An Analysis of Women's Fertility and Labor Supply: Implications for Family Policies[†]

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Abstract: A drastic decline in fertility rates in Korea is accelerating the unprecedentedly rapid population ageing. This phenomenon calls into question what role the economic forces play in the decisions and which public policies can be effective. As population ageing induces a shortage of labor force that sustain the economic growth, this paper notes that stimulating women's labor supply as well as encouraging fertility is a very important policy goal in an ageing society. Having this in mind, I investigate the effectiveness of family policies that are frequently used in developed countries. For this purpose, I first analyze the dynamic decisions of fertility and labor supply in a lifecycle framework, where time costs associated with children, time and goods investment in children, and uncertainties in earnings are important determinants of women's decisions. Based on the model, I then conduct policy experiments which evaluate the effects of policies including child allowances, conditional childcare subsidies, pronatal income tax, and maternal leaves. The findings show that providing benefits conditional on or through labor market activities are more effective than the provision of unconditional transfer in encouraging fertility without reducing labor supply of women.

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I. Introduction

"Bear two and rear them well." As this propaganda slogan from the 1970s suggests, the Korean government has made efforts to stop explosive population growth through family planning, which contributed to a reduction in the total fertility rate (TFR) from 4.53 in 1970 to 1.59 in 1990. However, the TFR continued to decrease to a record low of 1.08 in 2005 (See the first panel in Figure I), among the lowest of the OECD countries and a main factor accelerating the ageing of society. If this fertility trend persists, the dependency ratio, the ratio of those aged over 65 to those aged between 15 and 64, is expected to rise dramatically to the unprecedented level (the second panel in Figure I). This will pass on a huge burden to future generations since only a limited number of the working young will have to sustain the economy. Although the ageing of society is a common phenomenon among developed countries, the problem in Korea is more serious in the sense that the ageing process is far more speedy and little preparation for it has been done.[1] Thus, effective policy measures are in great need to resolve problems induced by low fertility and population ageing.

A number of factors can in part explain such a drastic change in fertility, among which an increase in women's market activities is often attributed as a main determinant. The upheaval of women's social status due to higher education and a reduced gap between male and female wage rates stimulated women's market activities. Considering a well established fact that an increase in price of women's time raises opportunity cost of children and reduces fertility, but increases labor market returns, there seems to be a negative relationship between fertility and labor supply. However, encouraging and utilizing women's

[1] The period during which the proportion of elderly increases from 7 to 14 percent is expected to be only 19 years in Korea, whereas in other countries such as France (114 years) and Sweden (82 years) the same process took much longer. Although the TFR has been below 2.1 since 1980 for almost 25 years, no family policies to encourage fertility is introduced until year 2004.

labor supply is critical to compensate for a shortage of labor force in a low fertility era. In this case, increasing women's labor supply without reducing the fertility rate or vice versa is a crucial policy goal. This could relieve numerous problems associated with an ageing society by boosting the current and future labor force. However, there is little understanding about women's fertility and the labor supply decisions of married women in Korea, and few attempts has been made to suggest effective policy measures to encourage both fertility and labor supply of women.[2]

In this study, I explain how a woman determines the timing and number of births as well as her labor supply, based on which I investigate some family policies. A dynamic lifecycle model is constructed to endogenously determine women's fertility and labor supply. Following Becker (1960), the demand for children is not different from the demand for durable goods for which a economic agent considers its quality and quantity. In determining the quality of a child, both goods and time investment in children are considered. This is particularly important because the expenditure for children in Korea is higher than other countries (Choi ,2003). In particular, when children are young and need time intensive care, women's drop out rate from the labor market is higher than any other periods. This temporal drop out from the labor market due to child birth or care is rarely observed in developed countries partly due to abundant child care facilities and family friendly labor market policies. I further investigate these under a more realistic setup by incorporating varying childcare costs, uncertain environment, heterogenous initial asset and borrowing constraints.

A large volume of literature is devoted to examining women's labor supply in response to fertility decisions. These studies focus on women's labor supply, treating fertility as an

[2]Birth out of wedlock is a rare event in Korea, partly due to cultural reasons and severe social stigma. Single parent families (either divorced, widowed or never married) consist of less than 10 percent of the total number of families according to reports by the Ministry of Gender Equality and Family. Thus, the analysis here is confined to the fertility decisions of married women.

exogenous decision (Heckman, 1974; Heckman and Macurdy, 1980). The findings suggest that the presence of children discourage women labor supply by reducing effective wage rates because they have to hire child care while working. Thus, the provision of child care and reduction of its cost is suggested as a policy measure that encourages women's labor supply. However, the estimates of women's labor supply treating fertility exogenous may be biased since these decisions are simultaneous. Other studies focus on women's fertility decision. A common approach is to consider the trade off between quality and quantity of children(Becker and Lewis, 1973; Becker and Barro, 1988). In this case, the theory predicts that women's wage rates, labor force participation(LFP, hereafter) and education would have a negative effect on fertility by increasing the opportunity cost of having children, while household income has an ambiguous effect on fertility depending on substitutability of the quantity and quality of children. There are studies that incorporate both fertility and labor supply of women, and they often use a lifecycle model to capture the dynamic aspect of the decisions (Moffitt, 1984; Rosenzweig and Wolpin, 1980; Hotz and Miller, 1988). In line with this, an investigation into a simultaneous decision of women's fertility and labor supply within a dynamic framework is conducted.

For this purpose, I use panel data from 1998 to 2003 and calibrate the model to capture the main features of them. Through this exercise, the model shows how the fertility and labor supply are determined and respond to changes in exterior factors. Findings suggest that the increase in real wages of women is largely responsible for the growth in women's LFP. However, as women's earnings increase, the investment in children increases as well, compounding the effect on fertility. Increase in education costs and uncertainties in earnings also play a role in reducing fertility and increasing labor supply. Having described how the model works, policy experiments using the model are conducted. In particular, the effectiveness of family policies is investigated, that are frequently used in countries

where a high proportion of women work. These policies include child allowances (e.g., Sweden, France, and U.K.), childcare subsidies (e.g., U.S. and Sweden) and tax credits (U.S. and U.K.), and maternity leaves (e.g., Sweden, Japan, and U.K.). Although these are all family friendly policies to help mothers with children, each policy has different policy goals and consequences. I discuss the objectives of these policies and consider policy environment where these policies take effects. The results suggest that transfers conditional on work to raise real wages (e.g., tax credits or childcare subsidies for working women) are more effective than universal transfers (e.g., child allowances).

