THE CURVILINEARITY BETWEEN INCOME AND FERTILITY: EVIDENCE FROM KOREA*

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This study analyzes a relationship between income and fertility in Korea. Based on the methodological considerations, this study employs a standardization technique in polynomial regression analysis to deal with curvilinearity and multicollinearity problems. An alternative measure of family income is constructed to cope with the difficulties associated with survey income data. The research is based on the 1974 Korean National Fertility Survey (KNFS).

The findings of the analyses suggest that the relationship between income and fertility is more complex than a simple linear pattern. An accurate description involves a cubic relationship: Those in the lowest income group tend to have more children ever born (CEB) as income increases. Among those in the middle income group, the relationship between income and CEB is negative. For the highest income group, CEB tends to rise slightly as income increases. The pattern of demand for children with respect to income is similar to the CEB pattern. Implying the existence of unwanted fertility, CEB is found to be consistently higher than demand for children, although the gap between the two becomes smaller as income increases.

Introduction

Since Becker (1960) claimed that variation in fertility could be understood within the same framework economists used for the analysis of the demand for durable goods, many economists have been interested in the determinants of and differentials in fertility, while differing in the importance attached to various causal variables. Various theories of fertility behavior have developed from the microeconomic perspective such as the utility model, the investment model, and, more recently, the time-allocation model. In different ways, these theories have contributed to our understanding of income differentials in fertility (Becker, 1960, 1964, 1965; Leibenstein, 1957, 1975, 1977, 1981; Easterlin, 1969, 1975, 1978; Mincer, 1963; D. Freedman, 1963; Willis, 1973; Cain and Weininger, 1973; Leriden, 1976).

An enormous amount of empirical research is available on fertility determinants and differentials. Numerous studies have been reviewed by Hawthorn (1970), United Nations (1973), R. Freedman (1975), Andorka (1978), Miró and Potter (1980), and recently by the United States National Academy of Sciences Panel on the determinants of fertility (Bulatao *et al.*, 1983).

Despite theoretical speculations and predictions during the last twenty years that the relationship between income and fertility will reverse itself from a negative to a positive one in advanced societies (Goldscheider, 1965; Andorka, 1978), some studies have found that there still exists an overall negative relationship between income and fertility (Bern-

* I am very grateful to Drs. Calvin Goldscheider, Sidney Goldstein, Robert M. Marsh, Alden Speare, Jr., Robert D. Retherford, and Bhassorn Limanonda for their helpful comments on earlier drafts of this paper. I would also like to thank Helen F. Takeuchi for her editorial assistance.

hardt, 1972; Stokes, 1973; Westoff and Ryder, 1977), while others found a positive relationship (Ridker, 1976; Heer, 1966), or even no significant relationship (Goldberg, 1959; United Nations, 1973; Mueller and Cohn, 1977). Studies that used relative income based on the couple's socioeconomic status, as an indicator of income, generally found a positive relationship between income and fertility (D. Freedman, 1963; Kunz, 1965; Easterlin, 1972; Chaudhury, 1977). Recently, Repetto (1979) and Easterlin (1975) argued a curvilinear relationship, that is, income has positive effects on fertility at low income level, but the relationship becomes negative as income increases. However, the curvilinearity between income and fertility has not yet been sufficiently explored in empirical studies.

The objective of this paper is to examine the theoretical and empirical basis of the relationship between income and fertility in Korea. To demonstrate and overcome some of the methodological difficulties researchers face when analyzing variations in fertility, the present study explores a standardization technique for dealing with curvilinearity between income and fertility in polynomial regression analysis. In this paper, it is assumed that the flow of causation is unidirectional, from income to fertility. In other words, income is considered an exogenous independent variable in relation to fertility. The direction of causation between income and fertility can be two ways. Unfortunately, however, the statistical techniques available do not allow us to deal with bi-directional causality properly. It is particularly true when the polynomial terms are involved in the analysis. It is well known that income is correlated with other socioeconomic determinants of fertility. However, it is not the main concern of this study to distinguish "pure" income effects and indirect income effects caused by the association of income with other fertility-influencing variables.

Theoretical Framework

This study attempts to decompose fertility into three component factors: demand for children, fertility regulation, and fecundity. It is designed to examine the effect of income on each of these three component factors.

Demand for children (more specifically, desired number of children under the perfect control of fertility) has become more important as the knowledge and practice of contraception became widespread. In many studies, it has been considered one of the important determinants of fertility behavior (Campbell, 1963; R. Freedman, 1963; Sagi and Westoff, 1963; Rainwater, 1965; Stycos, 1965; Bumpass, 1967; Yaukey, 1969; Bumpass and Westoff, 1970; Gustavus and Nam, 1970; Knodel and Prachuabmoh, 1973). In particular, it has been a key concept of the microeconomic theory of fertility (Becker, 1960; D. Freedman, 1963; Easterlin, 1969, 1975, 1978; Willis, 1973; Leibenstein, 1975, 1977, 1981).

There have been arguments on the errors in the concept and measurement of demand for children or desired family size. We cannot be sure that respondents are answering in terms of similar frames of references (Blake, 1966). The intensity of opinion or attitude reported might be difficult to handle (Hauser, 1967). In addition, some people revise their demand or preference over the life cycle (R. Freedman *et al.*, 1965; Bumpass, 1967; Sagi and Westoff, 1963). The problem of rationalization of unwanted births into wanted births is also well known. Despite these limitations, however, demand for children or desired family size has been considered a fair predictor of actual size and has been continuously employed in many fertility studies.

A modified microeconomic model of demand for children is introduced into the theoretical framework of this study. The number of children demanded by the couple is assumed to be largely a matter of decision making based on an economic calculus. Demand for children is determined jointly by the cost and benefit of having children, opportunity cost (especially of the wife), and strength of desires for the alternative goods[1]. Children entail the expenditure of monetary and time costs. Children are also a source of economic and psychic benefits. Income strongly affects the ability to afford the cost as well as the perceived benefit of having children. The time cost of children depends on the amount and value of the time devoted. Value of the time depends on the alternative uses of the time available (e.g., earning capacity), which is affected by the couple's socioeconomic status or income. Finally, demand for children also depends on the couple's aspiration for a particular standard of living, more specifically, the strength of desires for the alternative goods other than children.

