Essays in Family Economics

by

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ABSTRACT

The demographic transition from high birth to low birth is a fundamental process that countries undertake. It can create substantial challenges for economic growth and social policy by straining public finance. This dissertation explores the sources of low fertility and examines the effects of government policies that aim to affect fertility behavior.

In the first chapter, I use a static model of fertility choices to estimate to what extent different factors contribute to low fertility in South Korea and examine the effects of child-related policies on fertility. In the model, two key factors affect fertility choices: the minimum consumption level required to have a child and women's opportunity cost of raising children. The model is calibrated to match the fertility behavior of Korean women and used to examine the impact of lump-sum transfers and childcare subsidies on their fertility. I find that transfers to households per child are more cost-effective than child care subsidies. Transfers per child can reach the target fertility at a lower cost by targeting women who already have children and whose wage is sufficiently low to choose to have another child rather than work. In the case of child care subsidies, on the other hand, women who are childless or have one child and whose wage is sufficiently high to choose working over having a child are the most responsive to the policy. Thus, transfers can achieve the target fertility most cost-effectively by inducing higher-order fertility among relatively lower-wage women.

In the second chapter, I document the empirical relationships between homeownership and fertility in South Korea. First, there is a positive relationship between the home price and fertility among homeowners. A rise in home prices by 7,346,000 KRW, equivalent to 8734.94 USD in 2010, is associated with a 2.95% increase in the

mean likelihood of giving birth. Second, for renters, the same increase in the local home price in the prior year is related to a 1.24% decrease in the mean likelihood of giving birth.

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Chapter 1

THE IMPACT OF CHILD-RELATED POLICIES ON FERTILITY CHOICES IN SOUTH KOREA

1.1 Introduction

Many developed countries have a total fertility rate below the rate at which the population would remain constant in the long run.[1] Declining fertility rates coupled with aging populations can create substantial challenges for economic growth and social policy by straining public finances. It is more challenging that fertility response is found to be resistant to attempted interventions (see Bick (2016), Doepke and Kindermann (2019), and Lalive and Zweimüller (2009)). South Korea is one of those countries whose projected population growth rate will be negative in 2029. Hence, there has been a continuing discussion on the causes of low fertility and how to design and evaluate policies that aim to raise fertility.[2] The objective of this paper is to develop a tool to diagnose the causes of low fertility in South Korea and examine the effectiveness of pro-natal policy by quantifying its impact on fertility choices.

To capture fertility behavior of Korean women, this paper uses the Korean Labor Income Panel Study (KLIPS) from 1998 to 2019. The main sample is women born between 1966 and 1980; the youngest woman in the sample is age 40 in 2019. Two

[1] The total fertility rate is the average number of live births a hypothetical cohort of women would have over their reproductive life if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. The population replacement fertility rate is about 2.1.

[2] Source: "Population Trends and Projections of the World and Korea, Statistics Korea", July 2015.

critical relationships between years of education and fertility outcome are observed. First, conditional on having a child, the average number of children born to women decreases with years of schooling. Second, the share of women who remain childless shows a non-linear relationship with years of education; the childlessness rate for women with six years of education is 14% while it is 4% for women with eight years of education. Subsequently, the childlessness rate increases with years of education. Similar relationships between levels of education and fertility outcome are also found in the U.S. For instance, Caucutt *et al.* (2002) note that women who are more educated have fewer children in their lifetime using the sample from Panel Study of Income Dynamics. Baudin *et al.* (2015) extensively document and provide the robust relationship between years of education and fertility outcome using the sample from 1950 and 2000 in the American Community Survey.

This paper rationalizes the documented relationships between education levels and fertility with a static model of household fertility choice with extensive and intensive margins. A household with a wife and husband faces costs of having children in terms of women's time. To the extent that women's time is necessary for raising children, having children is more costly to women with higher education which induces women to have fewer children as their years of education increase. In the model, each child requires a fraction of the mother's time which she can use in the labor market if she doesn't have children. On top of this variable time cost of having children, there is a fixed time cost when the household decides to have its first child.

The model is calibrated to match the fertility behavior of Korean women. The estimated cost of having children says that, for a woman who is at the bottom 20% of the female wage distribution of the sample, it takes five years of her working time to have her first child. In terms of income, she needs twice her wage to become a mother.

This finding suggests that both the fixed and variable costs of having children are sizeable.

Child-related policies such as lump-sum transfers to households or child care subsidies can reduce the burden of having children by financially supporting families willing to have more children. The Korean government has implemented means-tested child allowances and child care subsidies recently. Thus, there have been continuing discussions on whether to significantly increase the amount of funding for the child-related policy and its effectiveness. It also brings up a debate about implementing these policies, such as supporting all children or only the first child of the household.

Motivated by these debates, this paper conducts policy experiments with the calibrated model. Two types of policies are considered: per child lump-sum transfers to households and subsidy for women's child care time for each child. The household receives lump-sum transfers from the government that increase linearly with the number of children. This transfer is conceptually close to the child benefit in the U.S. The subsidy for childcare time, on the other hand, financially supports the woman in the household by reducing a fraction of her time with children, and hence, she can use that time in the labor market. For these reasons, the lump-sum transfer can be interpreted as a "goods subsidy" and the childcare subsidy as a "time subsidy".

The policy experiment has two main questions: which of the two policies, goods and time subsidy, is the most cost-effective to raise aggregate fertility? What are the heterogeneous effects of these policies on fertility choices? The measure for aggregate fertility is completed fertility which is the average number of children ever born to women in the same cohort when they reach the end of their fertile life. In this paper, the average number of children of women in the sample is 1.92. The targeted completed fertility is set to 2. In the main experiment, households receive subsidies per child. For example, if there are two children in a household and the amount of goods subsidy for one child is θ, the household is eligible to receive 2θ. In the case of the time subsidy, the variable time cost of having children is reduced by the subsidy rate λ, which enables mothers to spend that reduced amount of childcare time times the number of children working.

To raise fertility from 1.92 to 2, the goods subsidy costs 0.2% of the pre-reform total household income while it takes 0.6% of the pre-reform total household income to implement the time subsidy. The goods subsidy primarily affects women willing to have more children without working. Note that the estimated time cost for having children is high. According to the model, the variable time cost for mothers to raise each child is three years. Hence, the time subsidy rate has to be very high to have women both work and have more children if their wages are not highly competitive in the labor market.

On the other hand, a goods subsidy can raise the total household income without having women work, which can incentivize women with relatively low wages to have children. These women are likely to have children even before the policy is introduced. In fact, only 0.7% of childless households before the goods subsidy was introduced decided to have children at all after the policy. The impact of the goods subsidy stands out in the increase in the share of households with three or more children. The goods subsidy can achieve the target fertility at a lower cost by inducing higher-order fertility.

In the final experiment, households receive the goods or time subsidy only for their first child. These subsidies are called the goods or time subsidy for mothers because it supports when a woman chooses to become a mother. The goal of this exercise is the same as the main experiment, which is to calculate the cost of implementing the policy to raise fertility to 2. Since the subsidy for mothers supports only the first childbirth, its cost is higher than the cost of the per child policy. However, its impact on childless households is noticeable. For both the goods and time subsidy, more than 3% of childless households choose to have children at all.

This paper builds on the fertility literature that studies low birth rates in industrialized countries. Gobbi (2013) and Aaronson *et al.* (2014) study channels through which the opportunity cost of rearing children has an impact on fertility and childlessness in the U.S. Both papers study how increased female wages affect the fertility decisions of American women. Closely related to this paper is Baudin *et al.* (2015) that builds a unified theory of fertility, childlessness, and marriage in the U.S., where individuals can be childless due to poverty or opportunity costs. I complement this study by applying their framework to Korea to analyze the extent to which the model can generate fertility patterns and quantify the relative importance of each channel.

Another closely related to this paper is Kim *et al.* (2018), who also studies low birth rates in Korea using a structural model. In their model, parents care about their children's human capital relative to other children, which leads to over-investment in education and inefficiently low fertility. The assumption on parents' preference for children's human capital drives fertility and education investment decisions which are the channel they focus on. Relative to them, I take two explanations for low birth rates in Korea that are not considered in their work.

Lastly, this paper contributes to the literature on the response of fertility to financial incentives. Many empirical studies estimate the effects of parental leave policies and universal childcare on fertility. Bauernschuster *et al.* (2016), and Raute (2019) studies the impacts of a German reform that expands subsidized childcare for children under the age of three, where they find that positive fertility effects of increases in public childcare. Exploiting a major Austrian reform, Lalive and Zweimüller (2009) studies the effects of job-protected parental leave on higher-order fertility and finds that although there are positive effects of extended parental leave on higher-order fertility, there are lot of heterogeneity in effects across the population. Using a structural model, Bick (2016) quantifies the impact of the expansion of public childcare for young children on German mothers' labor supply and fertility and finds little changes in the overall fertility rate in Germany. Doepke and Kindermann (2019) also uses a quantitative model of household bargaining, where a key determinant of fertility is how couples share childcare burden. Although this paper abstracts some features considered in the literature, it differs from them by providing which policy between transfers and childcare subsidy can be effective in implementing it.

1.2 Empirical Analysis on Fertility Patterns in Korea

This section presents fertility patterns by education levels for Korean women born 1966-1980. The main data set used in this paper is the Korean Labor Income Panel Study (KLIPS). It is a representative household panel survey in South Korea and comparable to the Panel Study of Income Dynamics in the US. The KLIPS has been conducted on a sample of 5,000 households and their members. The data is drawn from the first wave in 1998 through the twentieth wave in 2019.

1.2.1 Data

Sample

The analysis is based on a birth cohort of women born between 1966 and 1980 who were at least age 40 at their last interview. To avoid selection into single mother or divorced households, it focuses on fertility decisions made by a married couple. In particular, there are only 2.4% of never-married women, 5.3% of divorced women, and 1.5% of unwed single mothers out of women born from 1966 to 1980. Thus, excluding the never-married and single mothers is unlikely to bias the results since the proportions are negligible. Women with no information on marriage history, never-married women, and women who were married or in a relationship with multiple men are excluded from the sample. In addition, women whose husband's information or fertility history is not available are excluded. Lastly, I only keep households if, for each spouse, there are at least three observations where the age of the wife or husband is between 25 and 55. After applying these criteria, there are 4102 households in the sample.

Married women in the sample are grouped into six education levels by their highest education completed. Table 1 shows the description for each education level and its corresponding average number of years of schooling used in this paper. The Korean education system structure is divided into six years of primary school, followed by three years of middle school, and then three years of high school. The grade in Table 1 corresponds to years of education over primary and secondary education. For instance, grade 10 indicates the first year in high school, which means ten years of education. Those who attained more than high school education are divided into

Table 1. Education Level

Level	Description	Years of Education (e)
1	Less than or equal to grade 6	3
2	Grade 7-9	8
3	Grade 10-12	11
4	1 or 2 years of college	13
5	3 or 4 years of college, or Bachelor's degree	16
6	Master of Doctorate degree	19

Note: The description for each level of education shows its corresponding education attainment. e denotes the average number of years of schooling in each education category.

three levels: less than or equal to two years of college, between three and four years of college or a Bachelor's degree, and finally, a Master's or Doctorate.

Labor Market Outcome

The Work History File of the KLIPS collects retrospective information on individuals' labor market outcomes in the previous interview year. Each respondent reports labor market outcomes for all jobs they have had in the given year. The labor market outcomes include starting and ending dates of each job, earnings from each job, and usual weekly hours worked for each job. I include the labor market outcome of a worker as an employee and a self-employed. Wages are hourly labor market income. I calculate average monthly earnings for those who report annual labor income, obtained by dividing the yearly income by the number of months employed. To obtain wages, the average monthly earning is divided by 4.3 times the weekly hours worked. If the respondent reports earnings every month, it is divided by 4.3 times the weekly hours worked at that job. If the respondent reports the hourly wage, I use this information for wages. The worker-wage observations are included if workers' ages are between 25 and 55, and their monthly earnings are between 0.3 million won and 20 million won in terms of 2010 won. Then I average wages over the observed period and use it as the lifetime wage for the individual. I also construct a measure for the experience each year. This experience in a given year takes 0 if the individual is not employed, 0.5 if employed as a part-time worker, and 1 if employed as a full-time worker. The individual is employed as a part-time worker if they report that the job is part-time or the weekly hours worked is less than 35. I then average this measure for experience over the period when the individual is between 25 and 55 to approximate lifetime labor market experience.