The paper is organized as follows. The next section provides a descriptive analysis on the pattern of fertility and labor supply, and their relationship. Section III presents a dynamic model through which a woman decides her lifetime fertility and labor supply. Section IV discusses the calibration and estimation results obtained. Section V conducts policy experiments based upon which policy implications are drawn. Section VI concludes.

II. Women's Fertility and Labor Supply.

Women's fertility and labor supply are so closely related that considering one without the other makes little sense. In this section, I describe the trend of declining fertility rate, increasing women's market activities, and their seemingly negative correlation. Then I present the underlying factors that might be important in determining both decisions.

A. Trends in Fertility and Labor Supply

The overall LFP of women in Korea is low, compared to other developed countries. As of year 2003, the average labor force participation rate of women is 52.8 percent in Korea, which is the fourth lowest among OECD countries ahead of Turkey (28 percent), Mexico

(41 percent) and Greece (51 percent).[3] This means that there is room for women's labor supply to increase. As Panel A of the Figure II presents, women's LFP in Korea is lower than that of developed countries for almost all age groups. One striking feature is that Korean women's LFP shows a 'M' shaped pattern, while other countries show a smooth reverse 'U' shaped one. This implies that a number of women drop out of labor market when they have births, some of whom return to the market as children grow. Panel B of the Figure II shows that this pattern has been persisted, although the timing of the sudden decline in the LFP has been delayed. In 1995, when the average age at first marriage is 25.4, the temporal drop out from the market prevailed for women between 25 and 34. As the age at first marriage increases to 26.5 in 2000 and to 27.5 in 2004, and the labor force participation of women between 25 and 29 increased from 48% in 1995 to 64% in 2004, most drop-out's happen for the women between ages 30 and 34. However, the LFP pattern is still 'M' shaped, suggesting births can be a impediment of women's labor supply.

The increases in LFP may explain or be explained by the reduction in the birth pattern. The last panel of Figure II shows the total number of births by women's ages. A significant decline and delay in births over time is observed. The number of births born to women of 25-29 has considerably dropped and the LFP of these women has increased at the same time. Regardless of the causality whether a decline in birth induces an increase in women's LFP or vice versa, reconciliating both family and working seems to be difficult for Korean women.

There are direct and indirect costs associated with fertility. The direct costs of fertility include inevitable time costs to take care of children especially when they are young, and goods and time investment in children's human capital. The indirect costs that are

[3]See OECD (2004) for detailed information on each country.

opportunity cost of fertility include foregone earnings when a woman has to give up her labor supply due to childbearing. This time cost associated with fertility reduces time available for market activities and causes labor supply decline. The increase in indirect cost of fertility due to the increase in women's wage rate further decreases fertility while increases their labor supply. However, defining the relationship between fertility and labor supply is not simple. The goods investment in children's human capital, for example, such as education expenses sometimes motivates women to work more to appropriate the money to pay. Lower labor supply and labor earnings may reduce the demand for children by income effect, *ceteris paribus*. Thus, specifying the relationship between the simultaneous decision of fertility and labor supply, requires a careful investigation.

III. Analytical Framework

In this section, a dynamic model to investigate how a woman decides her fertility and labor supply in a lifecycle framework is presented.

A. Model

An economic agent's decision problem throughout life is maximizing the expected value of the present stream of discounted utility. In each period, the economic agent derives utility from her composite consumption goods (c_t), child service (q_t), number of children (k_t) and her leisure (l_t). There is no explicit altruistic motive from parents toward children. The preference of a woman is assumed to be intertemporally separable. The expected lifetime utility over $t = I$ (age at marriage),...,D (age at death) is specified as

$$E[\sum_{t=I}^{D} \beta^{t-I} u(c_t, q_t, k_t, l_t)] \tag{1}$$

where the operator E denotes the expectation over the uncertainties in a woman's future earnings and her household income and β presents the time preference.

The number of children at t which represents the quantity of children is $k_t = \sum_{j=I}^{t} b_j$, where b_j indicates a birth at age j. The quality of children which provides child service (q_t) is produced with goods, g_t, and maternal time investment, m_t; $q_t = f(g_t, m_t)$. The last argument in the utility, the woman's leisure, is specified as $l_t = 1 - z_t - h_t - m_t$, where z_t is fixed time cost associated with children and h_t is her labor supply. The fixed time cost of children z_t is a function of the age of each child reflecting the intensity of care that varies with the child's age.

The budget constraint she faces when solving the maximization problem in each period is denoted as

$$c_t/\phi + g_t + a_{t+1} = w_t h_t - \tau(w_t h_t) + (1+r)a_t + y_t, \tag{2}$$

where ϕ is the woman's share of household income, $1+r$ is a risk free gross interest rate, τ denotes her income tax that depends on her labor earnings, w_t is the wage rate, and y_t is exogenously given non-mother after-tax income. Subject to this budget constraint, she chooses her consumption and asset level, the number and spacing of births, and goods and time investment in children in order to maximize her lifetime utility. Let the problem be presented in a recursive form using a Bellman equation.[4] The dynamic programming problem of a woman at age j where $I \leq j \leq Q$ is given by[5]

$$V(y, w, k, a, j) = \max_{c,g,m,h,b,a'} u(c, q, k, l) + \beta \int \int V(y', w', k', a', j+1) d\Phi_y(y'|y) d\Phi_w(w'|w) \tag{3}$$

[4]To simplify notation, time subscripts are omitted and the problem is specified at woman's age j. Variables at age $j-1$ and age $j+1$ are represented with subscript -1 and superscripts $'$ respectively.

[5]Note that she faces a similar problem except that $b = 0$ from time Q through D, and that $h = 0, g = 0$, and $m = 0$ after R (retirement).

subject to

$$\begin{aligned} c/\phi + g + a' &= wh - \tau(wh) + (1+r)a + y \\ k' &= k + b, \\ l &= 1 - m - z - h, \\ q &= f(g, m) \end{aligned}$$

where Q is the last reproductive period.