In this study, a cubic relationship between income and demand for children is proposed as follows. As income increases at the low level, the couple can afford the cost of having more children. However, opportunity cost and desires for the alternative goods, which have negative effects on demand for children, also increase as income rises. As Leibenstein (1976) argued, the committed income, which is based on the strength of desires for the alternative goods other than children, rises more rapidly as income increases and thus the ratio of the uncommitted income falls. In addition, as income increases, children's utility as a source of income and as a source of security after the parents' retirement declines. Above a certain point of low income these three factors (opportunity cost, desires for the alternative goods, and economic utility of children) raise the relative cost of children, and thus make the couple lower their demand for children to maximize their economic and noneconomic utility.

But, in the case of the highest income group, the couple is not so much affected by opportunity cost, desires for the alternative goods, and economic utility of children. Without being constrained by these three factors, the couple in the highest income group can afford to have more children and, therefore, demand for children increases again as income increases above a certain point of high income. Many studies report that those in the highest income group have higher fertility than those in the next higher income group (Cho *et al.*, 1970; Bernhardt, 1972).

In addition to demand for children, fertility behavior is also affected jointly by the effectiveness of fertility regulation and fecundity. Income influences fertility regulation. Income, or socioeconomic status in general, is positively related with the level of husband-wife communication and favorable attitudes toward fertility regulation. In addition, as income or socioeconomic status rises, contraceptive knowledge and services become more available and acceptable. Therefore, the couple can regulate their fertility more effectively and have lower unwanted fertility.

In most cases, actual family size is higher than desired family size because of the existence of unwanted children and contraceptive failure beyond a certain point of low income, where the nutritional factor does not impede fecundity. If actual family size is below the desired size, the couple would not try to regulate their fertility behavior. The couple with desired family size also would not use contraception with perfect efficiency unless the marginal cost of contraception is zero (Easterlin, 1980). Therefore, actual completed family size would usually be greater than the desired size when fecundity is assumed not to be a factor.

Finally, income affects fecundity; the potential biological supply of children. Income is related to the health of parents – especially of the mother – through knowledge of hygiene and nutrition, and by affecting access to modern medicine and adequate food supplies. For those in the medium or high income group, however, fecundity may not be an important

1. The alternative goods are defined as, given limited resources, the objects of expenditure that compete with children and thus alternatively consumed by the parents.

factor of fertility differentials nowadays. It is hypothesized in this study that for those in the lowest income group, the nutritional status of the mother can be improved as income increases resulting in a rise in fecundity.

Breastfeeding deserves attention in this context. It is generally agreed that breastfeeding has inhibiting effects on ovulation and menstruation and thus leads to temporary infecundity. Cross-national analyses of less developed countries recently indicate that wife's education, husband's occupation, and urban residence are associated with a shorter duration of breastfeeding (Jain and Bongaarts, 1980, 1981; Jain, 1981). This study also explores the relationship between income and breastfeeding.

From the theoretical background discussed above, as Figure 1 shows, a cubic relationship between income and fertility is hypothesized in this study:

$$F = a + b_1X + b_2X^2 + b_3X^3 \quad (1)$$

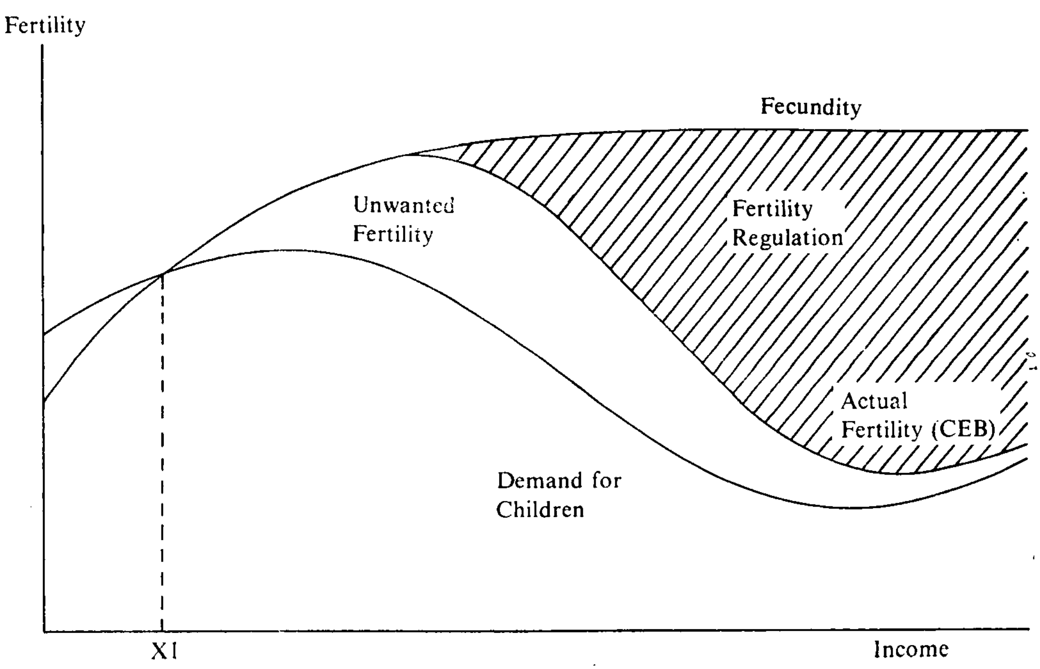
where F represents children ever born; X, income; a, constant; and b_1, b_2, and b_3, unstandardized regression coefficients. Specific hypotheses of this study are as follows:

1. Those in the lowest income group are likely to have more children ever born (CEB) as income increases. Among those in the middle income group, the relationship between income and CEB is negative. For the highest income group, CEB is likely to rise slightly as income increases.

2. Those in the lowest income group are likely to have higher demand for children as income increases. Among those in the middle income group, the relationship between income and demand for children is negative. For the highest income group, demand for children is likely to increase slightly as income increases.

3. For the lowest income group, among whom nutritional and health factors are likely to impede fecundity, demand for children (desired number of children) is likely to be

Figure 1: **Hypothesized Relationship Between Income and Fertility**



larger than CEB (actual fertility); above that level of income, CEB is always likely to be larger than demand for children, although the gap between the two becomes smaller as income increases.

