0.00019093	$\boxed{0.01064212}$	−0.00046186	−0.0005583	0.00053761	−0.0048155	0.000019222	−0.0006406	0.00101466	0.00008336
Elementary woman	−0.0073378	−0.0059661	0.00013914	−0.00046186	$\boxed{0.017711992}$	0.00043815	−0.003626	0.01139078	0.000068894	0.011127518	−0.005757	0.00002678
No. of dead children	−0.0038577	0.00205015	−0.0001655	−0.0005583	0.000438149	$\boxed{0.00390925}$	0.00078211	0.00070897	0.000065321	0.000883347	0.00201288	0.00003872
Elementary husband	−0.0233642	0.03010049	−0.000267	0.000537606	−0.00362599	0.00078211	$\boxed{0.03592898}$	−0.0033708	−0.0001292	−0.00362259	0.02933898	0.0000895
secondary plus woman	0.00832985	−0.023109	0.000455	−0.00481555	0.011390779	0.00070897	−0.0033708	$\boxed{0.06271115}$	−0.00088873	0.021503869	−0.0096372	−3.136E−05
Age at marriage	−0.0025126	−0.0003349	0.00005625	0.000019222	0.000068894	0.00006532	−0.0001292	−0.0008887	$\boxed{0.000147515}$	−0.00034956	−0.0001295	−7.318E−06
Secondary woman	−0.002226	−0.0139231	0.00058462	−0.0006406	0.011127518	0.00088335	−0.0036226	0.02150387	−0.00034956	$\boxed{0.024088593}$	−0.0099503	−7.134E−05
Secondary husband	−0.02418	0.0360515	−0.0002238	0.001014663	−0.00575699	0.00201288	0.02933898	−0.0096372	−0.0001295	−0.00995031	$\boxed{0.03891833}$	0.00010381
VARIANCE	−0.0005794	0.00024791	0.00008829	0.000083357	0.000026777	0.00003872	0.0000895	−3.136E−05	−7.3182E−06	−7.1343E−05	0.00010381	$\boxed{0.00836051}$

Note: The figures in the boxes are the asymptotic variances of the respective estimates

2. Five observations deleted

Esimates of Coefficients

Iteration Step

	1*	2	3	4	5	6	7	8	9	10	11
Constant	−0.434945	−0.4746163	−0.4970568	−0.50975411	−0.51691681	−0.5209874	−0.5233123	−0.5246217	−0.52534256	−0.52576243	−0.526007
Age at marriage	−0.016557	−0.0167486	−0.0168523	−0.01690922	−0.01693978	−0.0169568	−0.0169644	−0.0169694	−0.01697258	−0.01697432	−0.0169753
No. of dead children	1.178957	1.18052439	1.1814054	1.18190301	1.182181793	1.18233964	1.18242768	1.18247873	1.182506381	1.182522388	1.18253165
Desired no. of children	0.96869	0.97398561	0.97698761	0.978690691	0.979654606	0.98020314	0.98051528	0.98069227	0.980792761	0.980851359	0.98088553
Elementary woman	−0.089284	−0.0818296	−0.0776155	−0.07522611	−0.07387773	−0.0731104	−0.0726798	−0.0724314	−0.07229171	−0.07221041	−0.0721631
Secondary woman	−0.422054	−0.4198541	−0.418689	−0.41806154	−0.41773402	−0.4175512	−0.4174783	−0.417425	−0.41740083	−0.4173886	−0.4173826
secondary plus woman	−0.331456	−0.3248777	−0.3211833	−0.31908827	−0.31791406	−0.3172411	−0.3168861	−0.3166684	−0.3165444	−0.31647272	−0.3164313
Working outside	0.130633	0.13577215	0.13867457	0.140303293	0.141219213	0.14174073	0.14203986	0.14220151	0.142291204	0.142343151	0.14237323
Elementary husband	0.115085	0.12251981	0.12662938	0.12890634	0.13015231	0.13085113	0.1312317	0.13144676	0.131553822	0.13161427	0.13164834
Secondary husband	−0.19304	−0.1891687	−0.187092	−0.18596873	−0.18538036	−0.1850593	−0.1848953	−0.1848002	−0.18476313	−0.18474367	−0.1847336
Secondary plus husband	0.154913	0.17098535	0.18000945	0.185087186	0.187925373	0.18952742	0.19042914	0.19093919	0.191218319	0.191379494	0.19147254
SIGMA	1.11407	1.11268	1.11189	1.11144	1.11119	1.11105	1.11097	1.11092	1.1109	1.1109	1.1109
		Differences at each step									
		−0.0396713	−0.0224405	−0.01269735	−0.0071627	−0.0040705	−0.0023249	−0.0013094	−0.00072088	−0.00041987	−0.0002445
		−0.0001916	−0.0001036	−5.6970E−05	−3.0555E−05	−1.702E−05	−7.555E−06	−5.027E−06	−3.1988E−06	−1.7426E−06	−9.435E−07
		0.00156739	0.00088101	0.00049761	0.000278784	0.00015785	0.00008804	0.00005105	0.00002765	0.000016007	9.265E−06
		0.00529561	0.003002	0.001703078	0.000963915	0.00054854	0.00031214	0.00017699	0.000100488	0.000058598	0.00003417
		0.00745436	0.00421415	0.002389379	0.001348384	0.00076732	0.00043062	0.00024838	0.00013969	0.000081296	0.00004731
		0.00219987	0.00116516	0.000627424	0.000327514	0.00018287	0.00007283	0.00005331	0.000024178	0.000012237	6.031E−06
		0.00657834	0.00369436	0.002095032	0.001174212	0.00067295	0.00035496	0.00021779	0.000123954	0.00007168	0.00004145
		0.00513915	0.00290241	0.001628728	0.00091592	0.00052152	0.00029913	0.00016165	0.00008969	0.000051947	0.00003008
		0.00743481	0.00410957	0.002276964	0.001245971	0.00069882	0.00038056	0.00021506	0.000107064	0.000060448	0.00003407
		0.00387128	0.0020767	0.001123288	0.000588373	0.0003211	0.00016397	0.0000951	0.00003706	0.00001946	0.00001007
		0.01607235	0.00902411	0.005077731	0.002838187	0.00160205	0.00090172	0.00051005	0.00027913	0.000161176	0.00009304
		−0.00139	−0.00079	−0.00045	−0.00025	−0.00014	−8.000E−05	−5.000E−05	−2.0000E−05	0	0