For choice variables, c, g, m, h, and a', solutions at each period is obtained for each case where the birth takes place and not; $b = 0$ and $b = 1$. Then in terms of the fertility decision, the optimal decision is made by comparing the value function of each case:

$$\begin{aligned} V_0(y, w, k, a, j) = \max_{c,g,m,h,b=0,a'} & u(c, q, k, l) + \\ & \beta Emax[V_0(y', w', k, a', j+1), V_1(y', w', k, a', j+1)] \end{aligned} \tag{4}$$

$$\begin{aligned} V_1(y, w, k, a, j) = \max_{c,g,m,h,b=1,a'} & u(c, q, k, l) + \\ & \beta Emax[V_0(y', w', k+1, a', j+1), V_1(y', w', k+1, a', j+1)] \end{aligned} \tag{5}$$

If $V_0(y, w, k, a, j) > V_1(y, w, k, a, j)$ then $b = 0$, and vice versa. The dynamics of the model comes from the intertemporal allocation of resources and consumption smoothing, and the fertility decision that affects future stock of children and time available for market activities. The allocation of time between labor, investment in children, and leisure are static from equation given the maximum time available for mothers excluding the fixed time costs associated with children.

IV. Estimation and Calibration

A. Functional Forms

In this section, assumptions on functional forms of utility, time costs according to children's ages, and child quality production are made.

• Preferences: The utility function is assumed to be

$$u(c,q,k,l) = \frac{c^{1-\sigma}}{1-\sigma} + A\frac{q^{\kappa}}{\kappa}\frac{k^{\zeta}}{\zeta} + B\frac{l^{1-\xi}}{1-\xi}. \tag{6}$$

The consumption, the quality and quantity of children, and the leisure are separable. The quality and quantity of children, substitutable for each other, contributes to the utility of parents.

• Production Function of Child Service: Assuming that the child service is produced with goods and time inputs with constant elasticity of substitution (CES), the production function reads,

$$q_t = (g_t^{\eta} + m_t^{\eta})^{1/\eta}, \qquad \eta < 1 \tag{7}$$

where η represents substitutability of two inputs.

• Fixed time costs associated with children: The time cost is a decreasing function of child's age.[6] If $b_j = 1$, then the child's age at time t is $t - j$. Thus, at time $t > I$, when the number of children is $k_t = \sum_{j=I}^{t} b_j$, the total time cost associate with all children under

[6]It is common that the intensity of care that is reflected in the fixed time cost of children is assumed as a decreasing function of child's age. For example, see Hotz and Miller (1988) and Attanasio et al. (2005).

age six is

$$z_t = \sum_{j=t-5}^{t} \gamma b_j \phi^{t-j}, \quad 0 < \phi < 1.$$

Using the Korean Time Use Survey 1999 and 2004 waves, time costs to take care of children by age are obtained. Hotz and Miller (1988) report that a newborn requires 109 minutes per day. I find that $\phi = 0.95$ and $\gamma = 130.11$, which means the newborn child requires about 130 minutes per day and the time costs reduces with child's age by 5% per year. Assuming that a woman has 16 hours of non-sleeping time a day, a woman with newborn child loses 13.5% of her time that could have been used for her leisure or work.

• Wage equations: The latent variable of a woman's wage is specified as AR(1) process as follows.

$$\ln w_0^* = x_0'\beta_0 + \epsilon_0, \qquad t = 0, \tag{8}$$

$$\ln w_t^* = \rho \ln w_{t-1}^* + x_t'\beta + \epsilon_t, \qquad t = 1, ..., T, \tag{9}$$

$$\epsilon_t = c + \mu_t, \qquad \mu_t \sim N(0, \sigma_\mu^2), \tag{10}$$

where c is unobservable individual characteristics that do not vary over time. The latent variable of wages are only observed when the woman works. Thus the coefficients are obtained from the dynamic tobit model (See Table 1.).[7]

• Non-mother Income Process: Since the large part of non-mother income consists of

[7]It is noted that the current wages are not dependent on previous work history, which means that the disruptions of work does not affect the wage rate. This setup, seeming less reasonable, is justified from data that the wage rate does not depreciate when returned to work. It might be because women usually work for low skill sectors where experience or continuity of work matters little. Women with disrupted work history might have reduced her reservation wage that has otherwise risen. The answers for this puzzle should be investigated. However, this issue remain for future research.

Table 1: Estimates for the Mothers' Earnings Process

Variables	Initial period (t=0)	Subsequent periods (t>0)
Constant	-3.604***	-2.543***
	(0.580)	(0.350)
age	0.146***	0.076***
	(0.030)	(0.017)
0.01*age^2	-0.186***	0.085***
	(0.040)	(0.021)
High school graduate	0.369***	0.303***
	(0.097)	(0.052)
College and above	0.662***	0.548***
	(0.098)	(0.064)
Lag of ln(wage)		0.108***
		(0.019)
Variance of individual-specific		0.649***
errors(c)		(0.024)
Variance of error terms		0.609***
		(0.009)

Note:The dependent variable is log wage rate of women. Standard errors are in parentheses.
*,**, and *** denote statistical significance at 10%, 5% and 1% level respectively.

husband's labor earnings, the expected household income is specified with husband's characteristics including age and education as

$$\ln y_j = x_j'\beta + u_j,$$

$$u_j = \rho u_{j-1} + \epsilon_j, \epsilon_j \sim N(0, \sigma_\epsilon^2)$$

where y_j is household non-mother income when her age is j, x_j includes husband's age, education, indicator of big city and two earner household, u_j is an AR(1) error term of the equation, and ϵ_j is a zero mean i.i.d, normally distributed error term.

Table 2: Estimates for the Non-mother Income

Variables	Constant	Age	0.01*Age^2	High school	College+	City	$\hat{\rho}$	$\hat{\sigma_\epsilon}$
Coeff.	3.716**	0.154**	-0.166	0.346***	0.577***	0.040	0.429	0.934
(S.E.)	(1.439)	(0.079)	(0.107)	(0.079)	(0.083)	(0.050)		

Note:Omitted category is less than high school group.
*,**, and *** denote statistical significance at 10%, 5% and 1% level respectively.