Methodology

Data

The data used for the analysis is from the 1974 Korean National Fertility Survey (KNFS). The KNFS was conducted as part of the World Fertility Survey.

The present study focuses on women aged between 40 and 49, who had almost finished childbearing at the time of the survey. The size of completed fertility is the focus of interest. By focusing on this group, we can reduce substantially the direct and indirect effects of women's age as well as of the socioeconomic events on fertility. To avoid the effects of exogenous factors on fertility, the sample of this study is confined to the currently married women who were in their first marriage. The sample size of this study is 1,174.

It should be noted that there are potential biases in this selection. The fertility of this age cohort might have been affected by the socioeconomic events that occurred during the childbearing period of this cohort. During their childbearing period, women aged 40–49 in this study experienced the Korean War (1950–1953) and the post-war baby boom. The exact effects of these events on fertility differentials cannot be assessed. In addition, the exclusion of women who are not in their first marriage can be a source of bias. Given the problem of accuracy and reliability of the data used, the exact effect of these sampling biases cannot be ascertained.

Difficulties in Income Measurement

The adequacy of measurement is one of the most important problems in many empirical studies of fertility. Many studies are seriously hampered by problems of the inadequate measurement and the unsuitability of the underlying data base.

While income measures have an advantage in that they are easy to operationalize and interpret, the availability and quality of income data are poor in most cases. Since the nonresponse rate on income is relatively high, many studies allocate income for non-response cases according to other characteristics of these cases. In addition, income data in many studies must be handled with extreme caution since it is very difficult to obtain accurate information because of many forms of "hidden" income such as bonuses, business "gifts" and "compensation" for services (Barringer, 1971). Moreover, reported farm family income in Korea is somewhat suspect. Usually they are converted from the estimates of agricultural production, some of which are for their own consumption and not realizable as disposable income. Finally, the wealthier families have a variety of property income and would more likely underestimate their income than those with lower income. Therefore, as income increases, there might be a larger difference between reported income and real income (MacDonald and Mueller, 1975). It is also generally recognized that high income families are more uncooperative to interviewers and, therefore, are likely to be under-estimated in the survey (Barringer, 1971).

The measurement error in income weakens the observed relationship between income and fertility. This can be illustrated by the following formula (Lansing and Morgan, 1971: 311):

$$\mathrm{B}n=\frac{\Sigma(\mathrm{x}-\bar{x})(\mathrm{y}-\bar{y})+\Sigma(\mathrm{x}-\bar{x})(\mathrm{v}-\bar{v})+\Sigma(\mathrm{y}-\bar{y})(\mathrm{u}-\bar{u})+\Sigma(\mathrm{u}-\bar{u})(\mathrm{v}-\bar{v})}{\Sigma(\mathrm{x}-\bar{x})^2+2\Sigma(\mathrm{x}-\bar{x})(\mathrm{u}-\bar{u})+\Sigma(\mathrm{u}-\bar{u})^2} \tag{2}$$

where,

x is the true value of income measure;
u is the error in observed income;
y is the true value of fertility measure;
v is the error in observed fertility; and
B*n* is the regression coefficient from a sample size of n.

In this formula, we can assume that neither the true value of income (x) nor fertility (y) is correlated with the error in the other variable. We can also assume that the errors in income and fertility (u and v) are not correlated with each other. Therefore, the terms in the numerator are not the source of bias. However, we can suspect that the error in income (u) is likely to be positively correlated with the value of income (x), and hence the second term in the denominator can be a source of downward bias in the regression coefficient (B*n*). The last term in the denominator also indicates that the larger the error in observed income (u), the greater the downward bias toward zero in the regression coefficient (B*n*).[2]

Another source of difficulty is the unavailability of cumulative family income data. In many studies, ambiguity and confusion have been caused by the lack of proper definition and operationalization of income. This is particularly true when a measure of current income is used in the analysis of cumulative fertility or completed family size such as children evern born. Since income varies over time, ideally, income in the analysis of completed fertility should be the cumulative family income over a long period rather than any particular year. If income is the independent variable, it should be measured prior to fertility. However, these kinds of data are usually not available. Income data in most analyses of completed fertility refer to the point when a couple have already finished their reproductive behavior.

There have been arguments and suggestions over how best to define and operationalize an income variable for use in fertility analysis. Easterlin (1969, 1978) and Turchi (1975) have both suggested "potential income," which refers to amount of money the family could make over a lifetime if all sources were employed at full capacity. As long term variables of income, "permanent income" (Gardner, 1973; Stafford, 1969) and "full income" (Willis, 1973) also have been suggested. D. Freedman (1963) and Chaudhury (1977) employed "relative income" based on the couple's socioeconomic status, which also refers to capacity to produce rather than actual income. To consider the cumulative aspect of earning capacity, several studies (Goldberg, 1975; Thornton, 1979; MacDonald and Mueller, 1975) constructed indices of family assets or modern objects. However, it can be noted that they are affected not only by capacity but also by decisions about income allocation.

Variables

The independent variables in the present study are family income and expected family income. A group of fertility-component variables employed in this study include demand for children, fecundity, breastfeeding, and contraception. The dependent variable is children ever born. These variables are defined and operationalized as follows:

a. Family Income:
Total family income during the last month.

b. Expected Family Income:

2. The measurement errors in income also affect the adjusted mean of multiple classification analysis in the same way. For more discussion, see Lansing and Morgan (1971: 314–331).

Family income predicted on the basis of the couple's socioeconomic status. In this study, we do not have information on the shape and height of the life-cycle family income profile. In fact, income was measured long after childbearing took place. To cope with the problems of income data discussed above, expected family income was constructed by regressing the natural logarithmic value of family income on the various indicators of the couple's socioeconomic status. Several dummy variables were created in predicting expected family income by including place of residence and working experience of a wife, which were measured in nominal and ordinal scales[3].

$$\text{ExpInc} = 9.673 + 0.025(\text{WEduc}) + 0.034(\text{HEduc}) + 0.015(\text{HOccPr}) + 0.378^{*} (\text{Seoul}) + 0.281(\text{City}) - 0.145(\text{Home}) - 0.107(\text{Farm}) - 0.215(\text{Out}) \quad (3)$$

where ExpInc represents expected family income; WEduc, education of wife; HEduc, education of husband; and HOccPr, occupational prestige of husband. The dummy variables in the above equation were operationalized as follows:

Seoul = 1, if woman lives in Seoul; zero, otherwise.
City = 1, if woman lives in a city other than Seoul; zero, otherwise.
Home = 1, if woman has worked at home; zero, otherwise.
Farm = 1, if woman has worked on a farm; zero, otherwise.
Out = 1, if woman has worked outside the home; zero, otherwise.