Household Asset

Assets refer to sources of wealth, including housing, stocks, savings, and bonds. In the KLIPS, respondents report income from rents from real estate owned by the respondent, income from stocks and bonds, and average monthly savings in the previous year. With this information for each household, I define household assets in a given year as the total sum of monthly income from assets and savings multiplied by twelve. To obtain the lifetime asset, I average assets over the period when the wife's age is between 30 and 45. The reason for the choice for ages is the following. Recall that I used the KLIPS from 1998 to 2012, of which a sample cohort is a group of women born between 1960 and 1980. The oldest women were 41 years old in 1998, and the youngest women were 35 years old in 2012. By setting the age range from 30 to 45, I make the number of observations for household assets to be at least 5.

Fertility and Childlessness Rate

To measure the fertility of each education level, I use the number of children ever born to a woman, that is, the completed fertility. For women without information on fertility history, I assume that they are childless if she is at least of age forty at their last interview. Age forty is the assumed age of the end of women's fertile period. Based on the completed fertility for each woman, the childlessness rate and fertility of mothers, conditional fertility for each education level are measured based on definitions in the following. The childlessness rate for each education level is the fraction of childless women in each educational category. The conditional fertility in each education level is an average of the completed fertility of women conditional on being mothers.

1.2.2 Fertility Patterns by Education Levels

This section provides key facts on the relationship between education and fertility of the 1966-1980 cohort with a distinction between the extensive and intensive margin of fertility choice. The extensive margin of fertility choice refers to a decision to have children at all. The intensive margin of fertility choice depends on the number of children conditional on having a child. The literature on fertility choices has differentiated between the extensive and intensive margin of fertility choices and finds that there could be different mechanisms for the two margins. For instance, Aaronson *et al.* (2014) find that in the U.S., an increase in educational opportunity for women reduces the probability of becoming mothers. Still, it raises fertility because of the cheaper education for their children. Baudin *et al.* (2017) find that in most developing countries, both the conditional fertility and the childlessness rates have been decreasing over the last thirty years. Socioeconomic factors such as an improvement in contraceptive measures, women's higher education attainment, and hence an increase in labor force participation or population control policies in developing countries can account for the decline in conditional fertility. At the same time, fewer women remain childless as a country gets richer (see De Silva and Tenreyro (2017), Vogl (2020) and Sardon and Robertson (2006)). In developing countries, there could be poverty-driven childlessness where lack of resources such as housing and proper health care for delivery and malnutrition could prevent women from becoming a parent. This evidence and the discussion in the literature motivate me to distinguish the two margins in fertility choices.

The intensive margin of fertility choices is measured as conditional fertility, i.e., an average number of children of mothers, and the extensive margin of fertility choices is measured as a share of women with zero children. Table 2 reports conditional fertility and childlessness rates by education levels among women in the sample. Conditional fertility gradually decreases with years of education. Conditional fertility of women with 6 years of schooling is 2.34 children per woman while it is 1.72 children per woman for women with 19 years of education. This monotone negative relationship between fertility and education is a robust finding in Korea. In Hwang *et al.* (2018), they document this negative relationship between fertility and education for 1950s, 1960s and 1970s cohorts in Korea. Also, it is consistent with findings on this relationship in the U.S., where Jones and Tertilt (2008) documents a strong negative relationship between women's education and fertility for women born between 1826 and 1960.

Unlike the patterns in the intensive margin, the extensive margin shows a non-linear relationship with education. As years of education increase from 3 to 8 years,

Table 2. Fertility Distribution by Education Levels

	Fraction (%)	Childlessness Rate	Unconditional Fertility	Conditional Fertility
All		6.53	1.92	2.02
1	9.25	13.92	2.16	2.34
2	13.46	4.01	2.05	2.27
3	43.47	4.82	1.98	2.01
4	12.83	6.94	1.94	1.97
5	17.84	7.31	1.81	1.83
6	3.15	12.98	1.69	1.72

Note: The numbers in the first column indicate education levels defined in table 1

the childlessness rate drops from 13.92% to 4.01%, and then it rises to 12.98% with schooling. The coexistence of the high level of childlessness and conditional fertility is not unique to Korea. Baudin *et al.* (2015) also find this coexistence among poorly educated women born in 1940-1950 in the U.S., and explain it with a nonconvex constraint faced by households when they make fertility decisions. From their perspective, the poor might limit their fertility decisions and even remain childless because their income is too low to guarantee the minimum consumption level to become parents. This minimum consumption requirement is justified as the poor are more likely to be exposed to malnutrition and diseases and have less access to quality medical services needed for procreation. Thus, it has been found in the demographic literature that this social sterility, or childlessness driven by poverty, is more prevalent in developing countries (see Baudin *et al.* (2019), Ombelet *et al.* (2008), and Winter-Ebmer *et al.* (2016)). Even in the U.S., Baudin *et al.* (2015) find that social sterility concerns 2.5% of American women.

Along with the opportunity cost channel, this mechanism in fertility decisions is worth exploring, especially in Korea, when considering the potential effect of expanding child-related policies on fertility. Suppose a substantial proportion of households are constrained in their fertility decisions. That case implies that lower-income households are willing to have more children as their income increases. Indeed, Kim *et al.* (2018) documents a positive income elasticity of fertility with the 1967-1677 birth cohort in Korea, which means Korean families tend to have more children as their income rises. Even if few households are found to be constrained in their fertility decisions, they can contribute to the higher order of fertility. This motivates policy experiments conducted in this paper to evaluate the impact of child-related policies on fertility.

Not all lower-income households or poorly educated women are constrained by their income when they make fertility decisions. There could be selection into lower education where individuals have lower preferences to become parents and hence have fewer incentives to achieve higher skills. As argued in Kim *et al.* (2018), parents' preferences on the social status of their children can drive households to have fewer children and invest more in their education, which could lead to fewer children in lower-income households than in higher-income households. Acknowledging these potential explanations, this paper first studies the minimum consumption requirement channel in fertility decisions in a quantitative framework and examines how relevant this channel is in the context of Korea.

Motivated by the empirical anlaysis laid out in this section, I use a static model of fertility choices featuring the minimum consumption requirement and opportunity costs of having children to investigate the causes of low fertility.

1.3 Model

This section presents a static model of households that make fertility choices which is closely related to Baudin *et al.* (2015). The model economy is populated by wife-husband households that live for one period. At the beginning of the period, a woman is exogenously matched with a man by the marriage distribution, based on their education levels. Once the household is formed, it chooses the lifetime consumption and number of children. The fertility choice in the model has both extensive and intensive margins. Families decide whether they have children at all or not and if so, they choose how many children they have. Each individual in the household is endowed with one unit of time, and the wife earns w^f and the husband w^m if they work full-time. Wages depend on education, gender, and an idiosyncratic component of the wage function, which reflects ability heterogeneity. The household is alow endowed with non-labor income a, which is drawn from a distribution independent of an individual's education level. For simplicity, the sum of non-labor income and the husband's wage is denoted by $\tilde{a}$ and labeled as an extra income.

Preferences

The household receives utility from joint consumption c, and the number of children n:

$$u(c, n) = \ln(c) + \ln(n + \nu) \tag{1.1}$$

This specification is based on the utility functions in Aaronson *et al.* (2014) and Baudin *et al.* (2015). A preference parameter ν in the utility function for the number of children has two roles in this model. First, a non-negative value of ν allows households to remain childless and governs the utility of being childless, $\log \nu$. Second, ν guarantees that income and substitution effects are not canceled by each other in an optimization problem with a log utility function. There is empirical evidence that children are normal good because the number of children in a household increases as its income rises. The non-negative constant in the log utility assures that households choose to have more children as they get richer. I assume ν is homogeneous across individuals.

Budget Constraint

The household budget constraint is given by:

$$\begin{aligned} c + \phi\,[1 + \eta(n)]\, n w^f &= w^f + \tilde{a} \\ \text{where} \quad \tilde{a} = w^m + a, \quad \eta(0) = 0, &\quad \eta(n) = \frac{\eta}{n} \end{aligned} \tag{1.2}$$

The household's total income consists of the wife's wage w^f and extra income $\tilde{a}$, which is a sum of the husband's wage and non-labor income. Having children incurs costs in terms of the wife's labor income. There is a fixed cost, $\eta \in [0, 1]$, to become parents and a variable cost per child, $\phi \in [0, 1]$. Thus, $n > 0$ children would cost $\phi(n + \eta)$ units of the wife's time. Note that there is a time endowment of one from which a maximum number of children that a household can have is obtained as shown in 1.3.

$$\begin{aligned} &\phi\,(n + \eta) \leq 1 \\ &0 \leq n \leq \bar{n} \\ &\text{where } \bar{n} = \frac{1 - \phi\eta}{\phi} \end{aligned} \tag{1.3}$$

The assumption for the fixed cost is justified by findings that the first child costs more in terms of time than the following children.

Minimum Consumption Condition

To have children, households must meet a certain level of consumption. The condition is such that if consumption is less than the minimum consumption $\hat{c}$, then the household is not allowed to have children at all. Formally,

$$c < \hat{c} \quad \Rightarrow \quad n = 0. \tag{1.4}$$

This minimum consumption condition occurs only when the household wants to have the first child. Also, unlike the time costs of raising children, $\hat{c}$ does not depend on the number of children. This condition can prevent families with low resources from becoming parents in the model.

Household Decision Problem

The household chooses c and n to maximize utility subject to the constraint described below:

$$\begin{aligned} &\max_{c,n} \quad \ln(c) + \ln(n+\nu) \\ &\text{subject to } c < \hat{c} \quad \Rightarrow \quad n = 0, \\ &\qquad c + \phi\left[1 + \eta(n)\right] n w^f = w^f + \tilde{a}. \qquad (1.5) \\ &\qquad 0 \le n \le \bar{n} \\ &\text{where } \bar{n} = \frac{1 - \phi\eta}{\phi}. \end{aligned}$$

1.3.1 Optimal Fertility Choices

The optimal fertility choices are analytically obtained as it is a partial equilibrium model with a log utility function. There are thresholds on women's wage and extra income, w^f and $\tilde{a}$, which form five regions on a space of $(w^f, \tilde{a})$, and consequently five types of optimal fertility and consumption choices. Each household belongs to one of the five types, given its $(w^f, \tilde{a})$. The thresholds for women's wage W_k^f where $k \in \{1, \ldots, 5\}$ are as follows.

Definition 1.3.1 (Wage Thresholds)**.**

$$W_0^f(\tilde{a}) = \frac{\hat{c} - \tilde{a}}{1 - \phi\eta} \qquad W_2^f(\tilde{a}) = \frac{2\hat{c} - \tilde{a}}{1 + \phi(\nu - \eta)}$$

$$W_3^f(\tilde{a}) = \frac{\tilde{a}}{1 + \phi(\nu - \eta)} \qquad W_5^f(\tilde{a}) = \frac{\tilde{a}}{\phi(\nu + \eta)}$$

$W_1^f(\tilde{a})$ is the smallest root in w^f of the quadratic equation $u(c_{III}, n_{III}) = u(c_{IV}, n_{IV})$:

$$\hat{c}\left(\frac{w^f(1 - \phi\eta) + \tilde{a} - \hat{c}}{\phi w^f} + \nu\right) = (w^f + \tilde{a})\nu \tag{1.6}$$

$W_4^f(\tilde{a})$ is the highest root in w^f of the quadratic equation $u(c_I, n_I) = u(c_{IV}, n_{IV})$:

$$\frac{(w^f(1 + \phi(\nu - \eta)) + \tilde{a})^2}{4\phi w^f} = \nu(w^f + \tilde{a}) \tag{1.7}$$

The thresholds for $\tilde{a}$ are as follows.