• Income Tax: Following Scholz et al. (2006) and Gouveia and Strauss (1994), the income

tax is parameterized as

$$\tau(I) = a_0(I - (I^{-a_1} + a_2)^{-1/a_1}) \tag{11}$$

where $I = wh$, a_0 reflects the proportional part of the tax to the income, a_1 is the degree of progressiveness of the tax and a_2 reflects the lump-sum part of the tax. Using the Household Consumption Survey, I estimate a_0, a_1, and a_2 at 0.11, 2.47 and 0.13, respectively. This figures mean that the income tax is very progressive ($a_1 > 1$), which might provide a partial answer for the phenomenon that the labor supply of women is not proportional to their education.[8] Given this functional form, the derivative of tax amounts with respect to the marginal increase in working hours is $\tau'(wh) = a_0[1 - \{1 + a_2(wh)^{a_1}\}^{\frac{-1-a_1}{a_1}}]$.

B. Matching with Data

In addition to the parameters obtained as above, the discount factor (β) and the coefficient of relative risk aversion (σ) are assumed to be 0.96 and 2.0, respectively, which are conventionally used. For a benchmark case, I assume that the capital market is imperfect and that the current consumption depends only on the current income stream.[9] Then the coefficient of child service production function, η, and other parameters for utility function, A, κ, ζ, ξ, and B are to be estimated from the data. For this process, I select a sample of married women aged from 20 to 40 with at least one child. Since the model incorporates endogenous women's labor supply, I restrict sample women who has worked

[8]It is usually observed that the women with higher education work more because they have higher earnings potential and opportunity cost of not working. However, in Korea, the women with college and above education work less than those with junior college degree, although they work more than the high school graduates.

[9]Considering that a young couple has substantial credit constraint in Korea, which sometimes is a barrier to fertility itself, and a great amount of asset accumulation goes to housing, this assumption seems more realistic than a flexible credit market.

at least one year during the 6-year period. The data used are taken from the Korean Labor and Income Panel Study (KLIPS), a longitudinal survey of a representative sample of Korean individuals and the households. About 5,000 households and 13,300 individuals have been annually interviewed since 1998. This study uses 6 waves of the data from 1998 to 2003. For the empirical analysis, I select the sample with the following criteria: (1) the same husband and wife headed the households from 1998 through 2003, (2) the wife is less than 40 years old in 2003, (3) the household has at least one child prior to 2003, and (4) the wife has worked at least one year between 1998 and 2003.

Table 3: Summary Statistics

Wife's Characteristics	Mean	S.D.	Family Characteristics	Mean	S.D.
Age	36.2	(3.0)	Age_H	39.6	(3.5)
Less than High School	15.5	(3.6)	$\text{Less than High School}_H$	14.6	(3.5)
High School Grad	60.8	(4.9)	$\text{High School Grad}_H$	50.0	(5.0)
College and above	23.7	(4.3)	$\text{College and above}_H$	35.4	(4.8)
Annual Earnings (when positive)	2,467	(9,737)	Non-mother Annual Income	3,581	(10,404)
Overall LFP	57.3	(5.0)	Annual Educational Expenses	565	(698)
LFP within 5 years since birth†	34.0	(4.7)	Total Household Income	4,597	(15,750)
Age at First Birth	25.2	(2.9)	Number of Children	1.48	(0.5)
Individual Num. Obs.	452		Total Num. Obs.	2,712	

Note: Subscript H denotes husband's characteristics.
Earnings, incomes and expenses are presented in 2000 terms. The unit is 10,000 won.

From the data, the information on the wife and husband's demographic and labor market characteristics is collected. Household characteristics are included as well. The summary statistics of sample women are presented in Table 3. On average, the age and education level of husbands are higher than those of wives. About half of the women in the sample participated in the labor force and their annual earnings were 25 million won (about 25,000 dollars.). Non-mother income is the total household income excluding wife's labor earnings. The average non-mother income and total household income are 36 and 46 mil-

lion won, respectively. The average number of children in these households are 1.3, while the maximum number of children in the sample are four. Almost all of the households (93 percent) spend positive amount on their children. The educational expenses include childcare costs, and private and public education fees, which consists 12 percent of the total household income.

Using this data set, the parameters of interest is obtained by matching the simulated moments with the actual moments from data. The computational detail of the simulated methods of moments (SMM) including the numerical solution of the model and simulation is described in the Appendix. Table 4 presents the parameters estimated and their matching moments. The predicted and actual value shows that the model well captures the main features of the data.

Table 4: Parameters Estimated and the Model Fit

Parameter	Statistics	Data		Model
	Time and goods use of women			
A=0.01	Labor supply(annual hours of work)	2,489	(1,041)	2,519
B=0.03	Overall LFP	57.3%	(5.10)	60.1
$\xi = 1.1$	LFP within 5 years since birth	34.0%	(4.7)	60.1
$\kappa = 0.6$	Income share of expenditure on children	29.3%	(5.5)	27.8
	Fertility			
$\zeta = 0.3$	Number of children	1.48	(0.6)	1.5
$\eta = 0.7$	Age at first birth	25.2	(2.9)	25.7

The model also captures the 'M' shape pattern of the labor force participation. Before a woman has a birth, she maintains a high participation rate. While she has births and children are still young, she drops out of the labor market. She then returns to work when children get older and her wage rates increase with her age.

C. Explaining Fertility and Labor Supply Decisions

The model suggests a few factors that can shift the overall fertility and labor force participation of women over time. The main factor is women's wage rates that determine the

cost of children and returns to work. The wage rates of women compared to those of men have largely increased over time. The average women's wage rate increased from about 260 dollars per month in 1980 to 1,120 dollars per month in 2004, which is equivalent to an increase from 44 percent to 66 percent of men's wage rates. Due to both absolute and relative increases in wage rates increase women's labor supply and the opportunity cost of having children, inducing decline in fertility. Increases in volatility and uncertainties of income also affect women's decisions. The income inequality due to the gaps between and within skill groups increased, which reflects more volatility of income. The risk averse economic agent responds to the increase in income uncertainties. The greater the uncertainties, the less likely to reduce working and have children.

