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MEASURING THE VALUE OF CHILDREN BY SEX AND AGE USING A LIFE CYCLE MODEL OF FERTILITY

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ABSTRACT

One of the important determinants of fertility is the value of children as perceived by parents. This paper estimates gender and age specific value of children using a dynamic programming model. The underlying hypothesis is that the observed fertility outcomes for any couple are the solutions to their life cycle optimization problem. Findings from Korean data indicate that, compared to daughters, sons impose higher costs at young ages but yields greater benefits at mature ages. Both the early costs and later benefits increase with parental education. Also, using the estimated parameters, simulations are performed to show the effect of the screening test of fetal gender on fertility, gender-specific abortion and the sex ratio.

1. Introduction

The value (costs and benefits) of children is one of the important determinants of parental fertility behavior and related household decisions, such as women's labor force participation. The value is expected to depend upon the child's age, sex, birth order, parental characteristics (such as, age of parents), household income, and socio-economic environment. However, the researchers face a number of questions during investigation of this issue, such as, what is the value of children to parents? and how is it measured? The value of children may be economic or non-economic in nature. How can one evaluate non-economic costs and benefits relative to economic ones? The true value of children can only be obtained after a proper aggregation of these two different types of value.

A few previous studies on value of children were from anthropological and demographic perspectives (see, for example, Caldwell, 1982 and 1983), or they were based on qualitative and attitudinal survey data.[1] There are also some time-use studies and a few studies which attempt to compute the direct economic costs and benefits of children.[2] However, there is little consensus on the net value of children even in terms of direct economic costs and benefits. A most agreed upon conclusion may be that children's most significant economic contributions might be old age support and insurance against extreme adversity, especially in societies where other forms of insurance or

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[1]See Arnold et. al. (1975), Bulatao (1981), Fawcett (1983), and Arnold and Kuo (1984), and Vlassoff (1990).

[2]See Mueller(1976), Cain (1977, 1981), Nag et al. (1978) and Lindert (1980) for developing countries and Lindert (1978), Espenshade (1984) and Robinson (1985) for U.S.

alternative investment opportunities are not available.

This paper does not measure the value of children qualitatively or by time-use, nor through direct economic costs and benefits. Instead, this analysis estimates gender-age specific value of children from observed fertility outcomes using a dynamic programming model.

Fertility decision-making can be viewed as stochastic dynamic control problems where the outcomes take integer values.[3] Uncertainty exists in many biological and socio-economic aspects, such as, fecundability, mortality, child's gender prior to birth, and children's as well as own financial conditions in future. Essentially, fertility decisions involve not only the number but also the timing and spacing of children. Consider that parents' primary concern is to secure old age support, which can be accomplished only by transfers from sons. Parents without a son are likely to put more efforts into having another child, other things being the same. Furthermore, parents would try to time their childbearing so that the period of transfers from children coincide with own old age, a definite phase of low income. The dynamic model employed in this paper integrates the overlapping children's, and parent's life cycles.

Recently, there has been a growing literature on this issue. Heckman and Willis (1976) developed a pioneering stochastic dynamic model of fertility in which parents choose a monthly conception probability in a discrete time framework. A study by Wolpin (1984) developed a pioneering work of an estimable stochastic dynamic model. In particular, he addresses the dynamic implications of the uncertain child mortality on fertility. Hotz and Miller

[3]See Heckman and Willis (1976), Wolpin (1984), Rosenzweig and Schultz (1985), Newman (1988), Montgomery (1988), Hotz and Miller (1988), and David and Mroz (1989).

(1988) examine fertility and female labor supply over the life cycle in a simultaneous decision framework. They show, using U.S. data, that the material costs of children do not vary much with age while the time costs decrease with child's age.

Rust (1987,1989) developed an estimation framework of a structural dynamic model which is derived directly from the optimization problem. Applying Rust's dynamic algorithm, Montgomery (1988) estimated a structural dynamic model of contraceptive use. Montgomery focused on imperfect fertility control, and a revealed-preference estimation of desired family sizes.

This paper builds on Wolpin (1984) and Hotz and Miller (1988), and adopts Rust's (1989) framework to estimations. While previous researches have used dynamic models to explain the number of children ever born, desired probability of a birth, or the effect of mortality on fertility, this research focuses on estimating the costs and benefits of children. By estimating the relative costs (and benefits) of boys to girls by age, it attempts to uncover the causes, types, and the extent of parental gender preferences of children and their effect on fertility. Furthermore, using the estimated parameters, it shows the impact of the medical determination of fetal gender on fertility and sex ratio.

The subsequent exercise uses Korean data to estimate the value of children, which indicate that, compared to daughters, sons impose higher costs at young ages but yield greater benefits at mature ages. The early costs and later benefits increase with parental education. Furthermore, simulations in this research suggest that, given the estimated age-sex specific value of children, a decrease in the costs of screening test will drastically increase the male birth ratio, which is supported by evidence from Korean vital statistics (National Bureau of Statistica, Korea, 1990).

The rest of the paper is organized as follows. Section 2 describes a dynamic model of household fertility choice and the estimation strategy. The data is discussed in section 3. The estimation results and the sensitivity test of the model are in section 4. In the following section, the effects of the screening test of fetal gender on fertility pattern and sex ratios are simulated using the parameter estimates from the section 4. The last section summarizes the findings and discusses possible extensions.

2. A Stochastic Dynamic Model of Fertility

A couple's lifetime after marriage is divided into a series of periods. Denote t=1 as the first fertile period, τ the last fertile period, and T the last living period. The couple's problem is to choose a contraceptive method (or a combination of multiple methods) and the extent of its use at each fertile period to maximize lifetime utility (utility is accrued only while one is alive) under a budget and a biological constraint.

For analytical simplicity the model contains several assumptions. First, it is assumed that there is no savings or dissavings.[4] It is further assumed that the costs and benefits of children can be evaluated as money equivalents, that is, children and consumption are perfect substitutes. Under these assumptions, one of the primary reasons of having children is that they will provide parents with consumption (support) when the parents' income is reduced or eliminated.

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[4]The inclusion of capital market in the model will make the model too complicated to be estimable.