Definition 1.3.2 ($\tilde{a}$ Thresholds)**.**

$$\underline{a} = \hat{c}\left(\frac{\phi(\nu + \eta) - 1}{\phi\nu}\right), \qquad \bar{a} = \hat{c} \tag{1.8}$$

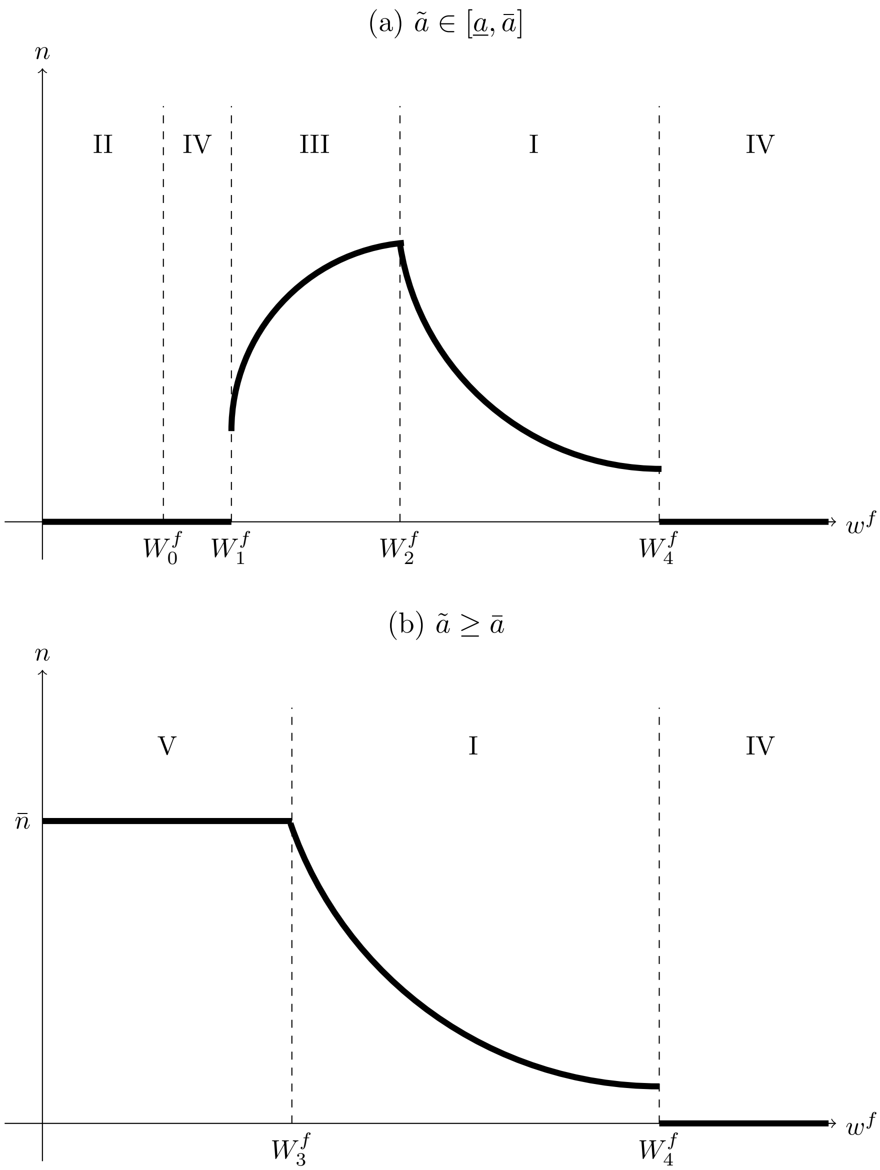
Figure 1 shows the optimal fertility choices as a function of w^f for a given $\tilde{a}$ assuming that households can choose a continuous number of children. The five regions are also denoted in Figure 1. When $\underline{a} < \tilde{a} < \bar{a}$, there are four types of fertility choices. First, when households have enough income to satisfy the minimum consumption condition and have a non-zero number of children, their fertility choices belong to Region I . When $W_2^f < w^f < W_4^f$ and as w^f goes up, the optimal number of children decreases. Next, Region II is where households do not meet the minimum consumption level $\hat{c}$, and hence remain childless. Households are in Region III when they can enjoy the exact minimum consumption level and, at the same time, have a non-zero number of children. In Region III , as wife's wage w^f increases in an interval $[W_1^f, W_2^f]$, the households can raise fertility holding their consumption at $\hat{c}$. Lastly, households can remain childless as the opportunity costs of having children are too high to have children even though they can meet the minimum consumption condition. As shown in 1a, there are two parts for Region IV . For $w^f > W_4^f$, it is straightforward to see that women decide not to have children as they have to give up their relatively high labor market income. When $W_0^f < w^f < W_1^f$, on the other hand, it is less intuitive to think that these women would determine to be childless because their wages are too high. Rather, it is the case where women's wages are not high enough to enjoy consumption that is above $\hat{c}$ and, at the same time, have children. Households with $W_0^f < w^f < W_1^f$, then find it optimal to raise their consumption instead of having children at all.

When $\tilde{a} > \bar{a}$ which is in 1b, households have sufficient income from husband's wage and non-labor income to be able to have consumption above $\hat{c}$ and children. Thus, Region II and Region III disappear, and Region V occurs. Region V is where households can have the maximum number of children as the wife's wage is low enough to choose to spend her time with her children over working. As w^f increases, fertility declines and finally hits zero when $w^f > W_4^f$.

1.4 Model Parameters and Estimation

To assign values to the model's parameters, I take a two-step estimation approach. In the first step, parameters exogenous to the model are externally estimated from

Figure 1. Fertility of Married Couples



Note: Panel (a) and (b) show the optimal fertility when $\tilde{a}$ is low and high, respectively. Each roman number in the figure refers to the following: Region I refers to the unconstrained regime, Region II to the social sterility, Region III to the constrained fertility regime, Region IV to the opportunity cost driven childlessness regime, and Region V to the maximum fertility regime.

the data. These parameters are related to the distribution of wages and asset income. Given the parameter values set in the first step, the remaining parameters are estimated by the Simulated Method of Moments (SMM) following Duffie and Singleton (1990). For a given initial guess of the parameter values, I simulate the model with 100,000 households to obtain the simulated moments. To form a household, I match one woman to one man based on the joint distribution of the couple's education in the sample, which is reported in Table 12. Once matched, the husband and wife draw their abilities from a joint normal distribution. Each individual is then characterized by their level of education and ability, which would determine their wage. Finally, the couple draws asset income from a parameterized distribution that is explained below. Holding this set of households fixed, simulated moments with the given guess of the parameter values are obtained. The parameter guess is updated for the next simulation based on the distance between the simulated moments and data moments.

Formally, let $\hat{\psi}_1$ denote the vector of the parameters estimated at the first step and ψ_2 the vector of parameters that are estimated in the second step. The SMM estimates $\hat{\psi}_2$ is such that it minimizes the weighted distance between the vector of data moments v_d and the vector of simulated moments $v_d(\hat{\psi}_1, \psi_2)$.

$$\hat{\psi}_2 = \arg\min_{\psi_2} \left[v_d - v_d(\hat{\psi}_1, \psi_2)\right]' \hat{W} \left[v_d - v_d(\hat{\psi}_1, \psi_2)\right] \tag{1.9}$$

where $\hat{W}$ is a diagonal weighting matrix that has the inverse of the variance-covariance matrix of the empirical moments on the diagonal and zero elsewhere. The intuition for the choice of the weighting matrix is that when calculating the distance between the simulated and empirical moments, it places higher weights on statistics that have smaller variance.

1.4.1 Externally Estimated Parameters

1.4.1.1 Wages

To generate the distribution of wages for individuals in the model, I choose to parameterize it. In the model, an individual wage is a function of education level and unobserved ability, and formally,

$$\begin{aligned} \ln w^f &= \eta_0 + \eta_1 e + \epsilon \\ \ln w^m &= \eta_0^* + \eta_1^* e + \epsilon^*. \end{aligned} \tag{1.10}$$

where e denotes the years of education. Wife and husband are assigned shocks to wages ϵ^f and ϵ^m, which are drawn from the joint normal distribution:

$$\begin{bmatrix} \epsilon \\ \epsilon^* \end{bmatrix} \sim N\left(\begin{matrix} \mu_\epsilon \\ \mu_{\epsilon^*} \end{matrix}, \begin{bmatrix} \sigma_\epsilon^2 & \zeta \\ \zeta & \sigma_{\epsilon^*}^2 \end{bmatrix} \right), \tag{1.11}$$

where $\zeta = cov(\epsilon, \epsilon^*)$.

There are nine parameters to estimate; $\eta_0, \eta_0^*, \eta_1, \eta_1^*, \mu_\epsilon, \mu_{\epsilon^*}, \sigma_\epsilon, \sigma_{\epsilon^*}, \zeta$. These parameter values are obtained by estimating the following regression equation.

$$\ln w_i = \eta_0^* + \eta_1^* e + \gamma \mathbb{1}_i(female) + \epsilon_i, \tag{1.12}$$

where e denotes the years of education and $\mathbb{1}(female)$ is a dummy variable for female. I assume that the coefficient for education for both sexes are the same, i.e. $\eta_1 = \eta_1^*$. The gender gap γ is introduced to capture the gender differences in occupation, experience, and potential discrimination. Hence, the constant in female wage equation would be $\eta_0 = \eta_0^* + \gamma$. Lastly, the residuals in this regression are used to estimate the joint distribution of unobserved characteristics in wages between spouses. The average and variance of residuals for women (men) are the estimates μ_ϵ and σ_ϵ^2 (μ_{ϵ^*} and σ_{ϵ^*}). Each woman's residual is paired with her husband's residual, and the correlation of residuals between spouses is the estimate for ζ. **??** reports the regression results from different controls for wage regressions, of which the result in column (1) is used for the parameterization of the wage distribution.

1.4.1.2 Asset Income

To parameterize the distribution of asset income a, I group households into three subgroups based on the couple's education. In the first group, there are couples where none of the spouses has a bachelor's degree, which is denoted as LL, and in the second group where only one of the spouses has at least a Bachelor's degree which is denoted as LH. The last group of couples is where they have at least a Bachelor's degree and are denoted as HH. Each household is assigned to asset income a based on the couple's education level. To account for unobserved ability in asset accumulation, I allow that there are household-level idiosyncratic shocks, and formally:

$$\ln a = \alpha_0 + \alpha_1 \mathbb{1}(LH) + \alpha_2 \mathbb{1}(HH) + \epsilon \qquad \epsilon \sim N(\mu, \sigma_\epsilon), \tag{1.13}$$

where $\mathbb{1}(HL)$ is an indicator for the group LH, and $\mathbb{1}(HH)$ is an indicator for the group HH. The shocks to income ϵ is assumed to follow normal distribution. Then the LL has asset $\alpha_0 + \epsilon$, and LH (HH) is assigned to α_1 (α_2) + ϵ. Table 15 reports estimated values for $\alpha_0, \alpha_1, \alpha_2, \mu, \sigma_\epsilon$.

1.4.2 Internally Estimated Parameters

Given the estimated distributions of wages and assets, the remaining four parameters are estimated through SMM. The four parameters are the preference parameter ν, the minimum consumption level to have children $\hat{c}$, the time cost per child ϕ and the fixed child care cost η. These four parameters are jointly estimated to match the empirical moments listed in Table 4.

