

# Two Birds with One Stone: Female Labor Supply, Fertility, and Market Childcare \*

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## Abstract

The correlation between the female labor force participation rate (FPR) and the total fertility rate (TFR) has switched from negative to positive in some developed countries. In this paper, we show how increasing the substitutability between mother's direct childcare and indirect market care can raise both FPR and TFR, and provide an explanation for the change in the TFR-FPR correlation. Simulations of a life-cycle model of married women's work and fertility decisions indicate that the FPR increases, whereas the TFR is U-shaped with regard to substitutability. The dynamic relationship depends on the relative strength of behavioral and composition effects: greater substitutability allows working women to have more children but it also attracts less productive women to enter the labor force, who trade childbirths for labor supply. The findings imply that raising substitutability to a sufficiently high level can achieve the two seemingly conflicting goals—increasing female labor force participation and fertility rates.

JEL Codes: J11, J13, J22, D10

Keywords: female labor supply, total fertility rate, childcare substitutability

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# 1 Introduction

Women in developed countries are more likely to work than ever before, but many still ask the old question of family or career once they have children. The difficulty of managing both drives some women out of the labor market or makes them less inclined to have children in the first place, manifesting the myth that “women can’t have it all.” Rapidly aging population and slower economic growth mean this is a problem not only at the individual, but at the national level as well.

Recently, however, we observe cases in which the total fertility rate (TFR) and the female labor force participation rate (FPR) rise together. According to United Nations estimates in five-year intervals, the TFR in the US declined from 3.23 (1960–1965) to 1.77 (1975–1980) then rose back up to 1.88 (2010–2015). In Sweden, the TFR fell from 2.31 (1960–1965) to 1.64 (1980–1985) but increased thereafter to 1.90 (2010–2015).<sup>1</sup> Meanwhile, the FPR from the 1960s to 2010s increased from 42 percent to 67 percent in the US and from 55 percent to 80 percent in Sweden.<sup>2</sup> Similar trends are observed in France, Norway, Finland, and Denmark, where both TFR and FPR are higher than a few decades ago. Analogous trends are documented in cross-country data as well; the TFR-FPR correlation across OECD countries, which was about  $-0.5$  during the 1970s, turns positive in the mid-1980s, and reaches  $0.5$  in the 1990s (see Figure 1 in [Ahn and Mira, 2002](#)).

In this paper, we show how increasing the substitutability between mother’s direct childcare and indirect market care can serve as a “one stone” to raise both fertility and female labor force participation rates, and provide an explanation for the change in the TFR-FPR correlation. We focus on within-country dynamics in order to draw policy implications controlling for other country-specific factors. We construct a life-cycle model of married couple’s labor supply and fertility decisions, then simulate how married women’s work (both intensive and extensive margins) and fertility (number and timing of childbirths) choices respond to different values of the substitutability parameter. Results indicate that female labor supply increases, whereas total fertility is U-shaped with regard to childcare substitutability. As market childcare becomes increasingly available, the dynamic TFR-FPR correlation thus evolves from negative in the decreasing phase of the TFR to positive in the increasing phase of the TFR.

The nonlinear relationships among the TFR, the FPR, and substitutability can be explained by a combination of behavioral and composition effects. For working women, an increase in substitutability gives incentive to supply more hours in the labor market, raise

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<sup>1</sup>Source: United Nations World Population Prospects: The 2017 Revision.

<sup>2</sup>Source: OECD data, 2017.

per-child expenditure on market childcare, and have more children (“behavioral effects”). Enhanced substitutability, however, attracts additional women from the non-market sector as well—those who are lower-wage and less productive, compared to the existing pool of working women (“composition effects”). While higher substitutability allows this group to supply more labor on both the extensive and intensive margins, they trade childbirths for labor supply.

Because the relative size of the behavioral effects grows with the size of the female labor force, and because the current female employment level increases with substitutability, composition effects dominate behavioral effects at low levels of substitutability. Only a small portion of productive women are working, and hence the number of increased births among them is smaller than the number of reduced births among less productive women entering the labor market. As the degree of childcare substitutability exceeds some threshold level, however, behavioral effects of working women begin to dominate composition effects, and hence the TFR increases with substitutability. It is noteworthy that composition effects also imply that changes in substitutability affect not only the total number but also the distribution of children across households: at all phases, “new” births are concentrated among relatively more productive women.