* Here also the figures in the first column are the least squares estimates obtained from the positive observations on Y*. As Fair suggested, if the number of negative observations on Y* are small these least squares estimates could be used as a starting value for the iteration. Here again the number of negative observations on Y* are only 18.

Matrix V (Five observations deleted)

Constant	558.36652	9641.28342	249.065547	2487.309415	168.6065582	195.197059	44.8892825	234.506904	166.490554	242.5175966	100.003075	10.8763913
Age at marriage	9641.28342	179423.207	3779.19319	41181.22519	2576.713036	3721.72074	1043.97764	4172.18467	2629.269298	4194.517424	2096.98081	221.118014
No. of dead children	249.065547	3779.19319	509.9223	1319.698656	93.03467073	34.6463345	7.29005288	117.206594	119.7949072	63.80817329	17.009589	0.60822445
Desired no. of children	2487.30941	41181.2252	1319.69866	13603.07688	833.165899	724.649422	154.969896	994.883473	836.7114078	1025.171138	382.989575	15.2321264
Elementary woman	168.606558	2576.71304	93.0346707	833.165899	168.6065582	0	0	64.9162615	69.43501501	76.83585435	8.06167939	1.91392676
Secondary woman	195.197059	3721.72074	34.6463345	724.6494222	0	195.197059	0	77.2938673	22.07120563	116.4920297	55.1963244	5.56983218
secondary plus woman	44.8892825	1043.97764	7.29005288	154.9698958	0	0	44.8892825	37.5125674	1.464871036	9.109202994	34.3152085	1.24399459
Working outside	234.506904	4172.18467	117.206594	994.8834731	64.91626147	77.2938673	37.5125674	234.506904	64.63206563	86.80949062	60.861312	4.45241936
Elementary husband	166.490554	2629.2693	119.794907	836.7114078	69.43501501	22.0712056	1.46487104	64.6320656	166.490554	0	0	2.50544742
Secondary husband	242.5175975	4194.51742	63.8081733	1025.171138	76.83585435	116.49203	9.10920299	86.8094906	0	242.5175966	0	5.01300628
Secondary plus husband	100.003075	2096.98081	17.009589	382.9895748	8.06167939	55.1963244	34.3152085	60.861312	0	0	100.003075	1.98491417
VARIANCE	10.8763913	221.118014	0.60822445	15.23212637	1.913926763	5.56983218	1.24399459	4.45241936	2.505447417	5.013006284	1.98491417	212.444345

Variance covarianc matrix (Inverse of V)