For the preference parameter ν, I target the unconditional fertility of the sample. Note that this preference parameter is in the utility function of fertility and affects both intensive and extensive margins of fertility choices. Also, in the model, all households have the same preference for the number of children. Hence, I select the unconditional fertility of the sample as the target moment for ν. The minimum consumption level $\hat{c}$ plays an essential role in the extensive margin of fertility choices among households with low resources. Hence, the share of childless women out of women with the lowest years of education is chosen as the target moment for $\hat{c}$.

The time costs for child care, on the other hand, are closely associated with fertility decisions of educated women. These time costs directly reduce the total labor income of women, which means that the opportunity cost of having children is higher for women with higher wages than for women with lower wages. Thus, fertility moments of the educated group, women with a bachelor's degree, are chosen to pin down the child care costs. Specifically, the conditional fertility of women with a bachelor's degree is picked as a target for the variable time cost ϕ, and the childlessness rate of women with a bachelor's degree as a target for the fixed time cost η.

1.4.3 Estimation Results

Table 4 reports the estimated parameter values and model fit of the targeted moments. The estimated value of ν is 8.53, which is smaller than the estimates for ν reported in Baudin *et al.* (2015). Given that the model in Baudin *et al.* (2015) takes single woman's decisions into account, and they are more likely to remain childless, it is not surprising that the value of ν is lower in the sample of this paper, which has only married individuals. Note that the average wage of the first quintile of the women's wage distribution is 6.94, and the minimum consumption $\hat{c}$ is 10. It implies that women with a wage of 6.94 would need an extra income that is higher than $\hat{c} + (1 - \phi\eta)w = 16.88$ to have a child. The estimated values for time costs for having children ϕ and η imply that it takes $\phi(1 + \eta) = 13.7$ percent of the time endowment of the married woman for the first child. That is, she has to stop working for five years to have her first child.

Table 3. Parameters set jointly and their moments

	Parameters	Moment	Data	Model
ν	Preference for childlessness	Unconditional fertility	1.92 (0.14)	1.92 (0.34)
$\hat{c}$	Minimum consumption	Share of childless women of Edu 1 (%)	13.92 (0.18)	14.43 (0.21)
ϕ	Variable time cost	Conditional fertility of Edu 5	1.83 (0.04)	1.82 (0.27)
η	Fixed time cost	Share of childless women of Edu 5 (%)	7.31 (0.02)	7.69 (0.29)

Note: Edu 1 refers to the group of women with 3 years of schooling, and Edu 5 refers to the group of women with 16 years of schooling or Bachelor's degree. Numbers in parenthesis are standard errors of estimated parameter values which are obtained by the bootstrapping method.

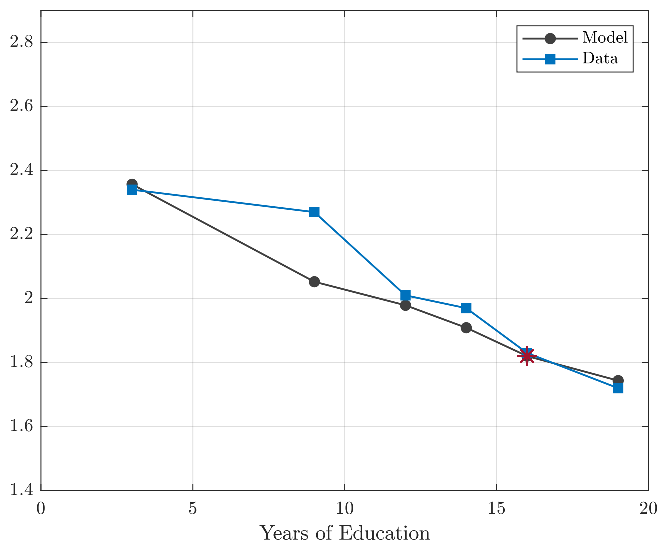
Table 4. Parameters set jointly and their estimated values

	Parameters	Value
ν	Preference for childlessness	8.53
$\hat{c}$	Minimum consumption	10.00
ϕ	Variable time cost	0.12
η	Fixed time cost	0.08

To obtain the standard errors of parameters estimated by SMM, the bootstrapping method is chosen following Berkowitz and Diebold (1998). The idea of the bootstrapping method in an estimated model is to generate a distribution for each estimator by randomly drawing samples from the original data set as if that original data set is population data, using the bootstrap sample to generate empirical moments. Here is the procedure that I follow. To begin, I draw 15 random new samples with replacements from the original data such that each new bootstrap sample is of equal size to the original one. I generate moments for every new data set and estimate the corresponding parameters. This set of two steps is repeated 5,500, which leaves 5,500 estimates for each parameter of which the first 500 estimates are dropped. Finally, it generates the distributions of the estimates for the parameters with 5,000 estimates.

The quantitative fit between data and model is fairly tight which is shown in Figure 2. The model replicates the negative relationship between conditional fertility and education while the model predicts conditional fertility rates slightly higher than their corresponding empirical moments. In the model, the completed fertility of mothers is predicted to decrease with years of schooling. The completed fertility of women with 3 years of schooling is 2.35 children per woman followed by 1.98 children per woman for women with 12 years of schooling; in the data, these figures are 2.34 and

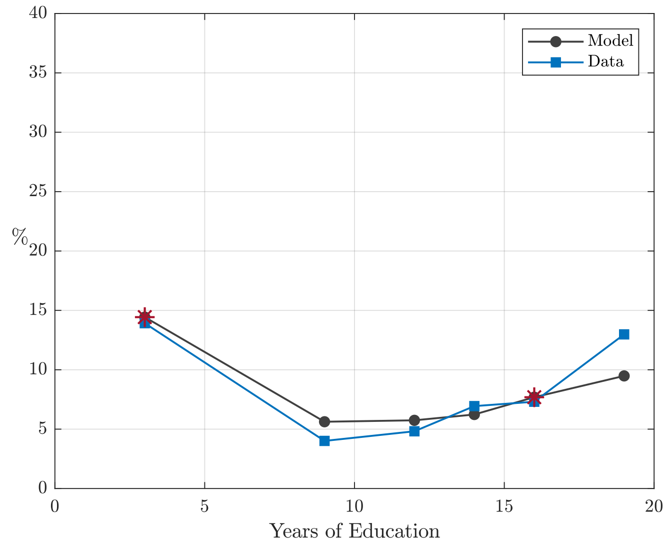
Figure 2. Conditional Fertility



Note: The blue solid line links the data points and the black solid line connects the model predictions on the conditional fertilty by the years of education. The red stars is the targeted moment.

2.97, respectively. Figure 3 compares the childlessness rates generated in the model with the data. The two targeted moments, childlessness rates at 3 years of education and 16 years of education, are estimated slightly higher than their corresponding data moments. For non-targeted childlessness rates, the model predicts higher rates for 9 and 12 years of education and lower rates for 14 and 19 years of education. Figure 6 shows shares of men with one child and two children by men's wage quintiles which are non-targeted moments. The model is able to replicate the general pattern of men's fertility.

Figure 3. Share of Women with Zero Children



Note: The blue solid line links the data points and the black solid line connects the model predictions on the shares of women with zero children by the years of education. The red stars is the targeted moment.

1.5 Policy Analysis

1.5.1 Per Child Policy

The estimated time cost of having children is high. For a Korean woman to have her first child, this cost is equivalent to 5 years of working. In terms of income, for a woman who is at the bottom 20% of the female wage distribution, it takes more than twice her wage to become a mother. These findings suggest that both time costs and the minimum consumption level are sizeable. Hence, child-related policies such as child benefits or child care subsidies can reduce the burden of having children by financially supporting families to have more children. The Korean government has implemented means-tested child allowances and child care subsidies recently. Thus, there have been continuing discussions on whether to significantly increase the amount of funding for the child-related policy and its effectiveness. It also brings up a debate about implementing these policies, such as supporting all children or only the first child of the household.

Motivated by these debates, this paper conducts policy experiments with the calibrated model. Two types of policies are considered: per child lump-sum transfers to households and subsidy for women's child care time for each child. The household receives lump-sum transfers from the government with the number of children, which are added to its budget constraint as an extra income. The transfer is conceptually close to the child benefit in the US, where households can directly buy goods. The subsidy for childcare time, on the other hand, financially supports the woman in the household by reducing her time with children, and hence she can use that time in the labor market. For these reasons, a goods subsidy refers to a lump-sum transfer and a time subsidy means a child care subsidy.

The policy experiment has two main questions: which of the two policies, goods and time subsidy, is the most cost-effective to raise aggregate fertility? What are the heterogeneous effects of these policies on fertility choices? The measure for aggregate fertility is completed fertility which is the average number of children ever born to women in the same cohort when they reach the end of their fertile life. In this paper, the average number of children of women in the sample is 1.92. The targeted completed fertility is set to 2. In the main experiment, households receive subsidies per child. For example, if there are two children in a household and the amount of goods subsidy for one child is θ, the household is eligible to receive 2θ.

Time subsidy is designed to reduce the maternal child care time by a fraction λ. Note that the variable time cost ϕ occurs whenever women have one additional child while the fixed time cost η takes place only in her first childbirth. It is then straightforward that in the model, time subsidy per child is such that the variable time cost decreases by λ_ϕ. Note that this model neither allows households to select childcare options nor have women choose labor supply. It would require an unusual concept of child care subsidy to be applied to the current setting. In this model, the idea of childcare subsidy is a public child care service to which every family with children has to send their children. One can think that parents in the model are mandated to send their children to the public child care service for some time during their childhood.

In the following paragraph, I clarify the budget constraint for each policy experiment and its corresponding total cost to implement the policy.

Goods subsidy per child

$$c + \phi(1 + \eta(n))wn = w + \tilde{a} + \theta n, \tag{1.14}$$

$$TC_{gsc} = \int \theta n(w, \tilde{a}) dF(w, \tilde{a}) \tag{1.15}$$

Time subsidy per child

$$c + \phi(1 - \lambda_\phi)(1 + \eta(n))wn = w + \tilde{a}, \text{ where } \lambda_\phi \in (0, 1) \tag{1.16}$$

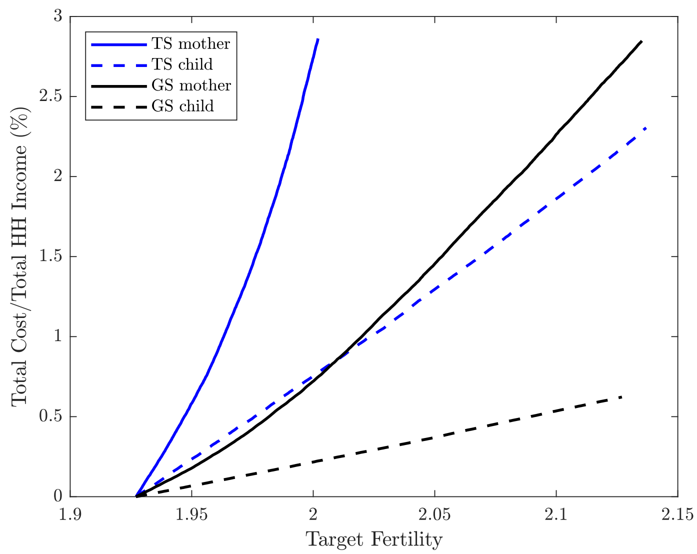
$$TC_{csc} = \int \lambda_\phi \phi(n(w, \tilde{a}) + \eta) wdF(w, \tilde{a}) \tag{1.17}$$

Each cost is divided by the total household income before the policy is introduced so that the cost of policy is interpreted as a share of the total income of the model economy. Formally, for each policy p, the total cost out of the entire labor and non-labor household income is

$$\frac{TC_p}{\int (w - \phi(1 + \eta(n^*(w, \tilde{a})))wn^*(w, \tilde{a}) + \tilde{a} + TC_p)\, dF(w, \tilde{a})}, \tag{1.18}$$

where $n^*(w, \tilde{a})$ is the pre-policy optimal fertility choice.