To estimate the parameters of the model, we use observed profiles of the 1960s cohort in South Korea. Korea is a particularly interesting case to study for this purpose because it is known to have one of the lowest fertility rates in the world (with TFR of 1.23 children per woman) as well as low female labor force participation rate among OECD countries (58 percent).<sup>3</sup> Like many other developed countries experiencing slow economic growth and rapid population aging, the government is desperately seeking ways to enhance fertility and female labor force participation rates.<sup>4</sup> Thus, demonstrating how childcare substitutability could achieve both goals within this sample is meaningful from a policy standpoint. We primarily focus on the 1960s cohort because it is the most recent cohort that completed the fertile stages of the life-cycle, but we find similar results for other samples as well (e.g., 1970s cohort in Korea and various cohorts in the US).

The paper builds on the literature documenting the correlation between the TFR and the FPR. The switch in sign of this correlation from negative to positive across developed countries has been noted by [Ahn and Mira \(2002\)](#) and [Rindfuss et al. \(2003\)](#).<sup>5</sup> Several

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<sup>3</sup>Source: OECD data, 2017.

<sup>4</sup>In addition to paid parental leave, the Korean government introduced subsidized childcare to all households with children ages 0–2 in 2012, and expanded the program to all households with children ages 0–5 in 2013. The usage rate of paternity leave is still very low, however, at only 4.5 percent of all male employees in 2014 (source: Ministry of Employment and Labor). The sustainability of the childcare subsidy program also remains controversial due to high costs.

<sup>5</sup>[Kögel \(2004\)](#) and [Engelhardt et al. \(2004\)](#) argue that the sign reversal in the TFR-FPR correlation

variables have been suggested as potential determinants of the transition: the degree of “role incompatibility” between work and family (Rindfuss and Brewster, 1996), labor market arrangements such as unemployment rates and stability of contracts (Adsera, 2004), the relative wage of skilled labor (Galor and Weil, 1996; Martínez and Iza, 2004), women’s status in the workforce and in the household (Feyrer et al., 2008), cultural attitude towards working mothers or external childcare (Borck, 2014), and improvements in maternal health (Albanesi and Olivetti, 2016).

Because we focus on the role of childcare substitutability, our findings also complement studies on the effects of family policies on fertility and female labor supply. There are two branches within this literature.<sup>6</sup> The first are papers that employ structural estimation methods: for instance, Haan and Wrohlich (2011) and Bick (2015) use dynamic models to test the effects of a subsidized childcare reform in Germany, and find positive effects on maternal employment but not on fertility rates. The second branch includes papers that use difference-in-differences strategy, exploiting quasi-experimental policy changes such as the introduction of universal childcare program in Quebec, Germany, and Norway (Baker et al., 2008; Bauernschuster et al., 2015; Havnes and Mogstad, 2011). Depending on the specifics of the intervention and target population, results vary across studies.

Our paper contributes to these related literature in at least four important ways. First, both labor supply and fertility choices are determined endogenously within a structural model, and thus we improve upon prior work in which either one is assumed to be exogenous. Second, we provide a unified explanation for both the negative and positive TFR-FPR correlations, whereas most of the existing research focuses on one part of the transition. Third, we show quantitatively how a change in a policy-relevant parameter can increase both the TFR and the FPR, other things equal. Thus, the paper moves a step forward from previous studies that either treat country effects as a black box, evaluate the impact of a specific reform, or descriptively discuss a battery of potential factors using cross-country data. Lastly, by distinguishing the behavioral and composition effects, we present a structural explanation of the underlying forces that drive the changes in the TFR–FPR correlation.

The rest of the paper is organized as follows. Section 2 introduces our analytical framework. Section 3 presents model estimation results. Using these results, Section 4 shows and explains how married women adjust their labor supply and fertility over the life-cycle with regards to changes in substitutability. Section 5 discusses the implications of our findings.

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among OECD countries can no longer be observed when alternative econometric specifications are used, such as country fixed effects or cointegration techniques. They also acknowledge, however, that the negative correlation has indeed become much weaker over time (albeit not positive) and that endogeneity problems remain in their analyses because the TFR and the FPR are simultaneously determined.

<sup>6</sup>See Anderson and Levine (1999) and Blau and Currie (2006) for a survey of the literature.

Section 6 concludes.