Second, it is assumed that there is no uncertainty in own (T) mortality, the onset of sterility (τ), lifetime income schedule, and perceived child value schedule. These assumptions are made to keep the model empirically tractable. Furthermore, it is assumed that children always survive their parents.[5] This simplifies the model by eliminating stochastic variations regarding child mortality.[6]

Third, parents can control their childbearing perfectly without incurring any costs. The extension to the imperfect control regime is theoretically straightforward, but it involves major complications empirically.[7]

Finally, the decision on the timing of marriage and marital dissolution as a consideration of fertility choice is not included in the model. Similarly, the simultaneous feature of other household decisions made along with fertility, such as labor force participation and expenditures on children, is not considered in this paper.[8]

2-1. Parental Optimization Problem

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[5]This assumption is less problematic in countries where the infant mortality rate is low.

[6]The model would be significantly more complicated to estimate if any of T, τ, or child mortality were treated as a random variable.

[7]This is particularly true if data are not available on the use of contraceptive use since the choice is not observed. Even when the choices of contraceptive method (for the entire previous fertile periods) are observed, it still is difficult to apply to estimation. The reason is because the choice set includes all the available contraceptive methods and the implied size of the state space exceeds easily the practical limit. For example, Montgomery (1988) used four choices of contraceptive method and Hotz and Miller (1988) estimate two levels of conception probability.

[8]Moffitt (1984), Rosenzweig and Schultz (1985) and Hotz and Miller (1988) discuss models which feature a simultaneous decision-making of fertility and labor force participation. See Becker and Lewis (1973) and Willis (1973) for the discussion of the interaction between quality and quantity of children, and Behrman, Pollak, and Taubman (1982, 1986) for a model of the differential expenditure on children according to gender.

The couple's utility function is assumed to be intertemporally additive, of identical form at all periods, and characterized by a constant rate of time preference. The control variable d_t takes the value of either 0 (not to have a child) or 1 (to have a child) at each t for $t=1,\ldots,\tau$. The couple's utility depends only on own consumption. The amount of consumption at period t is the income at t plus the money-equivalent value of children[9] during the period. The value of a k-period old boy (girl) at time t is denoted as ${m_k}^t({f_k}^t)$, which may be either positive or negative. It is assumed to depend on the child's age and gender.[10] It is also assumed that the couple may have at most one child per period.

At time t, the couple's problem is to maximize

$$E_t \sum_{k=t}^{T} \delta^{k-t} U(x_k) \tag{1}$$

where E_t is an expectation operator at time t, δ a discount factor, U a utility function, and the consumption amount of a composite good x is

$$x_t = Y_t + \sum_{k=0}^{t-1} (b_{k+1} m^t_{t-k-1} + g_{k+1} f^t_{t-k-1}) \tag{2}$$

where Y_t denotes the couple's income at t, and $b_t(g_t)$ takes a value of one if the couple has a male (female) birth at t and zero otherwise.

The state facing a couple at any time is determined by the choices made

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[9]It should be viewed as including noneconomic values (or disvalues) converted to monetary terms as well as economic ones. However, I abstract from the issue of aggregating different types of values.

[10]Later, I estimate the model separately according to the parent's socio-economic status, and therefore allow the net value of children vary according to parental socioeconomic status. However, I do not allow the variation by the age of parents, birth order of children, or calendar time. Espenshade (1984) shows that there is a large variation in expenditure on children depending on the parent's status.

during the previous periods and their outcomes. Let π denote the probability of any birth to be a male child. When d_t is chosen at period t, the state facing the couple is a new-born boy with a probability of πd_t, a new-born girl with a probability of $(1-\pi)d_t$, and no birth with a probability of $1-d_t$, in addition to the existing children at the beginning of the period.

The optimal choices for the entire fertile life cycle can be determined by the method of backwards recursion. Let b(t) represent $\{b_k\}_{k=1}^{t-1}$ the sequence of a male birth event up to t-1 and g(t) for the female birth event. Thus, b(t) and g(t) represent the state faced by a couple at the start of period t.

$$s(t) = \{ s_1, s_2, \ldots, s_{t-1} \} \quad for \quad s = b, g \tag{3}$$

Similarly, let m(t) and f(t) represent vectors of age-specific values of boys and girls as perceived by parents at t.

$$c(t) = \{ c^t_{t-1} , c^t_{t-2} , \ldots , c^t_1 \} \quad for \quad c = m, f \tag{4}$$

Therefore, the vector multiplication, b(t)m(t), denotes the net value of existing boys at time t, and g(t)f(t) for girls.

The post-childbearing value function is defined as discounted expected utility during the sterile periods $(\tau+1,\ldots T)$, and is written as

$$V_{\tau+1}(b(\tau+1), g(\tau+1)) = \sum_{k=\tau+1}^{T} \delta^{k-\tau-1}(Y_k + b(\tau+1)m(k) + g(\tau+1)f(k)) \tag{5}$$

At the last fertile period (τ), given the income and child's value schedule for the current and future periods $\{Y_t, m(t), f(t)\}_{t=\tau}^{t=T}$, the discounted expected utility if d_τ is chosen is as in equation 6.

Define the value function at the period τ as in equation 7.

It can be shown that a unique solution to the above equation exists, and the

$$EU_t = d_\tau[\pi U(Y_\tau + b(\tau)m(\tau) + g(\tau)f(\tau) + m_0^\tau) + (1-\pi)U(y_\tau + b(\tau)m(\tau) + g(\tau)f(\tau) + f_0^\tau) + \pi V_{\tau+1}(b(\tau),\ g(\tau),\ b_\tau=1) + (1-\pi)V_{\tau+1}(b(\tau),\ g(\tau),\ g_\tau=1)] + (1-d_\tau)[U(Y_\tau + b(\tau)m(\tau) + g(\tau)f(\tau)) + V_{\tau+1}(b(\tau),\ g(\tau))] \quad (6)$$

$$V_\tau(b(\tau),\ g(\tau)) = \max_{d_\tau = \{0,\ 1\}} EU_\tau(d_\tau \mid b(\tau),\ g(\tau)) \quad (7)$$

optimal choice is determined for each possible state at τ. Now, going one period backwards, we solve the problem for the second to last fertile period. Likewise, by a successive recursion, we can solve for the couple's state contingent optimal fertility problem over their entire fertile periods.