Figure 4. Total costs for implementing policies by target fertility levels



Note: "GS‘' stands for goods subsidy and "TS" stands for time subsidy. "GS child" means goods subsidy per child and "GS mother" means goods subsidy for mothers. The same rule applies for the time subsidy.

The total costs to implement each policy to reach target fertility is shown in Figure 4. The most cost-efficient approach is goods subsidy per child. To reach the target fertility 2, goods subsidy per child costs 0.2% of the total household income, which is one-third of the costs of implementing goods subsidy for mothers or child care subsidy per child. To raise fertility from 1.92 to 2, the goods subsidy costs 0.2% of the total household income while it takes 0.6% of the total household income to implement the time subsidy. The goods subsidy primarily affects women willing to have more children without working. The estimated variable time cost implies that it takes three years of a mother's time to raise each child. Hence, the subsidy rate has to be very high to have women both work and have more children if their wages are not highly competitive in the labor market. On the other hand, a goods subsidy can raise the total household income without having women work, incentivizing women with relatively low wages to have children. These women are likely to have children even before the policy is introduced.

Table 5. Policy impact on fertility

	Benchmark	(1)	(2)	(3)	(4)
Share of **n** children (%)					
0	5.66	−0.73	−3.12	−1.01	−3.5
1	27.29	−2.3	0.97	−2.33	1.33
2	43.98	−0.44	−0.3	0.19	−0.05
3+	24.06	2.48	1.47	2.16	1.22

Note: Column (1) refers goods subsidy per child, column (2) goods subsidy for mothers, column (3) time subsidy per child, and column (4) time subsidy for mothers.

The aggregate effect on fertility is in Table 5 which reports the changes in the distribution of the number of children after each policy. The noticeable difference between goods subsidy per child and time subsidy per child lies in its effect on the share of households with three and more children. Goods subsidy per child increases the share of households with three and more by 2.48 percentage points. Table 16 and Table 18 report the distribution of the number of children after each policy is introduced conditional on fertility in the benchmark. The critical impact of the goods subsidy stands out in the increase in the share of households with three or more children, which is 2.5%, while it is 2.1% when the time subsidy is introduced. The goods subsidy can achieve the target fertility at a lower cost by inducing higher-order fertility.

1.5.2 Subsidies for Mothers

In the final experiment, households receive the goods or time subsidy only for their first child. These subsidies are called the goods or time subsidy for mothers because it supports when women choose to become a mother. The goal of this exercise is the same as the main experiment, which is to calculate the cost of implementing the policy to raise fertility to 2. The changed budget constraints and the cost function for subsidies for mothers are as follows.

Goods subsidy for mothers

$$c + \phi(1 + \eta(n))wn = w + \tilde{a} + \theta \mathbf{1}_{n>0}, \tag{1.19}$$

$$TC_{gsm} = \int \theta \mathbf{1}_{n(w,\tilde{a})>0s} dF(w, \tilde{a}) \tag{1.20}$$

Time subsidy for mothers

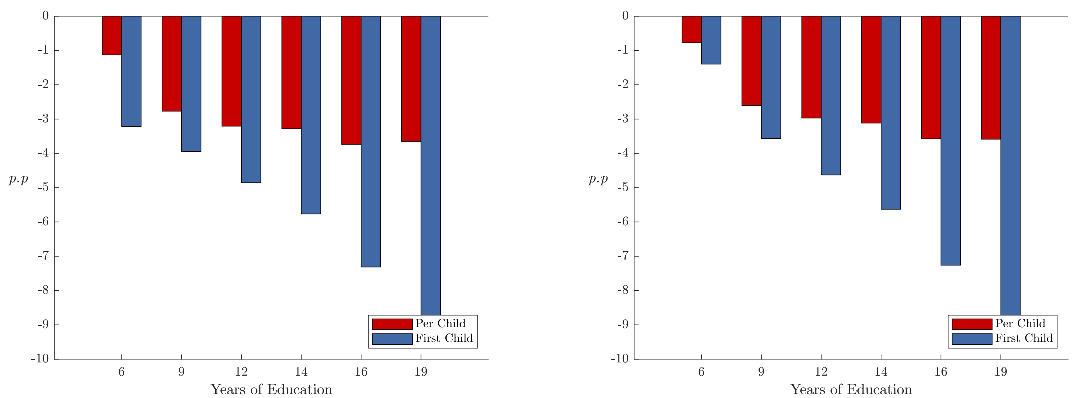
$$c + \phi(1 + \eta(n)(1 - \lambda_\eta))wn = w + \tilde{a}, \text{ where } \lambda_\eta \in (0, 1) \tag{1.21}$$

$$TC_{csm} = \int \lambda_\eta \phi \eta w \mathbf{1}_{n(w,\tilde{a})>0} dF(w, \tilde{a}) \tag{1.22}$$

Since the subsidy for mothers supports only the first childbirth, its cost is higher than the cost of the per child policy. However, its impact on childless households is noticeable. Figure 5 shows the changes in the share of households with zero children by women's years of education. There is a stark difference in the magnitude of the drop in childlessness between policies per child and for mothers. Both policies can lower the share of households with zero children, but policies for mothers induce more women to have children at all. For all years of women's education, the reduction in the share of women with zero children is much larger in the case of subsidies for mothers than in the case of subsidies per child.

Figure 5. Impact of Goods and Time Subsidies on Childlessness

(a) Goods Subsidy (b) Time Subsidy



Note: The figures show the percentage changes in the shares of women with zero children by years of education. The red bars indicate the effects of the per-child policy on the shares, and the blue bars show the effects of for-mother policy on the shares.

1.6 Conclusion

This paper seeks to find the most cost-effective policy that raises fertility in South Korea. It starts by documenting two empirical relationships between fertility and years of education of Korean women: (i) the completed fertility of mothers decreases as their years of education rises, and (ii) the share of women without children first decreases and then increases with years of education. These facts are rationalized in a static model of fertility choices featuring opportunity costs of having children and a minimum consumption requirement to become parents. The estimated opportunity cost of having children and the minimum consumption is high, and their relative size determines the effect of goods and time subsidy on fertility. Because the time cost of having children is high, it is very costly to raise fertility by inducing women to work and have children. Lump-sum transfers to households can increase fertility most cost-effectively by inducing low-wage women to have more children.

I finish this paper by pointing out limitations and proposing possible directions for future research on the fertility impact of child-related policies. In this paper, a government financing problem is not considered. In other words, I explicitly assume that implementing policies is feasible because the government has enough budget to introduce considered child-related policies, and the government collects no labor income tax to fund policies. Hence, the analysis does not consider the potential countervailing effects of subsidizing childcare costs. For instance, a reduction in childcare costs could be balanced by increasing tax rates needed to finance the expansion of childcare subsidies. Therefore, one extension is to endogenize the labor supply and consider trade-offs between lowering childcare costs and higher tax rates. This extension could decrease the magnitude of the fertility effects of child-related policies. The reduction in the fertility effect under the extended set is expected to be higher for high-skilled women because the tax would be more distortionary for high-ability individuals. Finally, it allows analyzing the welfare effects of child-related policies considered in this paper. Since transfers and childcare subsidies affect fertility by income levels, it would be interesting to examine how welfare implications differ across the two policies.

Moreover, this paper abstracts from parental choices on outsourcing childcare time and investment in children's quality of education. The model assumes that having a child requires a certain level of consumption. In the model, any parents who can afford this minimum consumption level have children, and raising children only incurs the time cost of mothers. It means that the cost of the goods for children is the same for all types of households. Therefore, one possible extension is incorporating parental choices on investment in children's quality into the model and studying the effects of child-related policies on fertility and spending on children's education. Previous studies on the impacts of pro-natal policy on fertility choices have found that its fertility effect is economically small. One possible reason could be that the reduction in childcare costs leads to increased spending on children's education. For instance, it could be the case where parents strongly prefer children's education. Hence, the effects of generous child-related policies would be crowded out by increasing spending on investment in children's quality. This extension would be used to study why pro-natal policy might not play an essential role in raising fertility.

Lastly, a significant shortcoming of this paper is that the analysis only focuses on fertility choices and abstracs from other relevant decisions that may interact with fertility. In particular, it would be interesting to study how family formation and fertility choices interact with residential location choices. When couples form a family, their major decision would be where to live and how many children to have. Hence, their residential location choice can depend on their preference for the number of children and their quality. Potential parents who value quality more than the number of children would sort into regions that offer quality amenities for their children's human capital at a high cost of living, such as high rents. It is difficult to expect these parents would have more children in response to a relatively small amount of transfers or subsidies for having one additional child. This mechanism can be essential for the potential effect of expanding transfers or subsidized childcare on fertility if it is true.

To my best knowledge, there is one paper that considers fertility with residential location choice, Garcia-Moran and Kuehn (2017). The authors examine how the geographical proximity between parents and adult children affects the mother's fertility and labor supply in a structural model featuring residence, fertility choice, and labor supply. However, this paper does not consider heterogeneity in preferences on the quantity and quality of children. To proceed with this idea, I would need a panel data set in which families have a history of residential location choices and their fertility choices and a model where one can infer parents' preferences over the quality and quantity of children. With this framework, I would like to study how much residential location choices are related to fertility and investment in children's education and think about what policy would effectively raise fertility.

Chapter 2

HOMEOWNERSHIP AND FERTILITY CHOICES

2.1 Introduction

Family resources are an important factor for the fertility decision of households. Housing is potentially the most significant component of household resources and can play an essential role in this behavior. A large body of studies have investigated this relationship across countries and time periods since Malthus (1798) and Becker *et al.* (1990). Recently, the interest in this relationship has been largely motivated by the demographic shift from high birth to low birth experienced among developed countries. In South Korea, for example, the total fertility rate has been below the population replacement rate since the early 1980s (Andrews and Sánchez (2011)), and recent analyses in South Korea have attributed the country's low fertility to housing affordability (Lee *et al.* (2021); Lim (2021)). Yet, there is a lack of empirical evidence for the significance of housing prices in fertility in the context of South Korea.

This paper brings the most recent data on fertility and housing and documents empirical relationships between housing wealth and family formation decisions in South Korea. Combining the Korean Labor and Income Panel Study (KLIPS) and the Korean Longitudinal Survey of Women and Families (KLoWF), I construct a sample of Korean households with a history of fertility and housing. Using this dataset, I explore the potential mechanisms through which shocks to local housing markets affect the fertility decisions of households and document how these relationships differ between homeowners and private renters.

The economic model of fertility decisions of households posits that housing prices may have an income effect and a substitution effect. Income effects can occur in the following way; assuming there are few substitutes for children and homeowners perceive increased home value as a permanent increase in their income, they raise the demand for children in response to home price changes. On the other hand, substitution effects are likely to occur to private renters because an increase in home prices raises the relative cost of children assuming housing is complementary to children. Such renters may reduce or delay fertility.

The empirical results indicate a positive relationship between the home price and fertility among homeowners. A rise in home prices by 7,346,000 KRW, equivalent to 8734.94 USD in 2010, is associated with a 2.95% increase in the mean likelihood of giving birth. In case of home renters, the mean of local home price changes is related to a 1.24% decrease in the mean likelihood of giving birth.

This paper is related to a strand of literature studying the interaction of family resources and fertility. The demographic shift from high birth to low birth in many countries over the last two decades has led to a vigorous research effort in understanding the interaction between the housing market and households' fertility behavior. Using shocks to the housing market and micro-level data, Lovenheim and Mumford (2013) and Daysal *et al.* (2021) present evidence of the positive effect of housing wealth on fertility in the US and Denmark, respectively. Mizutani *et al.* (2015) and Atalay *et al.* (2017) also document the impact of home prices on fertility using aggregate data in Japan and Australia, respectively. Using aggregate data, Currie and Schwandt (2014) and Chatterjee and Vogl (2018) study the interaction of macroeconomic conditions and fertility behavior and show evidence that fertility is procyclical. This paper provides supportive evidence of this positive effect in Korea and suggests that the result can be larger in an environment with a less generous social welfare system.