Based on examinations of residuals against the independent variables and the fitted values of the above equation, it was concluded that the disturbances for the regression line have expectations of zero. The multiple R of this regression equation is 0.58; about 1/3 variance in family income is explained by the additive effects of the independent variables[4].

c. Demand for Children:

Number of children couples wanted and agreed on at the time of marriage. Although the couple did not have exactly the same number of wanted children, if the difference is just one, the midpoint is taken as the couple's demand for children. If the difference in the wanted numbers of children is two or larger, the missing value is assigned to this variable.

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3. One of the interesting findings in the KNFS data is that, as indicated by negative regression coefficients of Home, Farm, and Out in equation (3), the average income level of families with working wives is lower than that of families with nonworking wives. For more discussion on this relationship, see Kim (1984: 214–226).
4. In this study, expected family income is used as an alternative measure of family income. The correlation coefficient between family income and expected family income is 0.49. Expected family income explains more of the variations in CEB and the fertility-component variables than family income does. For example, when the linear and higher order terms of family income are used as independent variables in the polynomial regression analysis of CEB, the R^2 is 0.04. In contrast, when expected family income is used in the polynomial regression of CEB, the R^2 is 0.15 (Table 3). Considering that expected family income was constructed by regressing family income on the indicators of the couple's socioeconomic status, this substantial difference reflects, in part, the difficulties and problems of using survey income data discussed earlier. Given the measurement error in family income, equation (2) illustrates a downward bias toward zero in the regression coefficient of family income. In fact, when CEB is regressed on the natural logarithmic value of family income and expected family income, the results are as follows:

$$\text{CEB} = 11.96 - 0.59 * \ln(\text{Family Income}) \quad (a)$$
$$\text{CEB} = 25.32 - 1.85 * (\text{Expected Family Income}) \quad (b)$$

Because of difficulties in the comparision of corresponding regression coefficients in two polynomial regression equations, ordinary regression equations are constructed. To produce linearity

d. Fecundity:
A dummy variable, equal to one, if woman reported that she had been fully fecund (including volunteered sterility); zero, if woman had been subfecund or infecund for biological reasons.

e. Breastfeeding:
Average duration (in months) of breastfeeding per child.

f. Contraception:
Percentage of closed birth intervals with contraceptive practice.

g. Children Ever Born:
Children ever born alive to a woman.

Findings

Overall, the KNFS sample of this study composed of 1,174 women reveals a high level of fertility. As Table 1 shows, 84.8 percent of women aged 40–44 have four or more children ever born (CEB). A peak occurs at parity 5 for women aged 40–44; 21.5 percent have 5 CEB, and the proportion by parity declines as CEB rises or falls. Women aged 45–49 show a different distribution pattern. For women aged 45–49, the proportion by parity increases as CEB rises, with 27.5 percent having eight or more CEB. The average CEB for these two age groups are 5.4 and 6.3, respectively[5].

The relationships of two income measures with CEB are presented in Table 2. Among women aged 40 or older in the KNFS, 83 percent of the respondents reported their family income of the last month. When family income is categorized into four groups, its relationship to CEB is found to be a linear and a negative one for both age groups. Table 2 suggests that expected family income is negatively related with CEB with a minor exception. However, differences in CEB are not substantial among the families which belong to the lowest 40 percent of expected family income, suggesting a curvilinear relationship.

Table 1: **Distribution of Children Ever Born to Women Aged Between 40 and 49**

	Age 40–44	Age 45–49	Total
	No. (%)	No. (%)	No. (%)
All Women	701 (100.0)	473 (100.0)	1,174 (100.0)
CEB			
0	5 (0.7)	5 (1.1)	10 (0.9)
1	16 (2.3)	7 (1.5)	23 (2.0)
2	31 (4.4)	8 (1.7)	39 (3.3)
3	54 (7.7)	18 (3.8)	72 (6.1)
4	115 (16.4)	50 (10.6)	165 (14.1)
5	151 (21.5)	83 (17.5)	234 (19.9)
6	130 (18.5)	84 (17.8)	214 (18.2)
7	100 (14.3)	88 (18.6)	188 (16.0)
8+	99 (14.1)	130 (27.5)	229 (19.5)
Mean of CEB	5.41	6.28	5.76

and to be comparable with equation (b), family income is transformed to the natural logarithmic scale in equation (a). It is clear that these two regression equations are comparable to each other, and that the regression coefficient of family income in equation (a) is depressed. Thus, the results of analyses justify the creation of an alternative measure of family income in this study.

5. For detailed interpretation of the different fertility patterns of the two cohorts in Table 1, see Kim (1984: 160–163).

Table 2: **Mean Number of Children Ever Born by Income Characteristics**

	Age 40–44	Age 45-49	Total
All Women	5.41	6.28	5.76
Monthly Family Income			
Under 30,000 (Won)[1]	5.61	6.45	5.95
30,000 – 59,999	5.21	6.24	5.59
60,000 – 99,999	4.88	5.49	5.14
100,000 +	4.73	5.32[2]	4.99
Expected Family Income			
Lowest 20%	6.23	7.06	6.65
21 – 40%	6.37	7.01	6.64
41 – 60%	5.80	6.01	5.88
61 – 80%	4.82	5.63	5.10
Highest 20%	4.19	5.18	4.54

Note: 1. The exchange rate between Won and U.S. dollar was 404 5 versus 1 in 1974.
2. Refers to figures based on less than 50 cases.

It should be noted that since the income characteristics are grouped into 4–5 categories in Table 2, some information was lost as a result. Thus, the curvilinearity between income and fertility is not appropriately investigated, and these findings may not reveal the true relationship between income characteristics and CEB.