2-2. Statistical Model

A couple decides on childbearing sequentially at each fertile period under the uncertainties in the sex of unborn children. For researchers, an additional stochastic element exists in the unobserved error terms of the utility function, e_t. Thus the single period utility associated with decision d_t at period t given $(b(t),g(t),e_t)$ is

$$U(d_t \mid b(t),\ g(t)) + e_t(d_t). \quad (8)$$

The unobserved term e_t is assumed to be choice specific and additive to the systematic part of utility. The value of $e_t(d_t)$ can be interpreted as an unobserved transitory utility costs of choosing d_t. Given the stochastic evolution of the state embodied by the transition probability and the choices made, the couple chooses a sequence of decision rules $\{d_t\}$ to maximize the discounted expected utility over their lifetime. The decision rule is determined from Bellman's equation

$$V_t(b(t),g(t)) = \max\{\, U(b(t),g(t),d_t) + \delta EV_{t+1}(b(t),g(t),e_t,d_t)\,\} \quad (9)$$

Note that the expectation in the last term is respect to both the randomness in the sex of the child (π) and the distribution of e_t.

If e_t are identically and independently distributed bivariate extreme value errors, the probability of choice d_t follows binary logit formula.

$$Pr\,(d_t \mid b(t),\, g(t)) = \frac{\exp\,[U(d_t \mid b(t), g(t)) + \delta EV_{t+1}(d_t \mid b(t), g(t))]}{\sum_{d_t=(0,1)} \exp\,[U(d_t \mid (b(t), g(t)) + \delta EV_{t+1}(d_t \mid b(t), g(t))]}. \qquad (10)$$

The sample likelihood then is

$$\sum_{i=1}^{I} \sum_{t=s_i}^{\tau_i} Pr(d_t^i \mid b^i(t),\, g^i(t)) \qquad (11)$$

where I is the number of women in the sample, and s_i and τ_i are the age at marriage and the age at the survey of woman i. Using an iterative method we can obtain consistent estimates which maximize the sample likelihood.

2-3. Empirical Specifications

The costs and benefits of children are assumed to depend on sex and age, but not on the birth order or age of parents.[11] However, by estimating the model separately for each subgroup, the model allows the value of children to vary according to parent's socio-economic status. The subgroups are formed according to the woman's age at survey, age at marriage, education level and labor force participation status. For the purpose of estimation it is assumed that the net monthly value of children are constant in four age groups for each sex: age 0 to 10, 11 to 20, 21 to 30, and 31 to 50.[12] The estimates should be interpreted as money equivalents of an average monthly net value of

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[11]However, the utility value of children even of the same sex and age could differ according to parental ages due to the different income levels.

[12]A specification which divides the child's age more finely would be desirable to obtain more accurate estimates, but it complicates the computation beyond the limit. The finer specification is assigned for future work.

a child during the interval. The utility function is assumed to take a logarithmic form,[13] and the discount factor per period is assumed to be 0.95.[14] The objective function then is

$$E_t \sum_{k=t}^{T} 0.95^{k-t} Log(x_k) \tag{12}$$

where x is defined as previously.

Since the dynamic problem proposed in this paper (as in most other discrete choice dynamic models) can only be solved numerically by backwards induction method, the estimation involves a burdensome computation. For computational tractability, a seven decision-period model is used here. Seven periods with two years of duration per period give 14 fertile years after marriage.

The model is identified by the variations in income profile, the sex and age composition of children at each period, and the non-linearity embedded in the utility function and the multi-period structure of the model.

3. Data

The data are drawn from a two percent subsample of 1980 Korean Population and Housing Census which was conducted by National Bureau of Statistics (Korea). The Census is organized as a household survey. The observation for each

[13] A logarithmic form of utility function emphasizes risk aversion of parents and the gains from a balanced consumption intertemporally.

[14] The attempt to estimate the discount rate has failed. However, other values of discount rates (e.g. 0.9 and 1.0) gave qualitatively similar estimation results.

household member is given in the order of household head, spouse, children and others. My working sample includes once and currently married woman. We observe the couple's age, age at marriage, education level, place of residence, work status, occupation, and children's age and sex.

A woman's life after marriage is divided into two year periods among which first seven periods (14 years) are assumed to be fertile.[15] Only a few cases were detected in which a woman had a birth later than the decision periods under the seven-period framework. In those cases a birth is moved to the last fertile period in which there is no birth. The couple is assumed to live 50 years after the marriage.

Unfortunately, the Census did not gather information on wages or income. The husband's income profile is constructed by matching his age and occupation to the average monthly wage for the same age and occupation reported in the Monthly Wage Survey (1980, Department of Labor, Republic of Korea). The income is assumed to increase by 5% each year until the twenty-second year, then decrease by 10% each year thereafter. The income during the last ten living years is assumed to be one tenth of the peak income. This arbitrary assumption on income profile is maintained due to the lack of data. Since the income profile is the main identifying variable of the model, inexactly predicted income profiles may yield incorrect estimates. A test is performed to see the sensitivity of the model by estimating the model with different income profiles, in particular, with different assumptions on old-age income.

The model is estimated separately of each subsample which is divided

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[15]There were 23, 18 and 15 periods with more than one birth among women in primary, high school, and college education group, respectively. In those cases the birth is moved to the previous period in which there is no birth. If there is no previous period without a birth, then a birth is moved to the next period in which there is no birth.

according to individual's biological and socio-economic conditions. The idea is to make each subsample more homogeneous. To begin, I select women who are residing in Seoul and currently not working.[16] The ages at marriage of the selected women are between 23 and 26, and current age between 35 and 40.[17] Due to the lack of information about the deceased children, I selected only women whose number of children ever born equals the number of existing children. I further select only women with at least one child.[18]

Three subsamples are formed according to woman's education level: primary or lower, high school, and college or higher. I estimate the model for each group separately. Total periods (women) observed are 1096 (179), 1198 (200), and 1161 (196) for primary, high-school, and college education group respectively. Table 1a-1b report the averages of the period-specific fertility rates, age at the beginning of each fertile period, and monthly income in 1000 Korean currency (won) for the whole lifetime.