This paper also complements the international literature studying sources of low fertility. Existing research has considered an increased return to education and labor force participation in France (Brée and De La Croix (2019)), the United States (Aaronson *et al.* (2014); Baudin *et al.* (2015)). Vogl (2017) and Eckstein *et al.* (1999) have attributed an improvement in child mortality to modern fertility transition, and Sommer (2016) and Guner *et al.* (2019) have argued that an increased income risk may be responsible for delay in fertility in the United States and Spain, respectively. This paper adds to this literature by examining the role of family resources in fertility decisions using a rich longitudinal data set from Korea.

The remainder of this paper is organized as follows. Section 2.2 describes the data used in the analysis, section 2.3 presents the empirical specification and results, and section 2.4 summarizes the key findings.

2.2 Data

The empirical analysis combines data from the Korean Labor and Income Panel Study and the Korean Longitudinal Survey of Women and Families (KLoWF). The KLIPS is a panel survey with a nationally representative sample of Korean households collecting the demographic information of members of the households as well as the information on their economic activities. It has been conducted on 5,000 households and their members annually from the first wave in 1998 through the twentieth wave in 2019. Note that the analysis needs the data on housing history in the KLIPS which has been collected consistently from the twelfth wave in 2009. Hence, the waves from 2009 to 2019 are used for this paper.

Similarly, the KLoWF is a longitudinal study of Korean women's family formation and economic activities with a panel of 9,997 women. There are seven waves of the KLoWF where the first and second waves were conducted every year, and the third to seventh waves were done every other year.[3] Out of these seven waves, only the first two waves in 2007 and 2008 are used in the analysis. The panel design of the KLIPS and the KLoWF allows one to track households' or individuals' history of fertility and housing over the years.

The outcome variable of interest is fertility. Both the KLIPS and the KLoWF have the *Fertility History* which includes all births a woman in the sample gave at the time of the interview. These data have information on the number of children and their birth year. I use women's childbirth information from these data sets to construct an indicator for giving birth in a given year.

Using the housing data in KLIPS and KLoWF, I construct a short-term housing price change. The two databases have collected information on housing type, ownership, and self-reported sales prices. I select households as private renters if they are one of two types of households: households with information on homeownership and indicate that they do not own a home and households with information on monthly rents for their home residence. Homeowners are defined as households who purchased a home and were owners at the time of the interview. Among those homeowners, some households rented out their properties. I only include households who were living on the property that they owned. I use the self-reported sales price data to construct

[3]The first and second waves were conducted in 2007 and 2008. The third to seventh waves were conducted in 2010, 2012, 2014, 2016, and 2018.

a variable for one-year housing price changes. The home prices in this analysis are in 10,000,000 Korean Won (KRW) adjusted to 2010 prices using the province-level consumer price index (CPI). The exchange rate in 2010 that takes the differences in purchasing power between Korea and the US into account is 840.99 KRW per USD, and hence 10,000,000 KRW is approximately 11890.75 USD.

In addition, I use the information on household characteristics as control variables. The KLIPS and KLoWF have rich information on an individual's sources of income, monthly employment status, and education. From these data, I construct household income, women's employment status, and women's years of schooling for controls in the empirical analysis. Household income of a household is defined as the sum of annual labor earnings of the wife and husband, income from financial assets, and two-thirds of business income if the household owns any businesses following the definition Fernández-Villaverde and Krueger (2007). I also take women's employment status into account in the empirical analysis. Women's fertility decisions are strongly tied to their labor market outcomes. For instance, women who strongly prefer children might choose to work less and become mothers. In this regard, I select non-employment status before their childbirth to reflect labor market outcomes. Both the KLIPS and KLoWF have collected 12-month employment status before each survey. The non-employment variable would indicate if she did not have a job over six months in a given year.

2.2.1 Sample

The combined data from the KLIPS and the KLoWF provide a set of households with information on women's fertility history and housing as well as demographic information and economic activities of the household's members. To construct a sample of homeowners, I impose following restrictions on this data set. First, I focus on women aged 20 to 44 who are in a marriage relationship. It is because the KLoWF does not ask single women about their history of childbirth, and out-of-wedlock births are rare in Korea (Tai-Hwan (2007); Rindfuss and Choe (2015)). Second, I drop observations with incomplete household income, home price, and homeownership data. Household income includes annual labor earnings, income from financial assets in the previous year, and two-thirds of business income for households who have a business. Finally, I only keep families whose home is for private use, which did not move during the observation period. Table 6 reports the number of households left after applying each of these conditions. In the final sample, there are 2,487 households from the KLIPS and 2,538 from the KLoWF left in the sample, and hence the total number of households in the sample is 5,025.

Table 6. Sample Construction: Homeowners

Sample criteria	
Women aged 20-44	10,725
Marriage relationship	8,743
With non-missing data on household income	6,562
With non-missing data on home price and ownership	6,008
Homeowner	5,594
Home for private use only	5,271
Did not move during the observation period	5,025

Note: In the final sample, 2,487 households are from the KLIPS, and 2,538 households are from the KLoWF.

To construct a sample of renters, I use 6,562 households with non-missing data on household income. I keep households with information on rents for their residence or indicate that they are renters at their current place. Note that 501 households have information on the rents for their residence and report them as homeowners. These households are excluded from the renters' sample. Households that moved during the observation period are also dropped in the final renters' sample.

Table 7. Sample Construction: Renters

Sample criteria	
Women aged 20-44	10,725
Marriage relationship	8,743
With non-missing data on household income	6,562
With non-missing data on rents or renters[a]	3,903
Not homeowners[b]	3,402
Did not move during the observation period	2,981

Note: In the final sample of renters, 1,138 households are from the KLIPS and 1,843 households are from the KLoWF.

[a] This keeps households either have information on their rents or indicate that they are renters.

[b] This screens households that are in the homeowner's sample.

Table 8 shows the descriptive statistics on the sample. Women in the final sample were born between 1963 and 1994, and the average number of children was 1.62. Some women are young and have not completed their fertility in the sample. Hence, the average number of children is smaller than the completed fertility of Korean women in Jeong (2022).[4] The sample average of lagged one-year home price changes is 7,346,000 KRW which is approximately 8734.94 in 2010 USD. The average increase in home prices in the sample is 8.34%. Compared to prior studies from Denmark, where the average increase in home prices is 7.24%, households in this sample are subject to slightly higher housing price changes.

[4]The sample in Jeong (2022) consists of Korean women in the KLIPS who have completed fertility. The completed fertility of Korean women found in Jeong (2022) is 1.92, which is larger than the average number of children in this sample.

Table 8. Summary Statistics: Homeowners vs. Renters

	Homeowners	Renters
Outcome variable:		
Birth (0/1)	0.1429	0.1244
Housing variable:		
Lagged one-year home price change (10,000,000 KRW)	0.7346	
Home price at the time of purchase (10,000,000 KRW)	8.8082	
Control variables:		
Number of children	1.6231	1.3812
Real household income (10,000,000 KRW)	5.5124	4.0129
Women's Years of education	13.7031	14.7218
Non-employed (0/1)	0.0821	0.0723
Women's Age	33.4510	29.4812
20-24 years old	0.0657	0.0721
25-29 years old	0.2329	0.3689
30-34 years old	0.3421	0.2412
35-39 years old	0.2284	0.2087
40-44 years old	0.1309	0.1091
Women's year of birth	1963 - 1993	
Number of households	5,025	2,981

Note: The exchange rate in 2010 that takes the differences in purchasing power between Korea and the US into account is 840.99 KRW per USD, and hence 10,000,000 KRW is approximately 11890.75 USD.

2.3 Empirical Analysis

This section looks at the empirical relationship between short-term home price changes and the likelihood of having a child. The estimation model is in the following form:

$$Birth_{i,s,t} = \alpha + \beta \Delta HP_{i,t-1} + \gamma X_{i,t} + \phi_{s,t} + \epsilon_{i,s,t}, \tag{2.1}$$

where $Birth_{i,s,t}$ is an indicator for whether household i who lives in state s had a child in year t. The housing variable $\Delta HP_{i,t-1}$ is the lagged one-year home price change experience by household i: $HP_{i,t-1} - HP_{i,t-2}$. This empirical model controls for observed household-year level characteristics that are available in the KLIPS and the KLoWF. The vector of controls $X_{i,t}$ includes indicators for women's age groups, women's years of education, number of children in the household, real household income and an indicator for being non-employed over 6 months in a given year.

The empirical approach in this paper uses the variation in housing price changes from two sources; state-level and within-state changes in home price. Studies in fertility behavior and cyclicality suggest that there are correlations between state-level macroeconomic conditions and fertility which are sources of bias (e.g., Currie and Schwandt (2014); Kearney and Wilson (2018)). To account for this potential bias, I include state-by-year fixed effects $\phi_{s,t}$. It captures any unobserved year-specific state-level shocks correlated with home prices and fertility decisions.

2.3.1 Home prices and fertility choices

Table 9 presents estimation results of (2.1). Column (1) reports estimation results when the state-year fixed effects and controls are excluded. In this simple regression, the estimate for β indicates a 10,000,000 KRW increase in home price is associated with a 0.61 percentage point increase in the likelihood of giving birth. It is statistically significant at the 5% level. In column (2), I control the state-year fixed effects, and the short-term housing price change is associated with a 0.34 percentage point increase in the likelihood of giving birth. Relative to the mean fertility and mean one-year home price change, this is a 1.75% change. This % change is calculated by dividing the estimate by the mean fertility and multiplying it by the mean of one-year home price change, i.e., $100 \times \hat{\beta}/0.1429 \times 0.7346$. Comparing columns (1) and (2), including the fixed effects, substantially reduces the estimated size. This reduction likely implies that unobserved local macroeconomic conditions are correlated both with home price changes and fertility.

Column (3) adds the observed characteristics, including real household income, and shows the preferred estimate. In column (3), I find that a 10,000,000 KRW increase in home prices is related to a 0.58% percentage increase in the fertility rate, which is a 2.95% change relative to the mean. This estimate is significantly different from zero at the 5% level. This estimate is larger than the similar estimates in Denmark. Daysal *et al.* (2021) find that a 100,000 DKK increase in home prices leads to a 2.32% effect on the mean fertility rate. Although many differences can contribute to this gap, the design of the empirical models can be the primary source of the gap between the two countries. Daysal *et al.* (2021) take the ages at which women or households purchased their home and the years in which they bought into account and add age-of-purchase-by-year-of-purchase fixed effects. Accounting for these fixed effects could reduce the estimated effect size, which leads to a difference in the results. On top of the difference in the empirical design, there are critical differences in the sample. Women in the Korean sample show a higher non-employment rate than women in Daysal *et al.* (2021). In Hannusch *et al.* (2019), the author points out that Denmark's generous maternity leave policy and childcare system can contribute to gaps in women's non-employment rates across countries. This institutional difference can also lead to the difference in the effect of home prices on fertility. Women in Korea might be more likely to be non-employed around their childbirth and lose their sources of income, and hence home price increases might have a more significant effect on them than on women in a stable labor market.

While home prices can affect fertility through an income effect among homeowners, an overall increase in home value might negatively impact private renters. Unlike

Table 9. Baseline Results

	Homeowners			Renters
	(1)	(2)	(3)	(4)
One-year home price changes	0.0061** (0.0027)	0.0034* (0.0017)	0.0058** (0.0029)	−0.0021* (0.0010)
Real household income			0.0082 (0.0065)	0.0001 (0.0005)
State × Year FE		X	X	X
Controls			X	X
% Change	1.07	1.75	2.95	−1.24
R^2	0.0331	0.0581	0.0723	0.0301
Number of households	5,025	5,025	5,025	2,981

Note: The controls include women's age, years of education, number of children, and indicator for being non-employed at least 6 months within a given year. Both one-year home price change and real houehold income are in 10,000,000 KRW in 2010. The % change is the change in the mean fertility rate in response to the mean home price change. Standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$

homeowners, renters are subject to local shocks in housing markets, but they do not experience positive income effects from home value changes. Rather, renters would face a higher cost of living, leading to lower fertility due to a substitution effect.