Partly due to the changes in relative wage rates of men and women, and income volatility, the timing of marriage has been delayed.[10] The increase in the age at marriage delays first birth, which reduce the remaining reproductive periods. Given the reversed 'M' shape of the age earnings profile, the later the births, the larger the opportunity costs of them. Thus, the delay in births reduces the total number of births. Since the out of wedlock births are rare events in Korea, the delay in marriage equivalent to the delay in first birth reduces total births by far. The age at marriage of Korean women increased from 22.6 in 1972 to 27.5 in 2004.

V. Policy

A. Family Policies Frequently Used

Child allowances

[10] Although the decisions whether and when to get married can be of great interest, they are left for future research.

Child allowances are tax exempt cash transfer provided to the households conditional upon the birth and the number of children. These allowances are used to provide equitable economic wellbeing to the households with and without children, noting that children are costly. They are also politically appealing because the society or government shares the responsibility for raising children with households. Child's allowances are in practice in many European countries including Sweden, France and the U.K., although the amounts and duration of allowances vary across countries. Generally, some fixed amounts of benefits are provided from birth to a certain age, and supplementary subsidies are provided for a birth or a large number of children. Since these benefits are universal and do not impose any eligibility criteria about income or labor market participation, they may have a negative effect on labor supply through an income effect. In addition, child allowances like other universal benefits are fiscally burdensome and thus benefit level is usually low, which in turn may not have a great impact on fertility. Even though they actually have an effect on fertility, it is likely to be upon the decision of low income families, which may expose these families to the child poverty problem. Therefore, apart from the political function of child allowances, there are disputes on actual effect of child allowances in encouraging fertility (e.g., Laroque and Salanie, 2005; Gauthier and Hatzius, 1997).

Childcare Subsidies

Childcare subsidies are widely proposed in-kind transfer to encourage both fertility and the labor supply of women. In the U.S. where the majority of childcare facilities are private, child care subsidies are provided as a sliding fee scale so that low income mothers pay reduced price for childcare. Providers' cost of childcare are then reimbursed by the government. In some European countries such as Sweden and France, universal public childcare provided by municipalities is available at low cost. However, this costly provision of universal public childcare is possible only when there is trust toward the public sector

that they provide no worse quality care than the private care givers. When the private market for childcare is already formed and the price and quality largely varies across child care, and there is little prospect that the public outperforms the private sector, there is little need to substitute private market with public facilities or universal subsidy schemes. Without considering market conditions, the introduction of universal and flat policy scheme may lower the quality of childcare as Baker et al. (2005) suggested. As far as the equity is concerned, partial subsidies in a form of a voucher for low income families can increase an access to child care at a low price.

Regardless of the form of subsidizing whether it is a subsidy or a direct provision of public facility, when government implements policies to help with child care, it aims to encourage women's labor supply. For example, child care subsidies in the U.S. requires women's labor force participation, job search, education, or other equivalent activities to receive them. Sweden's public child care, although it is well known for its wide coverage, also prioritize double earning families and working mothers. Single earning families and non-working mothers use private child care. Swedish women's labor force participation as high as almost 80% may be in large part due such policies that benefit working mothers. The Korean government currently provides child care subsidies in a sliding fee scale for low income families. In particular, the families with children younger than six are, depending on their income, subsidized upto 100, 60 and 40 percent of market price. However, it is planned that the coverage of subsidies extends to whole families without income eligibility. There is no requirement in labor force participation or education either. Subsidizing child care without income eligibility and any labor market requirement is not only costly but also discourages women's work incentives.

Pronatal Tax Scheme

An alternative way of supporting women's labor supply and fertility by reducing the cost

of children is to devise a pronatal tax scheme. Tax reduction for families with children can be either tax credits for working mothers or a reduction in tax base, both of which provides varying benefits according to the number of children. Although the tax reduction is not an explicit transfer of money or goods for children, it implicitly aims to encourage births. The main feature of these pronatal tax system compared to other family policies is that they are contingent upon working in most cases and encourages labor supply. Examples include the Child Care Tax Credit (CCTC) and the Earned Income Tax Credit (EITC) in the U.S., and Child Tax Credit (CTC) and the Working Families Tax Credit (WTC) in the U.K. The tax system in France reduces tax base by adjusting taxable income with the equivalence scale so that large families pay less tax. Many studies have found the positive effects of these programs on labor force participation; e.g., Blundell et al. (2000) and Scholz (1996). Although not immediately observable, these pronatal tax scheme also has positive effect on fertility (Whittington et al., 1990).

Maternal and Childcare Leaves

When a woman's market activities are interrupted by child bearing and rearing, there are associated costs: the foregone income, the loss of returns to experience and the depreciation due to non-participation. Since the latter two costs are not directly measurable, policies mainly target to reduce the foregone income. Maternal and childcare leaves provide a paid or non-paid recess to a woman (or sometimes a man) for her birth and childcare to reduce career disruption due to child bearing and rearing. The allowances and duration of those leaves vary across countries; e.g., leaves without payment for 12 weeks are provided in the U.S. upon a birth, while paid leaves for more than a year are provided in Sweden for a birth. These leaves are mandates to employers that they should guarantee the retainment of and return to a job. However, costs resulting from mandates to employers tend to be transferred to employees. When mandates cost employers to bear some

burden, they can always adjust employment and wages to avoid it. As a result, mandates originally aimed at benefiting some group may end up disfavoring them. Gruber (1994) find that the maternity benefits mandated to employers to provide health insurance for births reduces the employment and wages of young women who are likely to have births in the near future. Therefore, policies like parental or childcare leaves that tend to cost employers and coworkers should be carefully implemented.

B. Policy Experiments

Among these policies described above, only childcare subsidies have begun to be in practice since 2004 with a limited coverage. However, policy makers currently suggest additional policies that include almost all policies used in other countries. In this section, the effects of child allowances, conditional childcare subsidies, tax credits, and parental leaves among others are examined. In terms of projecting the effectiveness of program, cost and benefits should be carefully defined. Costs include direct subsidy amounts and the changes in tax revenue resulting from the changes in hours of work. Benefits are more difficult to specify because improving utility may not necessarily be the policy goal to pursue. In this paper, noting that the increase in labor supply is an important policy goal, I consider the policy impact on quantity and quality of children and women's labor supply as well as utility. In the following simulation, I make assumptions on program details to reflect the main features of each program.