(Table 1)

The fertility rate is highest in the first and second period and then decreases rapidly. However, after the third period the rate of decline is greater among better educated women than less educated women. Better educated women are more likely to stop childbearing early than less educated women even

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[16]This is imposed due to the problem of computing the wages for the whole life cycle for women. It is less problematic for men since they are more likely to work without interruption until they retire.

[17]For the sample under study the median age at marriage is 25 suggesting fertility is complete at age 39, which is true for more than 95% of women in Korea; 4.4%, 2.7%, and 2.6% of total births are from women older than 39 in 1970, 1975, and 1980, respectively (Korean Population and Housing Census).

[18]This is imposed to exclude innately sterile women, but this will also exclude those who have no children by their intention. However, it is believed that there are only very few couples who desire no children.

after controlling for age.

Another distinguished feature in observed fertility pattern among the sample of Korean women is the differential parity progression rate according to the sex composition of existing children.

(Table 2)

For example, at parity two, the probability to have another child among women whose first two children were girls is twice larger than among those who had two boys at their first two births. The similar pattern is present among higher parities as well (see Ahn, 1990 for more lengthy discussions). The differential parity progression pattern by sex composition of children will help identify the model to estimate the sex-specific value of children.

4. Estimation Results

Table 3 shows that the value of children varies substantially according to the child's gender and age, and the education level of parents. The estimates should be interpreted as overall values, non-monetary as well as monetary.

(Table 3)

The estimation results can be summarized by several notable aspects. First, young children impose net costs while mature children yield net benefits, and both costs of young children and benefits from mature children are larger for boys than girls. College educated women place greater net value on children of age 0 to 10 than less educated women do. It is hard to interpret this positive net value as an economic one. It then must be the case that the non-economic value is dominating the economic costs. However, it is not clear why it should not be the case among the less educated women.

Second, although in all education groups children impose highest costs during the age between 11 to 30 and yield net benefits after age 30, they show substantial differences according to sex and parental education level. While primary and high school educated women consider costs of children of age 11 to 20 and 21 to 30 about the same, college educated women consider children of age 21 to 30 most costly. This is suggestive of variations in expenditure plan for children according to parental education level. In particular, the substantial difference in net costs at age 21 to 30 between boys and girls among college education group might be suggesting the costs of college education for boys.[19]

Similarly, the costs of children of age 11 to 30 increase with parental education level: the average cost of a son (daughter) is estimated as 11.9 (14.0), 30.8 (11.0), and 38.1 (29.2) for primary, high school, and college education group.[20] This may reflect the differences in the opportunity cost of a child in terms of wife's potential earning power or/and the differences in expenditure (including investment) on children according to parent's education level.

Finally, better educated women expect greater benefits from grown-up sons (ages 31 or more) than less educated women do. This difference appears to reflect the differential earning power of children due to the different

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[19]In Korea, college enrollment rate among male has been much larger than among female. For example, according to Unesco (1988) the college enrollment rates were 23% and 39% among male in 1980 and 1984 respectively, while they were 8% and 19% among female. Also, Korean men usually have to serve for three years in military during their late teens and early twenties. In those cases, the college education is taken mostly during one's age of 20's. In general in Korea, the cost of college education is high and is financed by parents.

[20]These amounts are 13% (primary education group), 24% (high school), and 23% (college education group) of average household income during the first period.

investment received while they were young. The expected benefits from a son of age 31 to 50 are 23.6, 34.8, and 67.0 among primary, high school, and college educated women, respectively.[21] Contrasting to the substantial benefits from grown-up sons, grown-up daughters yield insignificant benefits to parents. This might be reflecting the Korean custom that married daughters are considered to be outside of the family.

Overall, the findings suggest that the old-age support from mature sons is the important variable in identifying the differential parental fertility behavior according to sex-age composition of children.

I tested whether the value of children is statistically different by gender or age. All the three tests (three education groups) reject at 1% significance level the null hypothesis that the child costs are the same between gender.[22] Also, all tests reject at 1% significance level the null hypothesis that the child costs are the same over the four age groups.[23]

4-1. Sensitivity of the Model to the Assumption of Old-Age Income

Since old-age security appears to play a major role in parents' fertility decision-making, I test the sensitivity of the estimates by changing the assumption on the old-age income level among the college-educated women (tests on other education groups yield similar result). In comparison to the

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[21]The value of mature sons is about the same as the own old-age income for primary or high school group, but a little higher for the college group.

[22]Twice the differences of the estimated likelihood with and without restriction are 14.24, 13.70 and 26.20, respectively for primary, high school, and college education group, and the critical value of Chi-square statistics is 13.28 at 4 degrees of freedom for 1% significance level.

[23]Twice the differences of the estimated likelihood with and without restriction are 19.82, 18.44 and 24.48, respectively for primary, high school, and college education group, and the critical value of Chi-square statistics is 16.82 at 6 degrees of freedom for 1% significance level.

benchmark case in which old age income is assumed as one-tenth of the peak income, new estimates were made assuming the old-age income equal to one-half, and one-fifth of the peak income. The results are reported in Table 4.

(Table 4)

Since the estimation is based on the same fertility data, one expects the estimated benefits from a grown-up child to increase as old age income increases. That is, to yield the same observed fertility pattern, the benefit from a child during parent's old age should be larger, or/and the costs of young children should be smaller when the parent's old age income is greater. The empirical results support our conjecture. The net positive value of very young children (age 0 to 10) and mature children (age 30 or higher) increases, as the old-age income increases.

4-2. Predicted Fertility Profile

One way of testing maximum likelihood estimation results of a discrete choice model is to compare the choices predicted by the estimates with those actually made (Table 5, first panel). The fertility rates in the first two periods are predicted higher than the actual. Given the slowly rising income schedule with reduced income in old age, the optimal strategy is to have births early (especially first two periods), and not to have in later periods. The prediction of higher fertility in early periods and lower fertility in later periods than the actual is due to a rather uniform income profile and the perfect fertility control across individuals, both by assumption. However, the predicted pattern and the total rate of fertility match reasonably well with the actual ones.