Constant	0.0684897	−0.0019034	−0.0028966	−0.00289096	−0.00547508	−0.0020539	0.00520243	−0.0038751	−0.01779742	−0.01866513	−0.0148564	−0.0003666
Age at marriage	−0.0019034	0.00011225	0.00004945	0.000041656	0.00004717 7	−0.0002616	−0.0006447	0.00001276	−9.8358E−05	−9.6616E−05	−0.0002641	−6.664E−06
No. of dead children	−0.0028966	0.00004945	0.00295699	−0.00013171	0.000316447	0.00068324	0.00059207	−0.0004297	0.000588686	0.001522761	0.00151647	0.00002554
Desired no. of children	−0.002891	0.00004166	−0.0001317	0.000470785	0.0000972	0.00048735	0.00044931	0.00012365	−0.00019609	−0.00011224	−0.0002706	0.00005989
Elementary woman	−0.0054751	0.00004718	0.00031645	0.0000972	0.013462587	0.00846323	0.00864941	−0.0003159	−0.00267633	−0.00437766	−0.0044728	0.00001278
Secondary woman	−0.0020539	−0.0002616	0.00068324	0.00048735	0.008463231	0.01816929	0.01632535	−0.0003751	−0.00269197	−0.00754933	−0.0105276	8.450E−06
secondary plus woman	0.00520243	−0.0006447	0.00059207	0.000449313	0.008649411	0.01632535	0.04841749	−0.0034586	−0.00255963	−0.0072694	−0.0177217	0.00002114
Working outside	−0.0038751	0.00001276	−0.0004297	0.000123652	−0.00031588	−0.0003751	−0.0034586	0.00801313	0.000462182	0.000786143	−0.0002509	0.00002081
Elementary husband	−0.0177974	−9.836E−05	0.00058869	−0.00019609	−0.00267633	−0.002692	−0.0025596	0.00046218	0.027234103	0.022242963	0.02280805	0.00006676
Secondary husband	−0.0186651	−9.662E−05	0.00152276	−0.00011224	−0.00437766	−0.0075493	−0.0072694	0.00078614	0.022242963	0.02953604	0.0273955	0.00010805
Secondary plus husband	−0.0148564	−0.0002641	0.00151647	−0.00027059	−0.00447277	−0.0105276	−0.0177217	−0.0002509	0.022808055	0.027395501	0.04357461	0.00015333
VARIANCE	−0.0003666	−6.664E−06	0.00002554	0.000059885	0.000012778	8.450E−06	0.00002114	0.00002081	0.000066757	0.000108054	0.00015333	0.00472279

Note: The figures in the boxes are the asymptotic variances of the respective estimates

Specification Test for Tobit Model

X'Y	1/n X'Y	(X'FXB+σX'Ø)	Exy= 1/n(X'FXB+σX'Ø)	1/nX'Y – Exy
2740	3.93113343	2742.9432838	3.93535621784	−0.0042228
44026	63.1649928	44092.592314	63.2605341669	−0.0955413
2102	3.01578192	2102.8064434	3.01693894324	−0.001157
15599	22.3802009	15619.109083	22.4090517692	−0.0288509
976	1.40028694	978.69498065	1.40415348731	−0.0038665
642	0.92109039	641.04090704	0.9197143573	0.00137603
144	0.20659971	145.88513796	0.20930435862	−0.0027046
1130	1.62123386	1133.3322744	1.6260147409	−0.0047809
1049	1.50502152	1051.2551686	1.50825705679	−0.0032355
996	1.42898135	991.96560422	1.42319311939	0.00578823
373	0.53515065	377.40972222	0.5414773633	−0.0063267

m = 0.3011

$Q = V^{-1}$ (On page 20)

U1=(1/n)X'UyX

1.1195708	19.057758	0.54348365	5.28609947	0.3574901959	0.35978538386	0.08764356	0.4799809	0.3478445	0.4711159	0.20115019
19.057758	348.9969	8.24609571	86.8293409	5.4393247316	6.80864620298	2.00487199	8.4342392	5.4406774	8.0340144	4.1472635
0.5434837	8.2460957	1.12173293	2.91512026	0.2038347339	0.07368131855	0.0160246	0.2550052	0.2626902	0.1379867	0.03724599
5.2860995	86.829341	2.91512026	29.5530641	1.8132654003	1.46139646331	0.31804771	2.1297873	1.8191304	2.1392053	0.80038631
0.3574902	5.4393247	0.20383473	1.8132654	0.3574901959	0	0	0.13617	0.1498205	0.1622428	0.01704251
0.3597854	6.8086462	0.07368132	1.46139646	0	0.35978538386	0	0.1549009	0.0413021	0.2055467	0.11118612
0.0876436	2.004872	0.0160246	0.31804771	0	0	0.08764356	0.0742076	0.0017607	0.0183139	0.06756895
0.4799809	8.4342392	0.25500517	2.12978727	0.1361699886	0.15490086142	0.07420759	0.4799809	0.1354641	0.1768583	0.12279956
0.3478445	5.4406774	0.26269024	1.81913043	0.1498205495	0.04130213813	0.00176069	0.1354641	0.3478445	0	0
0.4711159	8.0340144	0.13798667	2.13920534	0.1622427973	0.20554665978	0.01831391	0.1768583	0	0.4711159	0
0.2011502	4.1472635	0.03724599	0.80038631	0.0170425145	0.11118611984	0.06756895	0.1227996	0	0	0.20115019