## 2 The Model

### 2.1 Economic environment

The economy consists of married couples, with or without children. Both husband and wife live  $j_T$  periods. Let  $j \in \{j_1, j_2, \dots, j_T\}$  denote a period of the life-cycle, which corresponds to five years. Adults in the household start economic activity at  $j_1$  and retire at  $j_R$ . In each period, the household makes decisions on wife's labor supply and fertility, along with household consumption and savings. When the wife works, her human capital is endogenously accumulated depending on her job experience, while she loses human capital in a nonlinear fashion during her non-working period. The husband is assumed to work full-time.

The household also chooses the number of childbirths in each period until the wife becomes infertile at  $j_I$ . Newborn children are attached to the household until they reach a certain age, after which they leave the household permanently. Because the husband works full-time, the wife is the one who takes care of children.<sup>7</sup> Key ingredients of the model are as follows.

***Wages and human capital*** Both the husband's and wife's wages consist of deterministic and stochastic components. The stochastic components are subject to permanent shocks. Since the husband always works, his deterministic component depends on age. The wife's deterministic component, however, depends on endogenously accumulated work (non-work) experience. The husband's and the wife's deterministic wages are also affected by labor market conditions, as represented by unemployment rates.

***Childcare costs*** When the wife works, the household pays for childcare costs, which depend on the number of children, ages of children, and the wife's labor income. Similar to wages, childcare costs are subject to uncertainty. Childcare cost is broadly defined to encompass not only early-stage expenditures like daycare centers but also educational expenses at later-stages in order to fully represent the costs that couples consider when making their fertility decisions.

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<sup>7</sup>The wife is responsible for childcare and housework in Korea, as in many other countries, regardless of her contribution to household income (Kim, 2016). Instead of pushing the husband to contribute more to household production, wife's income tends to be used for outsourcing housework.

**Preferences** A household values children as well as consumption and wife’s leisure. Each married couple cares about not only the number of children but also the children’s human capital in a way that allows a quantity-quality trade-off in childcare production.

A typical household’s utility function is as follows:

$$U(c, n^w, k, M) = u(c, n^w) + x(k, n^w, M)\mathbb{I}_{(k>0)}, \quad (1)$$

where  $u(\cdot)$  is utility from consumption and disutility of work, and  $x(\cdot)$  represents utility from children.  $c$  denotes the household size-adjusted (adult-equivalent) consumption,  $n^w$  the wife’s working hours,  $k$  the number of children,  $M$  the total expenditure on market childcare, and  $\mathbb{I}(\cdot)$  the indicator function.<sup>8</sup>

As is standard in the literature,  $u(\cdot)$  is specified as

$$u(c, n^w) = \frac{c^{1-\gamma}}{1-\gamma} - \eta n^w, \quad (2)$$

where  $\gamma$  is the coefficient of relative risk aversion of consumption and  $\eta$  represents the marginal disutility of wife’s work.

We assume that utility from children takes the form

$$x(k, n^w, M) = \delta \frac{k^{1-\theta}}{1-\theta} \frac{[\sum_{j_c \in \{1,2,3,4\}} (g^{j_c} (\frac{1-n^w}{k})^\phi + (1-g^{j_c})(\frac{M}{k})^\phi)^{1/\phi} \mathbb{I}_{(j_c)}]^{1-\lambda}}{1-\lambda}, \quad (3)$$

where  $\delta$  is the weight on childcare production.  $\theta$  and  $\lambda$  concern utility from quantity and quality of children, respectively. Child quality is a combined output of mother’s time and services purchased in the market.  $\phi$  governs the elasticity of substitution between these two inputs: per-child mother’s childcare time  $((1-n^w)/k)$  and expenditure on market childcare  $(M/k)$ . Finally,  $g^{j_c}$  is the relative weight placed on mother’s childcare time against market childcare. Note that this weight is allowed to vary by children’s ages ( $j_c$ ). For example, mother’s direct care time becomes less important as children grow older (Olivetti, 2006).

We use the functional form of (3), which is an extension of Caucutt et al. (2002) as in Park (2015), because it best suits our research purposes.<sup>9</sup> The specification allows not only the quantity-quality trade-off of children but also substitutability between direct and indirect childcare. These two factors are essential for a structural understanding of how, following exogenous changes in the degree of substitutability, married women adjust both

<sup>8</sup>For  $c$ , we use the OECD-modified scale that assigns a value of 1 to the husband, 0.5 to the wife, and 0.3 to each child (Hagenaars et al., 1994).