• Child allowances: A fixed amount (M) is provided to the mothers with children from 0 to 5 years old. Child allowances could be provided until the child's age of sixteen like in the UK or six in Japan. However, following Korean government's current suggestion, I let child allowances be given until the age of five. This has a direct effect on the budget constraint. The budget constraint at t reads

$$c_t/\pi + g_t + a_{t+1} = w_t h_t - \tau(w_t h_t) + (1+r)a_t + y_t + M(k_t - k_{t-5}).$$

Child allowances are expected to increase women's utility and encourage fertility by increasing disposable income according to the number of children. However, the increased income may discourage work incentives by income effect and have a negative effect on labor force participation. Also, the increased income does not necessarily result in a one-to-one increase in goods investment in children(g_t).

• Conditional childcare subsidies: A in-kind transfer (G) is provided as goods investment in children for children from 0 to 5 years as well as long as a woman works. Whether government subsidize as a form of a voucher or direct service does not make difference in this model. These subsidies affect the production function of child's quality:

$$q_t = \{(G + g_t)^\eta + m_t^\eta\}^{1/\eta}$$

$$\begin{cases} G > 0, \text{ if } \quad LFP = 1 \\ G = 0, \text{ if } \quad LFP = 0 \end{cases} \text{ and } G = \bar{g}(k_t - k_{t-5}),$$

where $\bar{g}$ is the amount of subsidy per child.

As the production function of child service suggests, the two inputs of goods and maternal time investment are substitutable in determining child's human capital. When the public goods G are invested in children, maternal time is saved so that it can be used for leisure or labor supply. When the transfer is made contingent upon the labor force participation of women, women's time is directed to labor market, increasing women's labor market participation. As childcare subsidies reduce the cost of rearing children, they are likely to have positive effects on fertility.

• Pronatal tax credits: I consider tax credits that increase with the number of children. While some tax credits are provided only to low income families to encourage low income earners' labor supply, here I consider tax credits for all income levels. Given that the labor force participation is not necessarily higher for higher earners in Korea, tax credits for all income levels would encourage labor supply of women with all skill levels.[11] To be consistent with other policy experiments, tax credits are provided to mothers with children under age six. In the model, a_0 reflects the proportional part of income tax and is adjusted to capture the credits. When the tax credits are introduced, the income tax reads:

$$\tau(I) = (a_0 - E\bar{k_t})(I - (I^{-a_1} + a_2)^{-1/a_1}), \quad \bar{k_t} = k_t - k_{t-5}$$

Since only working women can enjoy the benefit of tax credits, and the longer hours of work, the greater the benefits, there is positive effect on labor supply. Also, the structure that the tax rates varies with the number of children will give a positive incentive of fertility.

• Maternal or childcare leaves: Depending on the replacement rate and the duration of leaves, the cost of introducing them largely vary. I consider a maternal leave that provides 20 percent of earnings for two years including birth year, reflecting current Korean rule.[12] When the average hours of work is $h^\star$, the budget constraint of the women who use leaves

[11] According to the *Economically Active Population Survey*, the labor force participation of women with college and above is about 60 percent, while that of women with junior college is 67 percent.

[12] It is a current rule in Korea that 90 days of maternal leaves for birth and one year of childcare leaves for women with children of age three or below are provided. For the maternal leave, only 30 days are paid one. For the childcare leaves, 400 dollars a month, about 20 percent of average workers, are paid to the employees. However, due to the cost to the employers, the utilization of childcare leaves is very low.

reads:

$$c_t/\pi + g_t + a_{t+1} = 0.2 \times w_t h^\star + (1+r)a_t + y_t \quad \text{and} \quad l_t = 1 - m_t - z_t$$
$$t = j, j+1 \quad \text{and} \quad b_j = 1$$

As mentioned, the younger a child, the greater the fixed time cost. When the maternal leaves are provided to women with zero and one year old children, the saved time can be spent for leisure and time investment in children. Most of all, women do not have to drop out of labor market due to childcare costs. Thus, leaves are expected to have positive effects on labor force participation. Since they do not have to fully give up their earnings, the reduced foregone earnings due to child bearing and rearing will encourage fertility.

C. Results

Having investigated the likely effects and the mechanism of each policy, I compare the effectiveness of them obtained from policy experiments. The costs of each policy includes subsidy amounts less the increase in the present value of tax revenue due to increased labor supply. The outcomes of interest in examining the effects of policies are changes in the expected utility, the quantity and quality of children, labor force participation by age, and hours of work. Table 5 presents the results of policy experiments. As expected, introduction of policies overall increase fertility and the expected utility. Most policies except for the universal child allowances have positive effects on labor supply. However, the results from the policy experiments are based upon the assumption that there is little lags or friction in introducing and conducting such programs.

As predicted, child allowances that make a universal transfer reduce the labor force participation and hours of work. On the contrary, the conditional childcare subsidies when provided contingent upon labor force participation have a great impact on overall partic-

Table 5: Results from Policy Experiments

	baseline	child allowances	conditional cc subsidies	pronatal tax credits	maternal leaves
(1) program costs (subsidy+Δtax)	-	6.572	3.528	9.014	6.194
(2) utility	-21.427	-21.363	-21.370	-21.383	-21.402
(3) quantity of children	1.50	1.87	1.73	1.73	1.82
(4) quality of children	11.6	12.0	11.8	13.2	11.6
(5) LFP (overall)	57.6	54.5	72.8	65.4	64.5
(6) LFP (young)†	34.6	29.8	58.0	46.6	45.0
(7) hours of work	2,490	2,454	2,500	2,536	2,406

† indicates the labor force participation of women within 6 years since birth.

ipation rates especially for mothers with young children. Positive labor market effects of the conditional subsidies also increase tax revenue from labor earnings and offset some of the subsidy costs. As a result, the overall costs of conditional subsidies, although the subsidy amount that each household receives is the same with child allowances, are much lower than those of child allowances. Then the effects on quality and quantity of children per unit cost are greater for conditional subsidies than child allowances.