(Table 5)

4-3. Income Effect

Now, given the estimates of the value of children in Table 3, the effect of the changes in old-age income on fertility can be predicted. Increases in old-age income from one-tenth to one-fifth and one-half of the peak income are examined among college educated women (Table 5, second panel). The fertility rate in the first two periods does not change much when the old-age income increases. The effect appears most prominently in the decrease of fertility rate in later periods. As old-age income increases, parents are not so desperate to have children to secure old age, even among those who have only girls. The expected fertility rate decreases from 2.56 to 2.06 and to 1.46, as the old-age income increases to one-fifth and to one-half of the peak income respectively.

4-4. Effect of the Changing Value of Children

Given that one of the main interests of the paper is to infer the type and intensity of the parental sex preference due to the differential value of children between boys and girls, it is interesting to predict the effect of the changes in value of children on fertility. Three different types of value of children are used for the simulation (Table 5, third panel).

First, if daughters have the same value as estimated for sons from table 3, the optimal fertility rate might increase due to the rise in the marginal value of children. On the other hand, it may also decrease since any child will provide support when parents are old, so that parents even with only girls do not have to go on having children to provide themselves with security in old age. The overall effect on fertility rate is ambiguous. The predicted fertility rate is higher early in life cycle and lower later than in the benchmark case. However, the total fertility rate is about the same at 2.56. In the opposite case (that is, sons have the same value as estimated for daughters), the fertility rate would be zero due to the negative values for any child of any age.

Finally, if a child of either sex has the value profile which is the average of the estimated value of boys and girls, the fertility rate increases slightly, from 2.56 to 2.64. This is due to the small costs and benefits of children. That is, as the benefits from mature children are small, parents need many children to secure some old age consumption. Moreover, the costs of young children is small relative to income so that parents can afford to have many children. This might be interpreted as higher demand for less risky investment.

5. Selective Abortion, Fertility and Sex Ratio

The modern technology which gives parents the ability to determine the gender of a fetus has added a new dimension to the problem of fertility choice (Bennett and Mason 1983; Bloom and Grenier 1983; Kobrin and Potter, Jr. 1983). For parents who prefer to have children of one sex to the other, this ability may lead to selective abortion. An immediate consequence may be a change in the sex ratio at birth, and eventually throughout the population if selective abortion is practiced broadly over a prolonged period.

One notable case is in Korea. According to the report of 1990 Korean Vital Statistics, during the 1980s the male-female birth ratio in Korea has increased dramatically, especially at high birth orders (Table 6). For example, in 1989, among the children born of the third or higher birth order, the male-female sex ratio approaches almost two[24] when it is normally less than 1.1 males to 1.0 female. The sex ratio might increase further in the future if many parents want only one or two children, but of a specific sex.

(Table 6)

It is likely from the estimates in Table 3 that unless the costs of screening test or abortion are high this sample of Korean women would have only boys. However, as shown in Table 6, the selective abortions are practiced mostly at high birth orders. In general, parents seem to leave the sex of the first two children to chance. Only those who were "unlucky" in their first two births are practicing selective abortion. This might be due to the high costs of the screening test or abortion relative to incomes or only a small gain from the selective abortion during the first couple of pregnancies. A good prediction of the effect of the selective abortion through a screening test will depend on the good measure of its costs, and of course on the accurate measurement of the value of children.

Using the estimated values of children from Table 3, we can simulate the effect of alternative test costs on conception, screening test, selective abortion, and consequently on the sex ratio of children. The estimated proportion who choose to conceive, and, among those, who take the screening test at each fertile period are presented in Table 7. If the test cost is 50 (in 1000 won per month during the period), no conception is tested for its gender during the first two periods. But at the third and fourth period, 44%

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[24]Infanticide or discriminatory child care which leads to differential mortality rate between male and female children would also cause the biased sex ratio. In the context of Korea these cases are believed to be trivial compared to the case of selective abortion. See Hull (1989) and Johansson and Nygren (1991) for the discussions of Chinese case.

and 88% of conceptions are tested. As the price of the test decreases to 30, 3% of women take the test at the first period, while the percentage goes up to about 88% at the second period and 100% at the third or later periods. In later periods, however, only few women choose to conceive.If the test costs nothing, most of women who choose to conceive take the test at all periods.

The time pattern of using the test mostly depends on the costs of the test relative to income, given the value of children. If the cost of test is high relative to income during the early periods, people are better off by delaying the test to later periods when the income is high.

(Table 7)

The figures on the number of conceptions, number of live births, and the sex ratio for alternative test costs are also computed (Table 7). It is assumed that the probability of any conception to be a boy is 0.515, that the test is perfectly accurate, and that female fetuses, if tested, are aborted. As the test cost becomes cheaper, the number of live birth decreases, while the number of conceptions goes up. Consequently, the sex ratio among children becomes larger with the decrease of the test cost. The male-female birth ratio rises to 2.91 from 1.33 as the test cost decreases from 50 to 30.

How realistic are these simulation results? Using the data for Seoul reported in Korean Vital Statistics (1982-1989) which provides number of births by sex at each birth order, the proportions who took the screening test during pregnancy are computed. The sex ratio among the first births is used as a natural sex ratio for any birth order, and it is assumed that female fetuses are aborted if the test is taken.[25] Table 8 indicates that an in-

[25]Under these assumptions the use of screening test is likely to be underestimated due to several reasons. First, some parents might take test to abort male fetuses. Second, it is not likely that all pregnancies which are

creasing proportions are taking the screening test over time, first among high birth orders, then gradually among lower birth orders. During 1989, in Seoul, 5% of the second births, 46% of the third, 60% of the fourth, 44% of the fifth, and 93% of the sixth births resorted to prenatal gender tests. The proportion of pregnant women who take the screening test (consequently the sex ratio) is likely to go up further in the future, in particular among low birth orders, if the desired number of children decreases while the parental son preferences persist.

(Table 8)

6. Conclusions

This paper estimates the value of children by gender and age using a dynamic programming model. The underlying hypothesis is that the observed fertility outcomes for any couple are the solutions to their life cycle optimization problem. The model is estimated using 1980 Korean Population Census.