Transformation

To examine the linear and nonlinear relationships between income and fertility, we create the linear, quadratic, and cubic terms of the income measures. First, both income variables are transformed in such a way that the resulting mean is zero and the resulting standard deviation is one. For example, family income is standardized by using the following linear transformation:

$$\text{Standardized Family Income } (Z) = (X - \bar{X})/Sx \quad (4)$$
$$= a + bX \quad (5)$$

where,
X = Family Income
$\bar{X}$ = Mean of Family Income
Sx = Standard Deviation of Family Income
a = $-\bar{X}/Sx$
b = $1/Sx$

Then, new quadratic and cubic terms are created by taking squared and cubed values of this standardized variable.

$$\text{Squared Family Income } (Z^2) = ((X - \bar{X})/Sx)^2 \quad (6)$$
$$\text{Cubed Family Income } (Z^3) = ((X - \bar{X})/Sx)^3 \quad (7)$$

Then, in this study, a polynomial regression equation

$$Y = c_0 + c_1X + c_2X^2 + c_3X^3 \quad (8)$$

becomes

$$Y = d_0 + d_1Z + d_2Z^2 + d_3Z^3 \quad (9)$$

The rationale is that, as illustrated in equation (5), no information is lost as a result of this transformation. The original metric can always be recovered when the mean and the standard deviation of the original variable are given. One of the advantages of this transformation is that multicollinearity among the linear, quadratic, and cubic terms is substantially reduced, while the correlation coefficients with other variables are not affected by this transformation. After the above transformation, under the standard normal distribution, 99.73 percent of the sample falls in the range of Z value between -3 and 3, regardless of the value range of the original variable. Therefore, the quadratic and cubic terms of the transformed variable vary between 0 and 9, and between -27 and 27, respectively. As a result, multicollinearity, as well as correlation coefficients among the linear, quadratic, and cubic terms of the transformed variable, declines substantially.

Theoretically, the equations (8) and (9) should provide the same fit and result in the same value of R^2. However, severe multicollinearity is likely to exist among X, X^2, and X^3 in equation (8). If so, one or more independent variables may be dropped from the stepwise regression procedures mechanically since their coefficients are not significantly different from zero.[6] But the true situation may not be that the variable has no effect but simply that the set of sample data has not enabled us to pick it up (Johnston, 1972: 160).

Severe multicollinearity also results in reduced precision of estimation so that it becomes very difficult to disentangle the relative effect of each independent variable on the dependent variable: specific estimates may have very large errors, and these errors may be highly correlated with each other. In addition, estimates of regression coefficients may become very sensitive to a particular set of sample data, and the sampling variances of the coefficients may be very large (Johnston, 1972: 160).

Another advantage of the above transformation into the standardized form is that calculations become more accurate. Without the above transformation, we may lose accuracy because of rounding errors in the course of calculating the variance or covariance. This is especially true when a variable with large values, such as income, is included as an independent variable in the regression equation, involving many variables and many cases.

The Pattern of Cuvilinearity

In polynomial regression, we can describe a curve with a series of linear slopes by using significance levels and signs of regression coefficients for the linear and higher order terms. The curvilinearity between the income measures and the fertility-component variables, as well as CEB, is shown in Table 3.

In a test of curvilinearity between family income and CEB, the quadratic, as well as the linear term of family income, is found to be statistically significant in Table 3. The signs of these terms imply that CEB declines as family income increases to a certain point, after

6. The problem of multicollinearity arises when an independent variable in a multiple regression equation is completely or almost completely collinear with other independent variables. In case of severe multicollinearity, a multiple regression equation cannot be solved since the rank of the matrix is less than its order. One measure of multicollinearity is the residual variance of a variable after accounting for the contributions from other independent variables:

$$\text{Residual variance} = 1 - R^2_{y\cdot(n-1)}$$

The residual variance of a variable is used to divide the residual correlations of a variable and appears as the "tolerance" value in stepwise regression of the SPSS or other computer programs. An absolute zero or very small value of the tolerance indicates the existence of severe multicollinearity. If the tolerance is absolute zero, the division is not possible and the computer stops. If the specified tolerance level is not met by a variable, it is not included in the regression equation. For example, in the Version 9 of SPSS computer program, the default tolerance level is set at 0.01. If the tolerance is very small, but still larger than the specified tolerance level, unstable beta weights and calculations can be expected. In this case, multicollinearity can also be detected by the size of the standard error of beta. Extremely small residual variance leads to high standard error of beta (Sakoda, 1976, 1983). For more discussion on the problems of multicollinearity and advantages of the transformation in this study, see Kim (1984: 315–319).

which an increase of CEB occurs.

In contrast, expected family income shows a cubic relationship with CEB. Since the F ratios of the quadratic and cubic terms, as well as the linear term of expected family income, are statistically significant at the 0.05 and 0.01 levels, respectively (Table 3), the null hypotheses that $d_2 = 0$ and that $d_3 = 0$ (in equation (9)) are rejected. Consequently, it can be concluded that the cubic equation of expected family income provides a better representation of CEB than does a linear equation. By using unstandardized regression coefficients and constant value from regression analysis, the relationship between expected family income and fertility can be expressed as follows:

$$CEB = 5.82 - 0.98Z - 0.13Z^2 + 0.09Z^3 \quad (10)$$

When this equation is presented in Figure 2, it clearly shows curvilinearity between expected family income and CEB, and supports Hypothesis 1.