To investigate this mechanism, I estimate the model with a sample of private renters from the KLIPS and KLoWF. Women in this sample are generally younger, have slightly higher years of education, and have fewer children and a lower propensity to have a child. A measure of housing prices for renters is an average of housing prices of homeowners in the sample in the same state and survey year.

Table 9 column (4) presents the results for the private renters. The result for private renters indicates a negative relationship between housing price changes and the likelihood of having a child. An increase in local residential property prices is associated with a decrease of 0.21 percentage points in the likelihood of having a child, which is not statistically significant. For an average home price change, it is a -1.24% change relative to the mean fertility rate of the renters in the sample. This negative estimate of housing price changes suggests that households that experience increasing local house prices can discourage their fertility. It is consistent with the theoretical prediction of the substitution effect of housing prices on fertility for renters. This finding is also consistent with prior studies on renters' fertility choices. Lovenheim and Mumford (2013) and Daysal *et al.* (2021) have found that housing prices have little effect or may reduce the likelihood of giving birth in the US and Denmark, respectively. Atalay *et al.* (2017), who have looked at fertility intentions in response to housing price shocks, show that there is a negative effect of housing prices on fertility in Australia.

In addition to the baseline analysis, I assess the sensitivity of the results to the use of one-year lagged home prices. For this exercise, I use two- and three-year home price changes, i.e., $HP_{i,t-1} - HP_{i,t-3}$ and $HP_{i,t-1} - HP_{i,t-4}$, in the specification (2.1). In response to the medium-term home price changes, the estimates are smaller in magnitude than the preferred estimate.

2.4 Conclusion

This paper examined the fertility response of Korean women to housing price changes. The empirical results indicate that the short-term home price change in the prior year is associated with an increase in the likelihood of having a child for homeowners. For renters, on the other hand, it may reduce fertility. These results are broadly consistent with recent findings from the United States (Lovenheim and Mumford (2013)) and Australia (Atalay *et al.* (2017)). This analysis contributes to the

Table 10. Fertility Choices: Two- and Three-Year Home Price Change

	2-Year (1)	3-Year (2)
Home price changes	0.0030* (0.0014)	0.0016 (0.0021)
Real household income	0.0053 (0.0092)	0.0071 (0.0091)
% Change	0.03	0.01
R^2	0.0412	0.0407
Number of households	3,014	2,132

Note: The controls include women's age, years of education, number of children, and indicator for being non-employed for at least six months within a given year. Household income is the total of labor earnings, financial income, and two-thirds of the business income of the wife and husband. Home price change and real household income are in 10,000,000 KRW in 2010. The % change is the change in the mean fertility rate in response to the mean home price change. Standard errors are in parentheses.
* $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$

literature by providing empirical support on the interaction between family resources, especially housing wealth and fertility, using microdata that contain information on housing and fertility history.

The empirical analysis in this paper highlights that homeowners' and private renters' fertility may react differently to the local home price shocks as the theory on fertility predicts. However, this paper does not investigate some important mechanisms due to the lack of data availability. For instance, fertility timing can play an essential role in fertility decisions over the lifecycle. An increase in home prices may be a reason for renters to delay fertility, reducing lifetime fertility. Home price increases may not directly impact fertility as parents can adjust their investment in their children. It would be interesting to explore how home price changes affect the timing of fertility and the spending on children's education.

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APPENDIX A

THE IMPACT OF CHILD-RELATED POLICIES ON FERTILITY CHOICES IN SOUTH KOREA APPENDIX

A.1 Analytical Solutions for the Household Problem

In this appendix, I solve the maximization problem of a married couple. Table 11 summarizes optimal fertility and consumption decisions for each regime. From now on consumption and fertility for each regime R are denoted as c_R and n_R, respectively. A married couple solves the following:

$$
\begin{aligned}
\max_{c,n} \quad & \ln(c) + \ln(n+\nu) \\
\text{subject to} \quad & c < \hat{c} \quad \Rightarrow \quad n = 0 \\
& c + \phi\left[1 + \eta(n)\right] n w^f = w^f + \tilde{a} \\
& 0 \le n \le \bar{n}
\end{aligned}
\tag{A.1}
$$

Table 11. Consumption & Fertility

	Regime	c	n
I	Unconstrained Fertility	$\frac{1}{2}\left[w^f(1+\phi(\nu-\eta))+\tilde{a}\right]$	$\frac{w^f(1+\phi(\nu-\eta))+\tilde{a}}{2\phi w^f} - \nu$
II	Social Sterility	$w^f + \tilde{a}$	0
III	Constrained Fertility	$\hat{c}$	$\frac{w^f(1-\phi\eta)+\tilde{a}-\hat{c}}{\phi w^f}$
IV	Opportunity Cost Driven Childlessness	$w^f + \tilde{a}$	0
V	Maximum Fertility	$\tilde{a}$	$\frac{1-\phi\eta}{\phi}$

A.1.1 Optimal Decisions of Married Couples

This section provides definitions of thresholds for female wages w^f and extra income $\tilde{a}$, and their derivations.

A.1.1.1 Thresholds for w^f

Definition A.1.1 (Wage Thresholds)**.**

$$W_0^f(\tilde{a}) = \frac{\hat{c} - \tilde{a}}{1 - \phi\eta} \qquad W_2^f(\tilde{a}) = \frac{2\hat{c} - \tilde{a}}{1 + \phi(\nu - \eta)}$$

$$W_3^f(\tilde{a}) = \frac{\tilde{a}}{1 + \phi(\nu - \eta)} \qquad W_5^f(\tilde{a}) = \frac{\tilde{a}}{\phi(\nu + \eta)}$$

$W_1^f(\tilde{a})$ is the smallest root in w^f of the quadratic equation $u(c_{III}, n_{III}) = u(c_{IV}, n_{IV})$:

$$\hat{c}\left(\frac{w^f(1 - \phi\eta) + \tilde{a} - \hat{c}}{\phi w^f} + \nu\right) = (w^f + \tilde{a})\nu \tag{A.2}$$

$W_4^f(\tilde{a})$ is the highest root in w^f of the quadratic equation $u(c_I, n_I) = u(c_{IV}, n_{IV})$:

$$\frac{(w^f(1 + \phi(\nu - \eta)) + \tilde{a})^2}{4\phi w^f} = \nu(w^f + \tilde{a}) \tag{A.3}$$

A.1.1.2 Thresholds for $\tilde{a}$

Definition A.1.2 ($\tilde{a}$ Thresholds)**.**

$$\underline{a} = \hat{c}\left(\frac{\phi(\nu + \eta) - 1}{\phi\nu}\right), \qquad \bar{a} = \hat{c} \tag{A.4}$$

A.1.2 Optimal Fertility Decisions

This section presents optimal fertility decisions by wage and non-labor income thresholds.

Assumption A.1.3.

$$1 > \phi(\nu - \eta)(1 - \hat{c}), \qquad \eta \geq \nu + \frac{1 - \sqrt{\phi\nu}}{\phi} \tag{A.5}$$

Proposition A.1.4. *Under Assumption A.1.3 , the optimal choice of a household, which is endowed with female wage w^f and $\tilde{a}$, is given by:*

1. *If $\tilde{a} < \underline{a}$:*

a) $\forall w^f < W_0^f$, *the household is in Regime II Social Sterility.*
b) $\forall w^f \geq W_0^f$, *the household is in Regime IV Opportunity Cost Driven Childless*

i.e. the household remain childless regardless of the level of w^f.

2. *If* $\tilde{a} \in [\underline{a}, \bar{a}]$*:*
   a) $\forall w^f < W_0^f$, *the household is in Regime II Social Sterility.*
   b) $\forall w^f \in \left[W_0^f, W_1^f\right]$, *the household is in Regime IV Opportunity Cost Driven Childless.*
   c) $\forall w^f \in \left[W_1^f, W_2^f\right]$, *the household is in Regime III Constrained Fertility.*
   d) $\forall w^f \in \left[W_2^f, W_4^f\right]$, *the household is in Regime I Unconstrained Fertility.*
   e) $\forall w^f > W_4^f$, *the household is in Regime IV Opportunity Cost Driven Childless.*
3. *If* $a \geq \bar{a}$ *:*
   a) $\forall w^f < W_3^f$, *the household is in Regime V Maximum Fertility.*
   b) $\forall w^f \in \left[W_3^f, W_4^f\right]$, *the household is in Regime I Unconstrained Fertility.*
   c) $\forall w^f > W_4^f$, *the household is in Regime IV Opportunity Cost Driven Childless.*

Proof. I will show that:

1. when $a \in [\underline{a}, \bar{a}]$, $W_0^f < W_1^f < W_2^f < W_4^f$
2. when $a \geq \bar{a}$, $W_3^f < W_4^f < W_5^f$

Proof of 1.
Let A and B denote the left- and right-hand side of the equation (A.2):

$$A(w^f) = \hat{c}\left(\frac{w^f(1-\phi\eta) + \tilde{a} - \hat{c}}{\phi w^f} + \nu\right) \tag{A.6}$$

$$B(w^f) = (w^f + \tilde{a})\nu \tag{A.7}$$

Recall that the equation (A.2) is such that the household is indifferent between the constrained fertility regime and the opportunity cost driven childless regime, and the smallest root of it is W_1^f. Note that if $\tilde{a} < \bar{a} = \hat{c}$, A is increasing and concave in w^f, and B is increasing in w^f. Hence, there would be at most two roots that solve the equation (A.2) if $\tilde{a} < \hat{c}$.

Claim 1: When $\tilde{a} \in [\underline{a}, \bar{a}]$, $W_0^f < W_1^f < W_2^f$.
First, I show that, for $\tilde{a} \in [\underline{a}, \bar{a}]$, $W_1^f < W_2^f$.

When $w^f = W_2^f = \dfrac{2\hat{c} - \tilde{a}}{1 + \phi(\nu - \eta)}$,

$$A(W_2^f) = \frac{\hat{c}^2}{2\hat{c} - \tilde{a}} \frac{1 - \phi(\nu - \eta)}{\phi} \text{ , and}$$

$$B(W_2^f) = \frac{2\hat{c} + \phi(\nu - \eta)\tilde{a}}{1 + \phi(\nu - \eta)} \nu$$

$A(W_2^f) > B(W_2^f)$ holds under Assumption A.1.3, which means that W_2^f lies between the two roots of the equation (A.2). By the definition of W_1^f, the smallest root of the equation (A.2), we get $W_1^f < W_2^f$.

Second, I show that, for $\tilde{a} \in [\underline{a}, \bar{a}]$, $W_0^f < W_2^f$.

$$\begin{aligned} W_2^f - W_0^f &= \frac{2\hat{c} - \tilde{a}}{1 + \phi(\nu - \eta)} - \frac{\hat{c} - \tilde{a}}{1 - \phi\eta} \\ &= \frac{1}{(1 + \phi(\nu - \eta))(1 - \phi\eta)} \left(\tilde{a} - \frac{\hat{c}(\phi(\nu + \eta) - 1)}{\phi\nu} \right) \\ &= \frac{1}{(1 + \phi(\nu - \eta))(1 - \phi\eta)} (\tilde{a} - \underline{a}) > 0 \end{aligned}$$

Note that $A(W_0^f) < B(W_0^f)$, which implies that $W_0^f < W_1^f$. Thus, we have:

- $W_0^f < W_1^f < W_2^f$
- for $w^f \in \left[W_0^f, W_1^f\right]$, $u(c_{IV}, 0) \geq u(\hat{c}, n_{IV})$
- for $w^f \in \left[W_1^f, W_2^f\right]$, $u(\hat{c}, n_{III}) \geq u(c_{IV}, 0)$

Claim 2: When $\tilde{a} \in [\underline{a}, \bar{a}]$, $W_2^f < W_4^f < W_5^f$.