The empirical findings in this research indicate that parental valuation of children varies according to child's gender and age, and own education levels. Although at young ages boys impose relatively higher costs, they are preferred to girls because of greater expected support in old age. Furthermore, the analysis suggests that the better educated women not only expect higher cost of rearing young children but also anticipate higher benefits from them when grown, than less educated women. Overall, the old-age support from mature sons appears to be the most important influencing factor in parental

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tested to be of the unwanted sex are aborted. Third, there might be selective abortions performed to the first births.

decisions on fertility choices. Simulations show that, as income increases in old age, parents would not be so desperate to have children, even among those who have only girls.

As the estimation results suggest, the son preference in Korea is still strong. Therefore, selective abortions subsequent to fetal screening tests which have become widely available in recent years bring in a new aspect to the problem of fertility choices. Simulations suggest that sex ratio would increase further in future, if the costs of screening tests and abortion decrease. The dramatic increase of male-birth ratio in Korea during the late 1980's provides evidence of this development.

How will sex ratio change in future? Will the perceived value of boys relative to girls change as sex ratios change? What will be the effects of the changes in income, education, and other socio-economic aspects of the environment on sex ratios? How effective will be legal or institutional regulations on prescreening test or gender selective abortions? This is an agenda for future research. The fertility choice model should include the availability of the selective abortion with an appropriate measure of price.

REFERENCES

Ahn, N. 1990. "Sequential Family Formation When the Children's Sex Matter." Unpublished manuscript. Yale University.

Arnold, F., R.A. Bulatao, C. Buripaledi, B.J. Chung, J.T. Fawcett, T. Iritani, S.J. Lee, and T.S. Wu. 1975. *The Value of Children: A Cross-National*

Study. Vol. 1, Introduction and Comparative Analysis. Honolulu: East-West Population Institute.

Becker, G.S., and H.G. Lewis. 1973. "On the Interaction between the Quantity and Quality of Children." *Journal of Political Economy* 81: S279-288.

Becker, G.S., and N. Tomes. 1976. "Child Endowments and the Quantity and Quality of Children." *Journal of Political Economy* 84: S143-162.

Behrman, J.R., R. Pollak, and P. Taubman. 1982. "Parental Preferences and Provision for Progeny." *Journal of Political Economy* 90(1): 52-73.

Behrman, J.R., R. Pollak, and P. Taubman. 1986. "Do parents favor boys?" *International Economic Review* 27(1): 33-54.

Bennett, N.E. and A. Mason. 1983. "Decision Making and Sex Selection with Biased Technologies." Pp. 101-112 in *Sex Selection*, ed. by N.G. Bennett. New York: Academic Press.

Bloom, D.E. and G. Grenier. 1983. "The Economics of Sex Preference and Sex Selection." Pp. 113-128 in *Sex Selection*, ed. by N.G. Bennett. New York: Academic Press.

Bulatao, R.A. 1981. "Values and disvalues of children in successive childbearing decision." *Demography* 18(1): 1-25.

Cain, M. 1977. "The Economic Activities of Children in a Village in Bangladesh." *Population and Development Review* 3: 201-227.

Cain, M. 1981. "Risk and Insurance: Perspectives on Fertility and Agrarian Change in India and Bangladesh." *Population and Development Review* 7: 435-474.

Caldwell, J.C. 1982. *Theory of Fertility Decline*. London: Academic Press.

Caldwell, J.C. 1983. "Direct Economic Costs and Benefits of Children." Pp. 453-493 in *Determinants of Fertility in Developing Countries, Vol. 1: Supply and Demand for Children*, ed. by Bulatao and Lee. New York: Academic Press.

David, P., and T. Mroz. 1989. "Evidence of Fertility Regulation among Rural French Villagers, 1749-1789: A Sequential Econometric Model of Birth-Spacing Behavior among Rural French Villagers, 1749-1789." *European Journal of Population* 5(1): 1-26; 5(2): 173-206.

Espenshade, T.J. 1984. *Investing in Children: New Estimates of Parental Expenditure*. Washington, D.C.: The Urban Institute Press.

Fawcett, J.T. 1983. "Perceptions of the Value of Children: Satisfaction and Costs." Pp. 429-457 in *Determinants of Fertility in Developing Countries, Vol. 1: Supply and Demand for Children*, ed. by Bulatao and Lee. New York: Academic Press.

Heckman, J.J., and R.J. Willis. 1976. "Estimation of a Stochastic Model of Reproduction: An Econometric Approach." Pp. 99-145 in *Household Production and Consumption*, ed. by N. Terleckyj. New York: Columbia University.

Hotz, J., and R. Miller. 1988. "An Empirical Analysis of Life Cycle Fertility and Female Labor Supply." *Econometrica* 56: 91-118.

Hull, T.H. 1990. "Recent Trends in Sex Ratios at Birth in China." *Population and Development Review* 16(1): 63-83.

Johansson, S. and O. Nygren. 1991. "The Missing Girls of China: A New Demographic Account." *Population and Development Review* 17(1):35-51.

Kobrin, F.E. and R.G. Potter, Jr. 1983. "Sex Selection through Amniocentesis and Selective Abortion." Pp. 47-71 in *Sex Selection* ed. by N.G. Bennett. New York: Academic Press.

Lindert, P.H. 1978. *Fertility and Scarcity in America*. Princeton, N.J.: Princeton University Press.

Lindert, P.H. 1980. "Child Costs and Economic Development." Pp. 3-79 in *Population and Economic Change in Developing Countries*, ed. by R.A. Easterlin. Chicago: University of Chicago Press.

Moffitt, R. 1984. "Profiles of Fertility, Labor Supply and Wages of Married Women: A Complete Life-Cycle Model." *Review of Economic Studies* 51: 263-278.

Montgomery, M. 1988. "A Dynamic Model of Contraceptive Choice." Office of Population Research, Princeton University.

Mueller, E. 1976. "The Economic Value of Children in Peasant Agriculture." Pp. 98-153 in *Population Development: A Search for Selective Interventions*, ed. by R. Ridker. Baltimore, MD.: The Johns Hopkins University Press.

Nag. M., B. White and R.C. Peet. 1978. "An Anthropological Approach to the Study of the Economic Value of Children in Java and Nepal." *Current Anthropology* 419: 293-306.

National Bureau of Statistics (Korea). 1990. *Annual Report on the Vital Statistics*. Seoul: National Bureau of Statistics.

Newman, J. 1988. "A Stochastic Dynamic Model of Fertility." *Research in Population Economics* 6: 41-68.