<sup>9</sup>Park (2015) extends Caucutt et al. (2002)’s specification of the childcare function by using a constant elasticity of substitution function instead of a Cobb-Douglas function for childcare quality.

their labor supply and fertility behaviors in the process of optimizing household's expected lifetime utility.

## 2.2 Household's Decision Problem

In each period, the household makes decisions on consumption and savings, wife's labor supply, and fertility. Specifically, the household faces six mutually exclusive alternatives depending on the fertility choice (represented by the number of new childbirths, 0 through 5) before the wife reaches the age of  $j_I$ . They are denoted by  $i \in \{1, 2, \dots, 6\}$ :  $i=1$  if 0 children,  $i=2$  if 1 child, ...,  $i=6$  if 5 children. Once the wife reaches  $j_I$ , the fertility choice is excluded from the decision problem. When the household reaches the age of  $j_R$ , couple's labor supply is eliminated from the choice set as well.

Let  $\Omega = \{a, j, \xi^h, \xi^w, \epsilon, k_-^1, k_-^2, k_-^3, k_-^4, X_-, NX_-\}$  be a set of state variables for the household's decision problem.  $a$  is assets.  $\xi^h$  and  $\xi^w$  are the husband's and wife's permanent wage shocks, respectively.  $\epsilon$  is the shock to market childcare costs.  $k_-^1$ ,  $k_-^2$ ,  $k_-^3$ , and  $k_-^4$  represent the number of children in the prior period by age group, with  $k_-^1$  denoting the number of children between ages 0 to 4,  $k_-^2$  ages 5 to 9,  $k_-^3$  ages 10 to 14, and  $k_-^4$  ages 15 to 19.  $X_-$  and  $NX_-$  are the wife's cumulative work experience and non-employment duration in the prior period, respectively.

Each household maximizes expected lifetime utility, and its decision problem is given by

$$V(\Omega) = \begin{cases} \max\{V^1(\Omega), V^2(\Omega), \dots, V^6(\Omega)\} & \text{if } j_1 \leq j < j_I \\ V^1(\Omega) & \text{if } j_I \leq j \leq j_T, \end{cases} \quad (4)$$

and the value function of each case is defined by

$$V^i(\Omega) = \begin{cases} \max_{c, a', n^w} \{U^i(c, n^w, k, M) + \beta EV(\Omega'|\Omega, i)\} & \text{if } j_1 \leq j < j_R \\ \max_{c, a'} \{U^i(c) + \beta EV(\Omega'|\Omega, i)\} & \text{if } j_R \leq j < j_T \\ \max_c U^i(c) & \text{if } j = j_T \end{cases} \quad (5)$$

subject to

$$C + a' = a(1 + r) + w^h + w^w n^w - M,$$

$$0 \leq n^w \leq 1, \quad C \geq 0,$$

$$a = 0 \text{ if } j = j_1 \text{ or } j = j_{T+1}, \quad a' \geq \underline{a},$$

where  $\beta$  is the discount factor,  $C$  the household size-unadjusted consumption,  $a$  the asset,

$r$  the interest rate,  $w^h$  the husband’s wage rate,  $w^w$  the wife’s wage rate, and  $\underline{a}$  the natural borrowing constraint.

Since the household can have up to five new children in each period, the number of children in each age group  $k^h = \{0, 1, 2, \dots, 5\}$  for all  $h = 1, 2, 3$ , and 4, evolves as follows:

$$k^h = k^{h-1} + d^e - d^l,$$

where  $d^e$  and  $d^l$  represent the number of children entering and leaving the age group, respectively, such that  $d^e = 0, 1, 2, \dots, 5$  and  $d^l = 0, 1, 2, \dots, 5$ .

The model is solved numerically. A numerical solution requires calculating  $EV(\Omega' | \Omega, i)$  by a typical backward recursion for all  $i$  and elements of  $\Omega$ . In solving the model, a potential nonconcavity problem arises because of the discrete nature of the choice associated with changes in the number of newborns in the future. With enough uncertainty, however, it is smoothed out, leaving the expected value function concave ([Attanasio et al., 2008](#)).