Tax credits here alleviate tax burden by about 2 percent of labor earnings per child for women with children younger than six. Since the benefits of tax credits depend on labor earnings and hours of work if the wage rate is the same, this tax scheme encourages labor supply. As a result, the labor force participation and in particular, hours of work increase. While child allowances provide the same amount to all income levels and are concerned to asymmetrically encourage low income families' fertility, tax credits proportional to their earnings can encourage fertility of broader group of women. The conditional childcare subsidies seem to be more effective than tax credits in the sense that they are less costly while the effects are similar. However, tax credits that provide higher benefits to higher earners can increase the average quality of children because they make transfers to high income families whose children are likely to have high quality.

Lastly, the effects of maternal leaves are presented in the sixth column of Table 5. As mentioned above, the experiments are based on the current rules on leaves that are limitedly in practice in Korea. Depending on program design including the replacement rate and duration of leaves, the costs can largely vary. In addition, leaves may be misused to avoid work by proper spacing of children. For example, if maternal leaves last two years, women can avoid labor supply by having births every three years. This is why the additional speed premium is devised to encourage short term spacing and to reduce such misusage. However, if women care about cooperation with coworkers or returns to work experience, such misusage would not be so frequent in reality. The policy experiments that consider only the benefits of maternal leaves without concerning employers or coworkers may show the maximum effect possible. Maternal leaves have a positive effect on the number of children and labor force participation. They can induce further labor force participation because they are available only for working mothers than they simply increase participation rates by counting those who are on leaves as workers. However, due to the reduced hours of work during leaves, the average hours of work decreases. If part time jobs as well as maternal leaves are available, more number of women would work and benefit from maternal leaves.

VI. Conclusion

The substantial reduction in fertility and steady increase in women's labor supply calls into question what role the economic forces play in the decisions and which public policies can be effective. The investigation of this is useful because many countries face the same problem of drastic fertility decline and accelerating ageing process. Countries that have not experienced such rapid ageing can draw some lessons through this exercise. To answer these questions, a dynamic lifecycle model where a mother makes decisions on fertility

and labor supply is developed. The economic framework presented here incorporates important factors including inevitable time costs associated with and mother's investment in children. Findings suggest women's wage rate, expenditure on children, and uncertainties in household income play important roles. In particular, the majority of women have their first birth just after their marriage because they face an increasing wage profile. However, having children significantly reduces women's market time.

Based on the model, this paper provided some policy experiments. Widely used policies such as child allowances, childcare subsidies, and tax credits are examined. Despite the superiority of lump sum transfer in improving welfare, I claim that the conditional subsidies such as tax credits are a more effective policy tool than the unconditional child allowances. The important policy goal is to help women with expenses associated with children without reducing the labor supply. Extensions of the model are available in many aspects. The introduction of endogenous wage rate, which varies with work experience and duration of non-participation would allow a deeper investigation of a role of work disruption due to births. However, as mentioned above, this require a careful specification of wage equation considering the heterogeneity of women since the aggregate data does not evidently show the depreciation of wage rate after work disruptions. An inclusion of marriage decision would permit incorporating of the effect of delay in marriage on fertility and labor supply of women.

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Appendix

Computational Details

This section describes the algorithm used to compute the solution to the economic agent's dynamic programming problem. The algorithm of the solution includes a few steps. First, make a guess for the parameters to be estimated from the model. Excluding the parameters obtained from previous literature or data sets directly, there are seven parameters to be estimated from the model; $\sigma, A, B, \kappa, \zeta, \xi$ for utility function and η for production function. Second step solves the finite period dynamic programming problem given all the parameters using the backward induction (See below for details about numerical solution.) Third, based on the decision rules computed in the second step, perform a simulation by drawing random error terms of wage and non-mother income equation from the normal distribution. Then individuals with lifetime consumption, fertility and labor supply paths are constructed. Fourth, using simulated data, compute the distance between the simulated and actual outcomes. Fifth, revise the guess for the parameters of interest for the distance to be minimized.

A. Numerical Solution

Consider all the cases where the woman has k children over t periods, which are ${}_tC_k$ cases. To reduce the computing costs, the case with the age difference between adjacent siblings greater than five is excluded. For each case, create grid points for ϵ_y and ϵ_w. Let $\epsilon_y \in \{\epsilon_{y1}, \epsilon_{y2}, ..., \epsilon_{ym}\}$, and $\epsilon_w \in \{\epsilon_{w1}, \epsilon_{w2}, ..., \epsilon_{wn}\}$. Using the parameters of Autoregressive process of y and w, obtain the probability matrix Π and Ξ, where $\Pi(i,j) = prob(\epsilon'_y = \epsilon_{yj} | \epsilon_y = \epsilon_{yi})$ and $\Xi(i,j) = prob(\epsilon'_w = \epsilon_{wj} | \epsilon_w = \epsilon_{wi})$. Assuming that the economic agent do not leave bequests or debt, $a_D = 0$, given the guess of final asset level for each state, a_{D-1}, compute a value function at $t = D$, which is a m×n matrix. According to the Euler

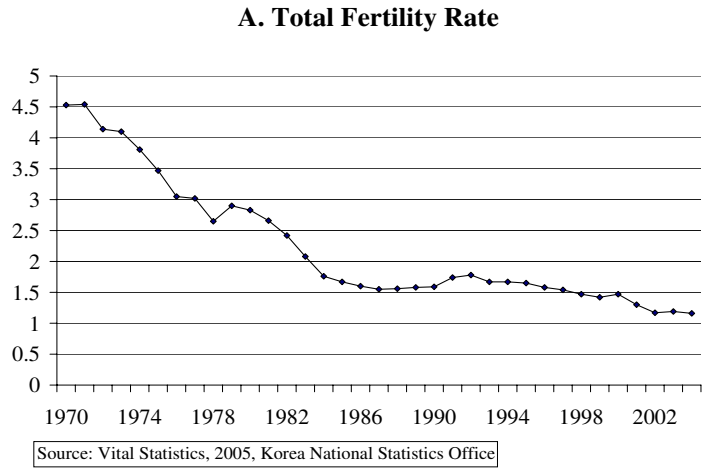
equation, we compute the solution at $t = D - 1$, satisfying

$$u'(C_{D-1}) = \beta(1 + r)\Xi\Pi u'(C_D). \tag{12}$$

When C_{D-1} is found at each state space, using the budget constraint, a_{D-2} is obtained. In a similar way, find the associated solution backwards to obtain a_0. Assuming that the initial asset level is zero because there is no bequest in the model, update the guess of a_{D-1} so that a_0 for each state space to be zero. Through this procedure, when the initial value function at each state space for each case of fertility is obtained, choose the fertility case for each state that gives the maximum value function.