Robinson, W.C. 1987. "The Time Cost of Children and Other Household Production." *Population Studies* 41(2): 313-323.

Rosenzweig, M., and T.P. Schultz. 1982. "Market Opportunities, Genetic Endowments, and Intrafamily Resource Distribution: Child Survival in Rural India." *American Economic Review* 72: 803-815.

Rosenzweig, M., and T.P. Schultz. 1985. "The Demand and Supply of Births." *American Economic Review* 75: 992-1015.

Rust, J. 1987. "Optimal Replacement of GMC Bus Engines: An Empirical Model of Harold Zurcher." *Econometrica* 55: 999-1033.

Rust, J. 1989. "Maximum Likelihood Estimation of Discrete Control Process es." *SIAM Journal on Control and Optimization* 26(5): 1-19.

Unesco. 1988. *Statistical YearBook*, 1988. Unesco.

Vlassoff, C. 1990. "The Value of Sons in an India Village: How Widow see it." *Population Studies* 44(1): 5-20.

Willis, R.J. 1973. "A New Approach to the Economic Theory of Fertility Behavior." *Journal of Political Economy* 81(2): S14-64.

Wolpin, K. 1984. "An Estimable Dynamic Stochastic Model of Fertility and Child Mortality." *Journal of Political Economy* 92: 852-874.

Table 1a: Period Fertility Rate and Average Age

Period[a]	1	2	3	4	5	6	7
(i) Primary or lower							
Fertility	0.84	0.75	0.56	0.38	0.21	0.05	0.04
Avg. Age[b]	24.5	26.5	28.5	30.5	32.4	34.4	36.3
N[c]	179	179	179	179	170	135	75
(ii) High school							
Fertility	0.78	0.81	0.54	0.36	0.12	0.08	0.05
Avg. Age	24.3	26.3	28.3	30.3	32.3	34.2	36.0
N	200	200	200	200	193	145	78
(iii) College							
Fertility	0.82	0.81	0.60	0.21	0.11	0.02	0.03
Avg. Age	24.7	26.7	28.7	30.7	32.7	34.7	36.6
N	196	196	196	196	187	132	58

[a]: two year period since marriage.
[b]: at the start of the period.
[c]: the number of women.

Table 1b: Income Profile (monthly income in 1000 won)

Period	1	2	3	4	5	6	7
Primary	95.95	104.68	115.41	127.24	140.28	154.66	170.51
(std. dev.)	36.16	39.87	43.96	48.46	53.43	58.90	64.94
High School	128.84	142.05	156.62	172.67	190.37	209.88	231.39
(std. dev.)	49.17	54.20	59.76	65.89	72.64	80.08	88.29
College	166.16	183.19	201.97	222.67	245.50	270.66	298.40
(std. dev)	44.54	49.10	54.14	59.69	65.80	72.55	79.99
Period	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Primary	187.99	207.25	228.50	251.92	217.62	187.99	162.39
(std. dev.)	71.60	78.94	87.03	95.95	82.89	71.60	61.85
High School	255.11	281.25	310.09	341.87	295.32	255.11	220.37
(std. dev.)	97.34	107.32	118.32	130.45	112.69	97.34	84.09
College	328.99	362.71	399.89	440.88	380.84	328.99	284.19
(std. dev)	88.18	97.22	107.18	118.17	102.08	88.18	76.18
Period	**15**	**16**	**17**	**18**	**19**	**20**	**21–25**
Primary	140.28	121.18	104.68	90.42	78.11	67.48	25.19
(std. dev)	53.43	46.15	39.87	34.44	29.75	25.70	9.60
High School	190.37	164.45	142.05	122.71	106.00	91.57	34.19
(std. dev.)	72.64	62.75	54.20	46.82	40.45	34.94	13.04
College	245.50	212.07	183.19	158.25	136.70	118.09	44.09
(std. dev.)	65.80	56.84	49.10	42.42	36.64	31.65	11.82

Note: Monthly income is computed by matching the husband's age and occupation in Census to the average male income by age and occupation reported in Monthly Wage Survey (1980, Korean Department of Labor).

Table 2: Parity Progression Rate (%) by Sex Composition

	Number of boys among existing children				
Progression	0	1	2	3	4
1 to 2+	96.4 (386)	94.1 (506)	---	---	---
2 to 3+	87.7 (179)	55.1 (439)	43.9 (230)	---	---
3 to 4+	54.4 (79)	31.2 (176)	7.8 (204)	22.0 (41)	---
4 to 5+	40.0 (25)	9.3 (43)	0.0 (39)	9.1 (11)	20.0 (5)

Note: Sample sizes in parentheses.

Table 3: Estimated Monthly Net Value of Boys and Girls
(in 1000 won)

	Woman's completed education level		
Parameter	Primary	High School	College
Boy's net value by age			
Age 0-10	-0.27 (0.01)	2.91 (1.64)	10.48 (5.76)
Age 11-20	-13.02 (5.67)	-25.50 (24.04)	-13.09 (5.10)
Age 21-30	-10.72 (7.06)	-36.18 (24.59)	-63.02 (25.78)
Age 31-50	23.57 (6.49)	34.79 (21.43)	67.04 (27.78)
Girl's net value by age			
Age 0-10	-0.26 (0.25)	8.66 (1.14)	10.82 (5.86)
Age 11-20	-13.59 (2.67)	-12.96 (8.60)	-26.99 (19.95)
Age 21-30	-14.40 (5.38)	-9.00 (8.90)	-31.33 (13.31)
Age 31-50	-0.07 (0.19)	12.31 (2.76)	3.13 (1.59)
Log-Likelihood	-708.08	-763.52	-684.54
Total fertile periods observed	1096	1198	1161

Note: Unsigned asymptotic t-statistics are in parentheses.