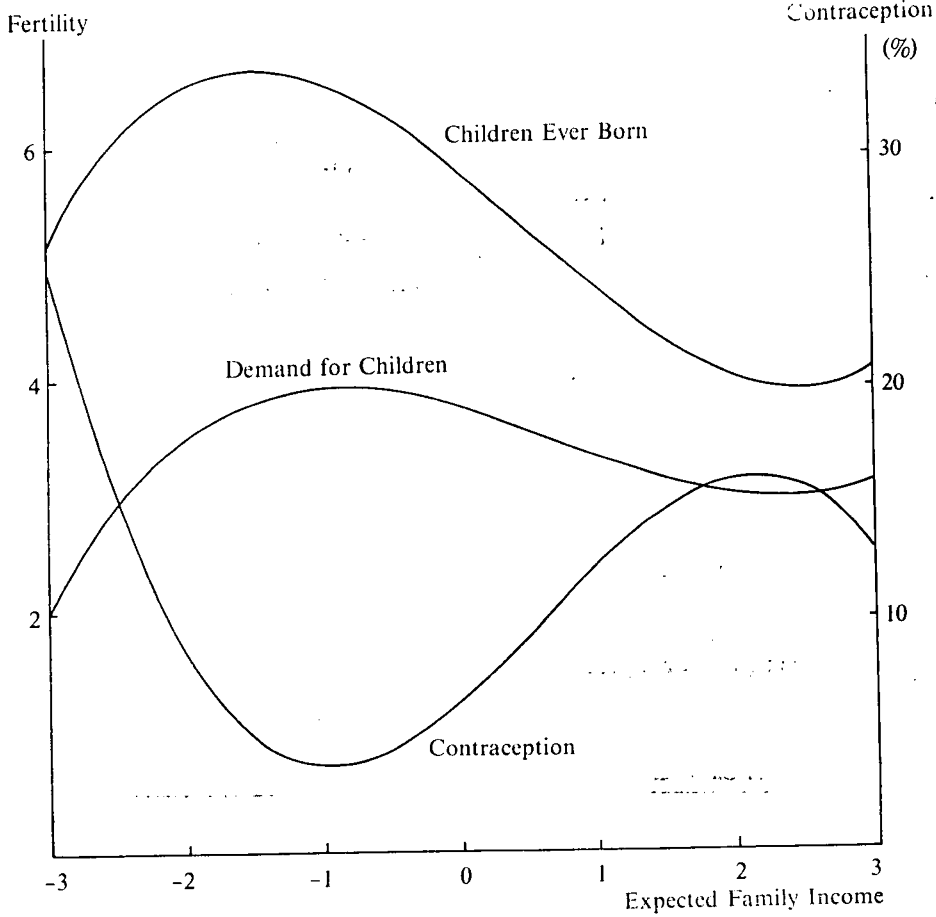
Table 3 also presents relationship between the income measures and the fertility-component variables. Table 3 shows that fecundity is not strongly associated either with family income or expected family income. Fecundity in this study is a dichotomous variable, equal to 1 for fecund woman and 0 for subfecund or infecund woman. The fecundity variable has a binomial distribution with asymptotic variance equal to P(1 − P), where P is the probability of fecundity of an individual. Therefore, the use of fecundity as a dependent variable in an ordinary multiple regression analysis violates the assumption of homoscedasticity (Speare, 1971). Another problem with the fecundity variable is that for some combinations of values of the independent variables, the expected value of fecundity may be either greater than 1 or less than 0. However, an event cannot have a negative probability of occurrence or a probability greater than unity.

Table 3: **Regression of Family Income and Expected Family Income on the Fertility-Component Variables and Children Ever Born**

	Fertility-Component Variables								CEB	
	Fecundity		Breastfeed.		Demand Ch.		Contracep.			
	B	Beta	B	Beta	B	Beta	B	Beta	B	Beta
F. Income	−0.01	−0.03	−2.41	−0.30**	−0.21	−0.19	5.33	0.38**	−0.85	−0.40**
F. Income Sq	−0.01	−0.08	0.28	0.18	0.04	0.20	−1.40	−0.52**	0.17	0.42**
F. Income Cb	0.00	0.09	−0.00	−0.00	−0.01	−0.18	0.08	0.22	−0.01	−0.15
Constant	0.89		20.97		3.70		8.32		5.62	
R^2	0.00		0.03		0.02		0.03		0.04	
F ratio	0.67		10.49		2.30		11.33		14.29	
No. of Cases	946		925		288		946		946	
ExpIncome	0.01	0.04	−2.50	−0.32**	−0.36	−0.32**	5.14	0.37**	−0.98	−0.46**
ExpIncome Sq	0.01	0.04	0.06	0.01	−0.13	−0.17*	1.39	0.15**	−0.13	−0.09*
ExpIncome Cb	−0.01	−0.12	0.10	0.05	0.06	0.23*	−0.80	−0.24**	0.09	0.17**
Constant	0.88		21.11		3.80		6.51		5.82	
R^2	0.00		0.07		0.07		0.08		0.15	
F ratio	1.54		30.54		7.95		34.33		67.73	
No. of Cases	1,168		1,142		327		1,168		1,168	

Note: * and** refer to regression coefficients statistically significant at the 0.05 and 0.01 levels respectively.

Figure 2: **Children Ever Born, Demand for Children and Use of Contracpetion by Expected Family Income**



Note: CEB $= 5.82 - 0.98Z - 0.13Z^2 + 0.09Z^3$
Demand $= 3.80 - 0.36Z - 0.13Z^2 + 0.06Z^3$
Contra. $= 6.51 + 5.14Z + 1.39Z^2 - 0.80Z^3$

As an alternative for dealing with the above problems, the logistic model is suggested. The logistic model limits the expected value of the dependent variable to the 0 to 1 interval: the extremes of 0 and 1 can never be reached. The predicted probability of fecundity (s/n) follows a logistic curve $exp(u)/(1 + exp(u))$, where, s is the sum of the dichotomous (0, 1) dependent variable, n is the total sample size, and u is a linear function of one or more independent variables.

In the present study, logistic regression analysis, based on an approximate asymptotic covariance estimate, is undertaken by using the BMDP-LR computer program. However, the logistic model does not provide a significantly better fit to the observed data of fecundity. The results of logistic regression analysis indicate that information on family income does not improve the prediction of fecundity significantly. None of the linear and higher order terms appear to have *p*-values for entry below 0.15 and *p*-values for removal greater than 0.10[7]. Thus the predicted probability of fecundity becomes a constant value around

7. These are the default *p*-values for entry and removal in the BMDP computer program. For detailed discussion on these *p*-values, see Dixon *et al.* (1981: 255–256, 339).

0.886, without having the independent variables in a logistic equation.