$$Uo = 1/n\,^\wedge 2\ \ [X'FX\ \ X'\varnothing]\ \ Q \begin{bmatrix} X'FX \\ X'\varnothing \end{bmatrix}$$

0.0015854	0.0269762	0.00077348	0.00751928	0.0005092426	0.00050222504	0.00012591	0.0006867	0.0004963	0.0006595	0.00028804
0.0269762	0.4935044	0.01174867	0.12351806	0.0077564627	0.00950688933	0.00286922	0.0120742	0.0077778	0.0112272	0.00592308
0.0007735	0.0117487	0.0015899	0.00413504	0.0002891176	0.00010647137	0.00002296	0.0003635	0.0003728	0.0001979	0.00005337
0.0075193	0.1235181	0.00413504	0.04205186	0.0025862226	0.00206362267	0.00045617	0.003043	0.0025915	0.0030303	0.00114537
0.0005092	0.0077565	0.00028912	0.00258622	0.0005068828	1.599122E−06	3.001E−07	0.0001929	0.0002128	0.0002317	0.00002485
0.0005022	0.0095069	0.00010647	0.00206362	1.59912E−06	0.00049830359	1.005E−06	0.0002241	0.0000603	0.000279	0.0001593
0.0001259	0.0028692	0.00002296	0.00045617	3.00074E−07	1.005245E−06	0.00012439	0.0001063	3.33E−06	0.0000266	0.00009588
0.0006867	0.0120742	0.00036351	0.00304298	0.0001929054	0.00022405819	0.00010633	0.0006828	0.0001931	0.0002544	0.0001753
0.0004963	0.0077778	0.00037277	0.00259147	0.0002127629	0.00006029522	3.332E−06	0.0001931	0.0004934	1.96E−06	6.885E−07
0.0006595	0.0112272	0.00019787	0.0030303	0.0002317388	0.0002790237	0.00002659	0.0002544	1.96E−06	0.0006551	1.729E−06
0.000288	0.0059231	0.00005337	0.00114537	0.0000248454	0.00015929856	0.00009588	0.0001753	6.89E−07	1.73E−06	0.00028542

U1 – Uo

1.1179854	19.030782	0.54271018	5.27858019	0.3569809533	0.35928315882	0.08751765	0.4792942	0.3473482	0.4704563	0.20086214
19.030782	348.50339	8.23434704	86.7058228	5.431568269	6.79913931365	2.00200277	8.422165	5.4328995	8.0227871	4.14134042
0.5427102	8.234347	1.12014303	2.91098522	0.2035456163	0.07357484718	0.01600164	0.2546417	0.2623175	0.1377888	0.03719262
5.2785802	86.705823	2.91098522	29.5110122	1.8106791777	1.45933284065	0.31759154	2.1267443	1.816539	2.136175	0.79924094
0.356981	5.4315683	0.20354562	1.81067918	0.3569833132	−1.599122E−06	−3.001E−07	0.1359771	0.1496078	0.1620111	0.01701767
0.3592832	6.7991393	0.07357485	1.45933284	−1.59912E−06	0.35928708027	−1.005E−06	0.1546768	0.0412418	0.2052676	0.11102682
0.0875177	2.0020028	0.01600164	0.31759154	−3.00074E−07	−1.005245E−06	0.08751917	0.0741013	0.0017574	0.0182873	0.06747307
0.4792942	8.422165	0.25464166	2.12674428	0.1359770833	0.15467680322	0.07410126	0.4792981	0.135271	0.1766039	0.12262426
0.3473482	5.4328995	0.26231746	1.81653897	0.1496077866	0.04124184291	0.00175736	0.135271	0.3473512	−1.96E−06	−6.885E−07
0.4704563	8.0227871	0.13778881	2.13617504	0.1620110585	0.20526763608	0.01828733	0.1766039	−1.96E−06	0.4704607	−1.729E−06
0.2008621	4.1413404	0.03719262	0.79924094	0.0170176691	0.11102682128	0.06747307	0.1226243	−6.89E−07	−1.73E−06	0.20086477

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