Table 4: Sensitivity of the Estimates to Changes in the Assumption on Old-Age Income (College Educated Women)

	Old-age income as a ratio to peak income		
Parameter	One-half	One-fifth	One-tenth
Boy's net value by age			
Age 0-10	26.60 (0.01)	16.80 (3.21)	10.48 (5.76)
Age 11-20	-32.93 (5.67)	-17.01 (7.20)	-13.09 (5.10)
Age 21-30	-72.30 (7.06)	-63.43 (35.35)	-63.02 (25.78)
Age 31-50	99.79 (6.49)	70.44 (17.22)	67.04 (27.78)
Girl's net value by age			
Age 0-10	32.32 (0.25)	17.82 (3.65)	10.82 (5.86)
Age 11-20	-26.10 (2.67)	-26.64 (10.82)	-26.99 (19.95)
Age 21-30	-14.98 (5.58)	-27.79 (17.65)	-31.33 (13.31)
Age 31-50	12.60 (0.19)	2.43 (2.50)	3.13 (1.59)
Log-Likelihood	-700.99	-691.33	-684.54

Note: Unsigned asymptotic t-statistics are in parentheses.

Table 5: Predicted Fertility Rate
(College Educated Women)

Period	1	2	3	4	5	6	7	Total
Actual	0.82	0.81	0.60	0.21	0.11	0.02	0.03	2.60
Predicted	1.00	0.86	0.42	0.17	0.09	0.02	0.00	2.56
<u>Income effect</u>								
One-fifth[a]	1.00	0.72	0.30	0.04	0.00	0.00	0.00	2.06
One-half[b]	0.98	0.47	0.01	0.00	0.00	0.00	0.00	1.46
<u>Effect of changes in value of children</u>								
Equal[c]	0.00	0.93	0.41	0.13	0.05	0.04	0.00	2.56
Average[d]	1.00	0.95	0.53	0.15	0.05	0.01	0.00	2.64
N	196	196	196	196	187	132	58	---

[a]: Old-age income increases to one-fifth of the peak income.
[b]: Old-age income increases to one-half of the peak income.
[c]: Value of girls is set as the same as the estimated value of boys.
[d]: Value of a child of either sex is set as the average of the estimated value of boys and girls.

Table 6: Male-Female Birth Ratios by Birth Order in Korea

		Birth order				
Year	Total	1	2	3	4	5+
1989	1.13 (613240)	1.05 (328044)	1.14 (241249)	1.90 (34794)	2.17 (6551)	2.14 (2605)
1988	1.14 (620316)	1.08 (335449)	1.14 (238279)	1.70 (35880)	1.99 (7402)	1.87 (3306)
1987	1.09 (613556)	1.05 (333111)	1.09 (230097)	1.37 (37523)	1.50 (8474)	1.63 (4351)
1986	1.13 (613703)	1.08 (325517)	1.12 (229794)	1.43 (42294)	1.61 (10406)	1.61 (5685)
1985	1.10 (636621)	1.06 (328212)	1.08 (241201)	1.33 (47228)	1.57 (12778)	1.54 (7191)
1984	1.09 (660234)	1.07 (326720)	1.08 (250939)	1.19 (55585)	1.32 (17188)	1.34 (9793)
1983	1.08 (757930)	1.06 (339091)	1.06 (291298)	1.13 (84508)	1.21 (27225)	1.28 (15801)
1982	1.07 (840279)	1.06 (351335)	1.06 (299408)	1.10 (124383)	1.13 (40708)	1.18 (24442)
1981	1.07 (864958)	1.06 (354298)	1.07 (290228)	1.07 (142096)	1.13 (47913)	1.15 (30347)
1980	1.04 (888355)	1.06 (351213)	1.04 (278814)	1.03 (149015)	1.02 (59370)	0.96 (49859)

Note: Number of births are in parentheses.
Data: Annual report on the Vital Statistics (1990), National Bureau of Statistics, Economic Planning Board of Korea.

Table 7: Predicted Proportion of Conception (D) and Screening Test (H) with Various Costs of Screening Test (College Educated Women)

Cost of screening test		Period 1	2	3	4	5[a]	Preg.	CEB	S.R.
TC=0	D	1.00	0.94	0.72	0.44	0.30	3.56	1.83	inf.
	H	1.00	1.00	1.00	1.00	1.00			
TC=30	D	1.00	0.89	0.53	0.25	0.16	2.92	2.02	2.91
	H	0.03	0.88	1.00	1.00	1.00			
TC=40	D	1.00	0.86	0.45	0.21	0.13	2.74	2.27	1.64
	H	0.00	0.16	0.90	1.00	1.00			
TC=50	D	1.00	0.86	0.42	0.18	0.12	2.65	2.39	1.33
	H	0.00	0.00	0.44	0.88	1.00			

TC : monthly cost during the period (24 months) when the screening test is taken.
Preg : average number of pregnancy.
CEB : children ever born.
S.R. : male-female chid ratio among children born.
D : the proportion who choose to conceive.
H : the proportion, among those who choose to conceive, who choose to take the test.
[a] : there are very few who choose to conceive at periods 6 and 7.

Table 8: Estimated Ratio (%) of Screening Test by Birth Order
Calculated Using Data from Vital Statistics
SEOUL

		Birth order					
Year	Total	1	2	3	4	5	6
1989	4.61	0.00 (91633)	4.60 (61507)	46.5 (6414)	60.2 (814)	44.1 (156)	92.7 (31)
1988	3.75	0.00 (92979)	3.90 (59899)	38.4 (6272)	59.5 (827)	49.0 (161)	40.6 (42)
1987	2.47	0.00 (90229)	2.70 (55352)	23.9 (6092)	44.4 (922)	30.8 (209)	29.0 (57)
1986	2.64	0.00 (90829)	1.50 (56240)	29.2 (6979)	45.6 (1287)	43.4 (288)	25.6 (76)
1985	2.04	0.00 (91807)	0.80 (59799)	21.7 (8037)	35.1 (1514)	32.0 (336)	51.8 (127)
1984	2.07	0.00 (89698)	1.40 (62492)	14.3 (9390)	30.9 (2105)	41.2 (493)	35.4 (161)
1983	2.13	0.00 (89775)	1.00 (73680)	11.9 (15029)	23.1 (3231)	31.6 (689)	20.8 (286)
1982	1.80	0.00 (92204)	0.00 (76850)	8.90 (22078)	18.8 (4797)	24.7 (1326)	31.9 (394)

Note: Number of births are in parentheses.
Data: Annual report on the Vital Statistics (1990), National Bureau of Statistics, Economic Planning Board of Korea.

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