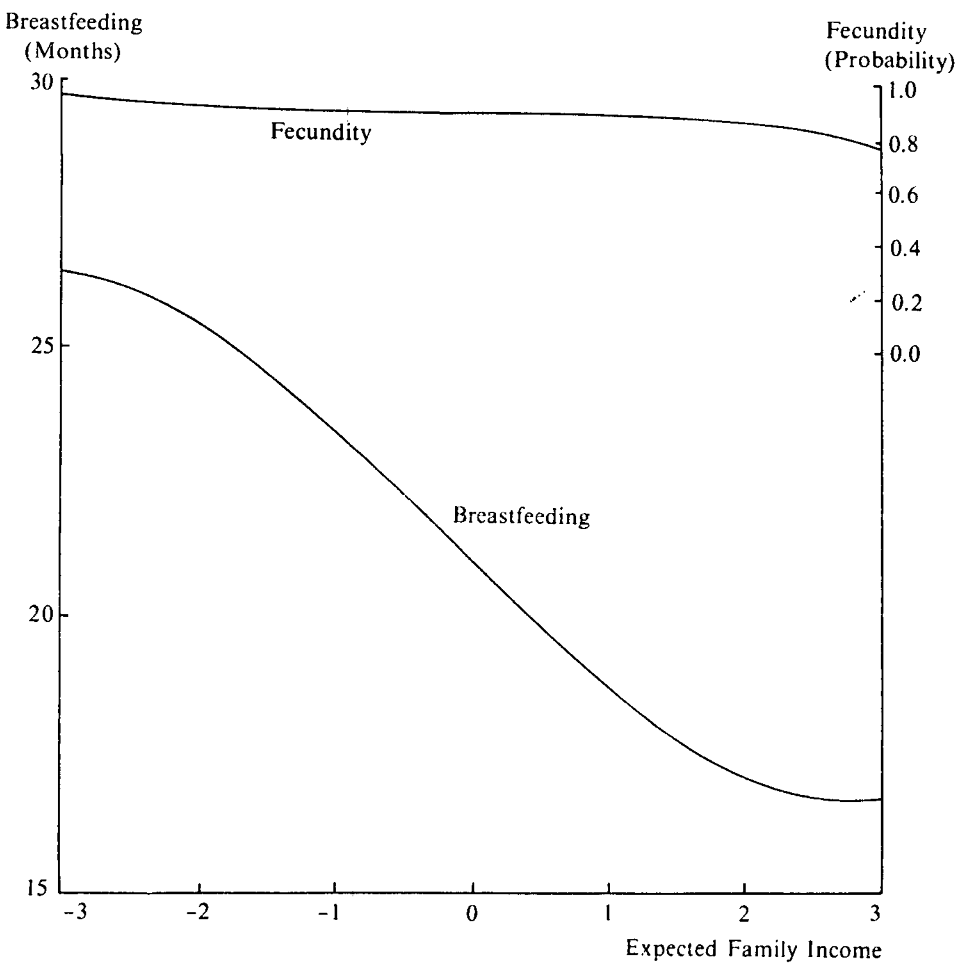
When the linear and higher order terms of expected family income are used as independent variables in logistic regression analysis, the predicted probability of fecundity becomes as follows:

$$\text{Fecundity} = 1 - \frac{exp(-\,2.084 + 0.031Z^3)}{1 + exp(-\,2.084 + 0.031Z^3)} \qquad (11)$$

This equation suggests that the probability of fecundity delines slightly as expected family income increases. However, as Figure 3 shows, a curve represented by equation (11) does not reveal substantial deviations from a straight line with slope zero. This suggests that, given the socioeconomic level in Korea, the variation in nutrition and health by the income level of the couple is not an important factor in differentiating fecundity levels.

In Table 3, the duration of breastfeeding is negatively associated with the income meas-

Figure 3: **Probability of Fecundity and Duration of Breastfeeding by Expected Family Income**



Note: $\text{Fecundity} = 1 - \frac{exp(-\,2,084 + 0.031Z^3)}{1 + exp(-\,2.084 + 0\,031Z^3)}$

$\text{Breastfeed.} = 21.11 - 2.50Z + 0.06Z^2 + 0.10Z^3$

ures. As income increases, women are likely to breastfeed for a shorter period. When the duration of breastfeeding is regressed on family income and expected family income, none of the quadratic and cubic terms are found to be statistically significant, implying a linear relationship. The relationship between expected family income and the duration of breastfeeding is presented in Figure 3.

Since the KNFS does not include information on the date of resumption of menstruation, we cannot directly analyze the mechanism through which breastfeeding affects the length of interval to the next birth. However, a shorter duration of breastfeeding implies a shorter duration of postpartum amenorrhea and thus provides less protection against pregnancy. The role of breastfeeding as a mechanism of fertility control is important when methods of contraception or deliberate fertility control are not widely available. Results of the present analysis suggest that income level, or socioeconomic level in general, may have a slightly negative effect on the potential biological supply of children, mediated by the probability of fecundity, and a positive effect, through the duration of breastfeeding.

Expected family income shows a cubic relationship with demand for children (Table 3 and Figure 2). It is clear that the relationship between expected family income and demand for children in Figure 2 supports Hypothesis 2. These in the lowest group of expected family income tend to have higher demand for children as expected family income increases. Among those in the middle group of expected family income, the relationship between expected family income and demand for children is negative. For the highest group of expected family income, demand for children is likely to increase slightly as expected family income increases. Family income reveals the same pattern of signs in their relationship with demand for children as those with CEB. However, as far as demand for children is concerned, beta coefficients are not statistically significant in Table 3.

Figure 2 clearly shows that CEB (actual fertility) is always higher than demand for children, implying the existence of unwanted fertility. The lowest level of expected family income among Korean women seems to be higher than X_1 in Figure 1. In other words, given the income or socioeconomic level of Korea, fecundity of those in the lowest group of expected family income is not impeded by nutritional and health factors. Figure 2 also shows that the gap between CEB and demand for children becomes smaller as expected family income increases (Hypothesis 3). This pattern can be ascribed to more deliberate and effective fertility control of those in the higher income groups.

While fecundity status or breastfeeding is not used deliberately to reduce fertility, contraception is used deliberately for this purpose. Modern methods of contraception became widely available in Korea since the early 1960s and became known as one of the most important factors accounting for the fertility decline in Korea (Kwon *et al.*, 1975; Kwon, 1981). In Table 3, family income shows a quadratic relationship with contraception. The cubic term of family income is not found to be statistically significant. The signs of the linear and quadratic terms imply that the proportion of birth intervals with contraceptive practice increases as family income increases to a certain point, after which a decline of contraceptive practice occurs.