B. Monte-Carlo Simulation

Draw a pair of (ϵ_y, ϵ_w) at each period according to the Normal distribution of each variable. Using the decision rules obtained above, find the solution paths for all choice variables. Make 500 draws to construct a simulated data set. Using this data set, obtain the moments of interest. Repeat this process of constructing simulated data sets for 1,000 times.



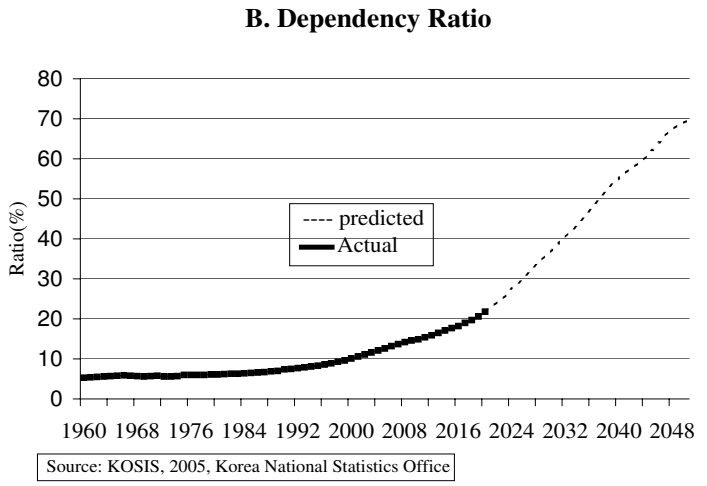
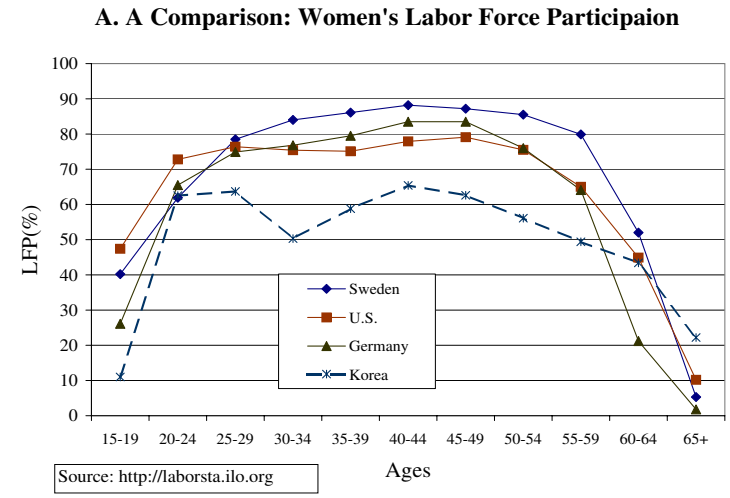
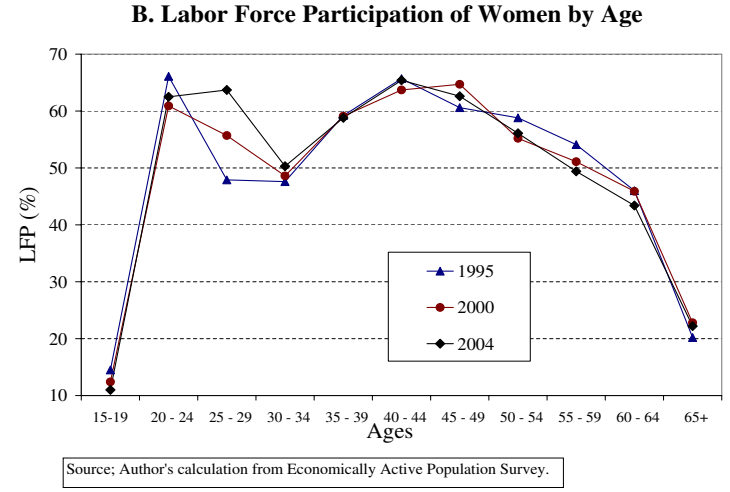


FIGURE I: TOTAL FERTILITY RATES AND DEPENDENCY RATIOS





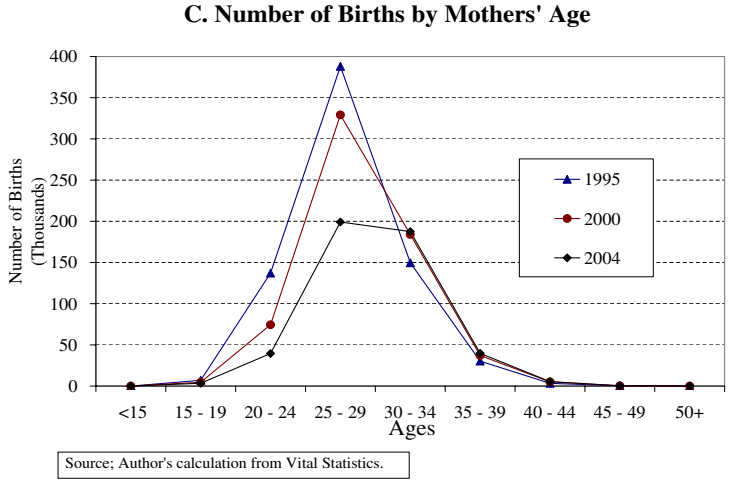


FIGURE II: LABOR FORCE PARTICIPATION AND NUMBER OF BIRTHS BY AGE