By the definition, $u(\hat{c}, n_{III}) = u(c_I, n_I)$ at W_2^f. From claim 1, we have $u(\hat{c}, n_{III}) \geq u(c_{IV}, 0)$ at W_2^f. Hence, we have

$$u(c_I, n_I) \geq u(c_{IV}, 0) \text{ at } W_2^f \tag{A.8}$$

Recall that Regime I exists for $w^f \in \left[W_2^f, W_5^f\right]$, and for $w^f > W_5^f$ Regime IV prevails. Moreover, W_4^f is such that $u(c_{IV}, 0) = u(c_I, n_I)$. Given this, we compare the utility in Regime IV with the utility in Regime I when $w < W_5^f$ to prove that $W_4^f \in \left[W_2^f, W_5^f\right]$.

$u(c_{IV}, 0) \geq u(c_I, n_I)$ if and only if:

$$\ln\left(\frac{w^f + \tilde{a}}{w^f(1 + \phi(\nu - \eta)) + \tilde{a}}\right) + \ln\nu \geq \ln\left(\frac{w^f(1 + \phi(\nu + \eta)) + \tilde{a}}{\phi w^f} - 2\ln 2\right) \tag{A.9}$$

Note that both the left-hand side (LHS) and right-hand side (RHS) are decreasing and convex in w^f. Moreover, LHS < RHS at $w^f = 0$, but we cannot rank the two limits at ∞. From this we know that there would be at most two roots of the inequality (A.9) holding at equality. Since LHS > RHS at W_5^f, it means that W_5^f is in between two roots or at the right of the root. Since $u(c_I, n_I)$ is not defined at $w^f > W_5^f$, the relevant root of LHS=RHS, W_4^f, is strictly lower than W_5^f. From this we have established that:

$$W_4^f < W_5^f \tag{A.10}$$

$$u(c_I, n_I) > u(c_{IV}, 0) \text{ for all } w^f < W_4^f \tag{A.11}$$

By combining (A.8) and (A.11), we can conclude that $W_2^f < W_4^f$. Therefore, we have shown that $W_2^f < W_4^f < W_5^f$.

From the claim 1 and 2, we have proved that when $\tilde{a} \in [\underline{a}, \bar{a}]$, $W_0^f < W_1^f < W_2^f < W_4^f$. Then the optimal decision is characterized as follows:

When $\tilde{a} \in [\underline{a}, \bar{a}]$.

- $\forall w^f < W_0^f$, $c = c_{II}, n = 0$
- $\forall w \in \left[W_0^f, W_1^f\right]$, $u(c_{IV}, 0) > u(\hat{c}, n_{III})$, and $c = c_{IV}, n = 0$
- $\forall w \in \left[W_1^f, W_2^f\right]$, $u(\hat{c}, n_{III}) \geq u(c_{IV}, 0)$, and $c = \hat{c}, n = 0$
- $\forall w \in \left[W_2^f, W_4^f\right]$, $u(c_I, n_I) > u(c_{IV}, 0)$, and $c = c_I, n = n_I$
- $\forall w^f \geq W_4^f$, $c = c_{IV}, n = 0$

Proof of 2.

Note that $\bar{a}$ is such that when $\tilde{a} > \bar{a}$ the household can consume $\hat{c}$ even when her wage is zero. This implies that Regime IV is feasible for $w^f \geq 0$, and Regime II and Regime III no longer exists even when $w^f = 0$. Hence, we will compare the utilities in Regime I , IV , and V.

First, I show that $W_3^f < W_4^f < W_5^f$.

By definition, $\dfrac{\tilde{a}}{1 + \phi(\nu - \eta)} = W_3^f < W_5^f = \dfrac{\tilde{a}}{\phi(\nu - \eta)}$.

At W_3^f, LHS < RHS, and hence it follows that $W_3^f < W_4^f$. Moreover we have:

$$u(c_{IV}, 0) > u(c_I, n_I) \text{ for all } w^f > W_4^f \tag{A.12}$$

Second, when $w^f < W_3^f$, the fertility in Regime I is larger than the maximum number of children one can have, i.e., $n_I|_{w_f} > \dfrac{1 - \phi\eta}{\phi} = n_V$. Hence, when $w^f < W_3^f$, the utility is not defined.

At W_3^f, $u(c_I, n_I) = u(c_V, n_V) > u(c_{IV}, 0)$. Note that $u(c_I, n_I)$ is increasing in w^f, and $u(c_V, n_V)$ is independent with w^f, then we have:

$$u(c_I, n_I) \geq u(c_{IV}, n_{IV}) \text{ for } w^f \in \left[W_3^f, W_5^f\right] \tag{A.13}$$

$$u(c_V, n_V) > u(c_{IV}, 0) \text{ for all } w^f < W_3^f \tag{A.14}$$

We have established that when $\tilde{a} > \bar{a}$:

- $W_3^f < W_4^f < W_5^f$
- $\forall w^f < W_3^f$, $u(c_V, n_V) > u(c_{IV}, 0)$, $c = c_V$ and $n = \dfrac{1 - \phi\eta}{\phi}$
- $\forall w^f \in \left[W_3^f, W_4^f\right]$, $u(c_I, n_I) > u(c_{IV}, 0) > u(c_V, n_V)$, $c = c_I$ and $n = n_I$
- $\forall w^f > W_4^f$, $u(c_{IV}, 0) > u(c_V, n_V)$, $c = c_V$ and $n = 0$

□

A.2 Estimation Results

Table 12. Marriage Distribution by Men and Women's Education Levels

	Women						
Men	1	2	3	4	5	6	Total
1	64.68	18.84	14.53	0.00	1.96	0.00	100
2	17.63	54.72	27.64	0.00	0.00	0.00	100
3	2.12	15.61	74.52	4.10	3.10	0.55	100
4	0.00	3.85	73.39	16.49	5.70	0.57	100
5	0.27	0.92	40.00	18.67	35.77	4.37	100
6	0.00	0.59	10.47	15.23	53.96	19.75	100

The numbers in the first row and first column indicate education levels defined in table 1

Table 13. Estimation Results on Wage Equations

	log Wage		log Full-Time Wage	
	(1)	(2)	(3)	(4)
Edu	0.081 ***	0.081 ***	0.087 ***	0.086 ***
	(0.001)	(0.001)	(0.002)	(0.002)
Female	-0.435 ***	-0.360 ***	-0.423 ***	-0.359 ***
	(0.010)	(0.011)	(0.015)	(0.016)
Experience		0.425 ***		0.495 ***
		(0.023)		(0.040)
Cons.	1.609 ***	1.271 ***	1.261 ***	0.936 ***
	(0.017)	(0.026)	(0.048)	(0.055)
Adj. R^2	0.301	0.324	0.374	0.395
Nobs.	6990	6990	5598	5598
μ^*	-0.005	-0.003	0.005	0.013
μ	0.071	0.050	0.022	0.006
σ^*	0.248	0.244	0.099	0.098
σ	0.272	0.256	0.107	0.103
ρ	0.125	0.148	0.205	0.216

Table 14. Estimated Parameters for Wage Functions

	η_0	η_1	γ	μ_ϵ	σ_ϵ	ρ
Women	1.174***	0.081***	−0.435***	0.071	0.272	0.125
	(0.048)	(0.001)	(0.010)			
Men	1.609***	0.081***		−0.005	0.248	
	(0.017)	(0.001)				

Table 15. Estimation Parameters for Asset Function

α_0	α_1	α_2	μ	σ_ϵ
−0.683***	0.738**	1.116**	−0.000	1.431
(0.040)	(0.091)	(0.102)		

Table 16. Post-Policy Distribution of Women by the Number of Children: Goods subsidy per child

n \ m	0	1	2	3+	
0	0.0493	0.0074	0	0	0.0566
1	0	0.2425	0.0304	0	0.2729
2	0	0	0.4050	0.0248	0.4398
3+	0	0	0	0.2406	0.2406
	0.0493	0.2499	0.4354	0.2654	1

Each element in the table shows the shares of women with m kids after the policy experiment who have n kids before the experiment. The last column reports the pre-policy distribution of women by the number of kids, and the last row the post-policy distribution of women by the number of kids.

A.3 Additional Policy Analysis Results

Table 17. Post-Policy Distribution of Women by the Number of Children: Goods subsidy for mothers

n \ m	0	1	2	3+	
0	0.0254	0.0313	0	0	0.0566
1	0	0.2513	0.0216	0	0.2729
2	0	0	0.4152	0.0147	0.4398
3+	0	0	0	0.2406	0.2406
	0.0254	0.2826	0.4368	0.2553	1

Each element in the table shows the shares of women with m kids after the policy experiment who have n kids before the experiment. The last column reports the pre-policy distribution of women by the number of kids, and the last row the post-policy distribution of women by the number of kids.

Table 18. Post-Policy Distribution of Women by the Number of Children: Time subsidy per child

n \ m	0	1	2	3+	
0	0.0465	0.0101	0	0	0.0566
1	0	0.2395	0.0335	0	0.2729
2	0	0	0.4082	0.0216	0.4398
3+	0	0	0	0.2406	0.2406
	0.0465	0.2496	0.4417	0.2622	1

Each element in the table shows the shares of women with m kids after the policy experiment who have n kids before the experiment. The last column reports the pre-policy distribution of women by the number of kids, and the last row the post-policy distribution of women by the number of kids.

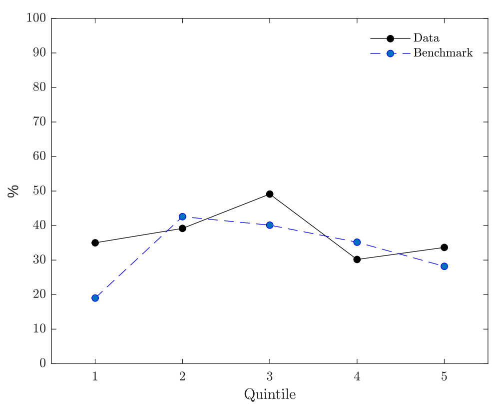
Table 19. Post-Policy Distribution of Women by the Number of Children: Time subsidy for mothers

n \ m	0	1	2	3+	
0	0.0216	0.0350	0	0	0.0566
1	0	0.2512	0.0217	0	0.2729
2	0	0	0.4176	0.0122	0.4398
3+	0	0	0	0.2406	0.2406
	0.0216	0.2862	0.4393	0.2528	1

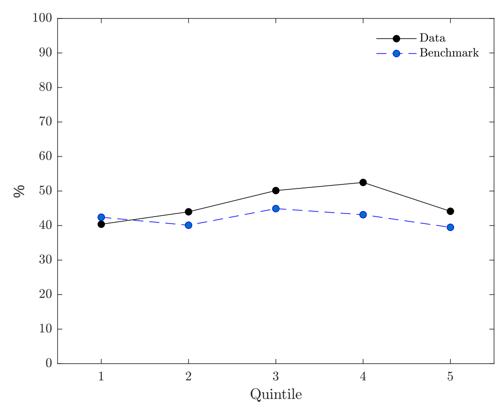
Each element in the table shows the shares of women with m kids after the policy experiment who have n kids before the experiment. The last column reports the pre-policy distribution of women by the number of kids, and the last row the post-policy distribution of women by the number of kids.

Figure 6. Fertility by Men's Wage Quintile

(a) Number of Children = 1



(b) Number of Children = 2



Note: Each dot denotes a fraction of men with children out of men in each income quintile.