In contrast, expected family income shows a cubic relationship with contraception (Table 3). In Figure 2, the pattern of association between contraception and expected family income is the reverse of one between CEB (or demand for children) and expected family income. Among those in the middle group of expected family income, the relationship between contraception and expected family income is positive. For the highest and the lowest groups of expected family income, the proportion of birth intervals with contraceptive practice declines as expected family income increases. An interesting pattern in Figure 2 is that those whose expected family income is extremely low reveal a relatively high level of contraceptive practice, although women in this group would compose a small proportion of the sample in normal distribution.

The relationship among expected family income, contraceptive practice and CEB needs further exploration. Despite the relatively high level of contraceptive practice, those in the lowest group of expected family income have a very high level of fertility. Analyses of differential contraceptive knowledge, as well as usage, unwanted fertility, and induced abortion by expected family income, may help to explain this inconsistency.

The number of contraceptive methods ever heard of, or ever used, increases as family income or expected family income increases. The mean number of contraceptive methods ever heard of, or ever used, for those in the highest income group is about twice as high as that for those in the lowest income group.[8] Unexpectedly, however, very high concentration (around 80 percent) on modern methods of contraception, such as the pill and the loop, is observed among the contraceptive users in the lowest income group. It may bepartly because of the intensive family planning program led by the Korean government since 1962. Couples in the rural areas and those in the lower income group of the urban areas were seen as the main target population for the family planning program, and major emphasis was placed on providing modern methods of contraception to them free of charge.

However, the high proportion of birth intervals with contraceptive practice does not necessarily mean effective fertility control. In fact, the gap between CEB and demand for children is the largest for those in the lowest group of expected family income (Figure 2). Despite the high rate of contraceptive use, couples in this group have a higher pregnancy risk by using contraceptive methods less effectively or having periods of discontinuation. This is also confirmed by the negative association between the unwanted pregnancy and the income level and socioeconomic status of the couple (Kim, 1984: 331-332).

The simple correlation between contraception and CEB is slightly negative ($R = -0.12$). But the relationship is not linear and somewhat equivocal[9], and thus requires further analysis. Induced abortion helps to clarify this relationship. Couples with a larger number of children tend to terminate their unwanted pregnancies or, in general, to limit their family size by induced abortion. As Davis (1963) notes, induced abortion has been used in many societies as one of the efficient ways of fertility reduction. Along with the increases in contraception and age at marriage, induced abortion has been one of the most important factors of fertility decline in Korea since the early 1960s (Kwon, 1981; Donaldson *et al.*, 1982).

The KNFS sample of this study shows that 36.8 percent of the women had experienced at least one induced abortion. There were 2.3 induced abortions per woman on average for those women with abortion experience. It was found that induced abortion is positively related with the income level and socioeconomic status of the couple (Kim, 1984: 333). Thus, as the income level or socioeconomic status of the couple increases, the level of fertility becomes largely affected by induced abortion as well as contraceptive practice.[10]

Conclusion

The assumption of a nonlinear relationship between income and fertility has provided

8. The highest and the lowest income groups indicate those who belong to the highest and the lowest categories, respectively, of family income and expected family income in Table 2.
9. Using the KNFS data, Tsui and others (1981) also found that the level of contraceptive availability of the community is positively related with contraceptive practice but unrelated to the level of fertility. This also indirectly implies an equivocal relationship between contraceptive practice and fertility.
10. Note the timing effects that women in the KNFS sample of this study were already in the midst of their reproductive span when modern methods of contraception were introduced to Korea in the early 1960s.

a basis for understanding the fertility patterns and differentials. The present study attempts to decompose fertility into three component factors: demand for children, fecundity, and fertility regulation. The theoretical framework outlining the effect of income on each of these component factors was provided. Based on the microeconomic model, a cubic relationship between income and demand for children was proposed. It was also hypothesized that, as income increases, the couple can regulate their fertility more effectively and have lower unwanted fertility. Although fecundity may not be an important factor of contemporary fertility, a positive relationship between income and fecundity was proposed for those in the lowest income group. Also, this study hypothesized a negative effect of income on temporary infecundity due to breastfeeding. Finally, based on this theoretical context, a cubic relationship between income and fertility was hypothesized.

To cope with difficulties in dealing with income data, and for the fuller investigation on the relationship between income and fertility, expected family income based on the socioeconomic status of the couple was constructed as an alternative income measure. Also, this study employed a standardization technique to deal with curvilinearity and multicollinearity problems in a polynomial regression analysis. Findings from the analyses of the KNFS data generally support the major hypotheses and can be summarized as follows:

Expected family income turned out to be a better indicator than family income in explaining CEB and fertility-component variables. Expected family income shows a cubic relationship with CEB as well as demand for children. Those in the lowest group of expected family income are likely to have more CEB (or demand for children) as expected family income increases. Among those in the middle group of expected family income, the relationship between expected family income and CEB (or demand for children) is negative. For the highest group of expected family income, CEB (or demand for children) is likely to rise slightly as expected family income increases. In contrast, family income reveals a reversed U-shaped relationship with CEB. Although statistically not significant, family income also shows the same pattern of relationship with demand for children.

Fecundity does not show a strong association with either family income or expected family income. This implies that, given the income level in Korea, the differentials in nutrition and health with respect to the income level do not differentiate the probability of fecundity substantially, even for those in the lowest income group. In contrast, the duration of breastfeeding is found to be negatively associated with the income measures. Thus, the income level of the couple has a positive effect on the potential biological supply of children, mediated by the duration of breastfeeding.

The pattern of contraceptive practice with respect to expected family income is generally the reverse of CEB pattern. It was found that among women in the lowest group of expected family income, however, a high proportion of birth intervals with contraceptive practice does not necessarily mean effective fertility control.

Finally, CEB is found to be consistently higher than demand for children, implying the existence of unwanted fertility. However, couples tend to regulate their fertility more effectively as income increases, and thus the gap between CEB and demand for children becomes smaller.

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