## 3 Model Estimation

### 3.1 Data

The primary data we use to estimate the parameters of the model are observed profiles of the 1960s birth cohort in the Korean Labor Income Panel Survey (KLIPS). Comparable to the Panel Study of Income Dynamics in the US, the KLIPS is a publicly available longitudinal survey of labor activities of households and individuals residing in urban areas. Since the first wave was launched in 1998 (approximately 5,000 households), annual surveys have been conducted by the Korea Labor Institute. Our analysis is based on the eighteen waves from 1998 through 2015. We focus on the 1960s cohort because it is the most recent group that completed the fertile stages of the life-cycle, but we find similar results for other samples (e.g., 1970s cohort in the KLIPS and various cohorts in the US) as we discuss below.

### 3.2 Externally Determined Parameters

**Periods** Individuals live ten periods, starting their lives at age  $j_1$  as adults and ending at age  $j_{10}$ . Each period (or “age”) consists of five years of actual ages, with  $j_1$  representing actual ages of 25–29, ..., and  $j_{10}$  representing 70–74. Wives become infertile from  $j_4$  (40–44). Both husbands and wives retire at  $j_9$  (65–69). Newborn children are assumed to be attached to the household for four periods.

***Some parameters in the wage function*** As in most existing studies in the literature, husbands are assumed to work full-time so that their wage depends only on age:

$$\ln w_{i,t}^h = \alpha_0 + \alpha_1 j_{i,t} + \alpha_2 j_{i,t}^2 + \alpha_3 u_t + \nu_{i,t}^h, \quad (6)$$

where  $w_{i,t}^h$  represents the real hourly wage rate of husband  $i$  in year  $t$  (deflated by the Consumer Price Index, with year 2000 as the baseline),  $j_{i,t}$  his age,  $u_t$  the unemployment rate in year  $t$ , and  $\nu_{i,t}$  the error term. The coefficients of the husbands' wage function are externally determined by applying Ordinary Least Squares (OLS) estimation to equation (6), based on the Korea Labor and Income Panel Survey (KLIPS) data.

The wife's wage function is specified as follows:

$$\ln w_{i,t}^w = \beta_0 + \beta_1 X_{i,t} + \beta_2 X_{i,t}^2 + \beta_3 NX_{i,t} + \beta_4 (NX_{i,t})^2 + \beta_5 u_t + \nu_{i,t}^w, \quad (7)$$

where  $w_{i,t}^w$  represents the real hourly wage rate of wife  $i$  in year  $t$ ,  $X_{i,t}$  her cumulative work experience since entry into the labor market,<sup>10</sup>  $NX_{i,t}$  her cumulative non-employment duration, and  $\nu_{i,t}^w$  the error term.  $NX_{i,t}$  is included to measure the extent of additional wage losses during a period of work interruption (other than forgone wages) that reflect human capital depreciation or negative signals to employers. Labor market conditions, as measured by unemployment rates  $u_t$ , affect the wife's labor supply through wage changes.

\*\*\* Table 1 here \*\*\*

On the basis of the KLIPS data, Table 1 reports estimation results of the husband's and the wife's wage functions.<sup>11</sup> Applying OLS estimation to equation (7), however, produces inconsistent estimates of the regression coefficients, as work and non-work decisions are endogenously made in the model. We therefore obtain OLS estimates of the coefficients of cumulative work experience, cumulative non-work experience, and their squares, include

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<sup>10</sup>To derive the cumulative variables, we use the information contained in the work history file of the KLIPS. For each respondent, the KLIPS reports the starting and ending points of each job held by the respondent since entry into the labor market.

<sup>11</sup>In estimating equation (7), we correct for sample selectivity in observed wages of working women, using the conventional two-step estimation method suggested by Heckman (1979). Following prior studies in the literature, we use the number of children and husband's income as the excluded variables from the wage equation (e.g., Olivetti, 2006). A Sargan-test barely accepts the null hypothesis of noncorrelation of the excluded variables and the error term in the wage equation. Although the results indicate endogenous selection of working wives, the findings remain valid even when the OLS results are used for estimating the model without correcting for selection. Also, in estimating equations (6) and (7), we correct for the potential downward bias in the estimated standard error of the coefficient on unemployment rate that arises from neglecting the cross-sectional correlation of individuals' error terms. This is done by conducting White's standard error estimation, which is robust with respect to within-year clustering.

them in the set of empirical moments to be matched by the model, and then internally determine the true coefficients by solving the model. The details are explained in subsequent sections. Because the unemployment rate is treated as exogenous in the current partial model, its wage effect is determined by data.<sup>12</sup>

Lastly, residuals from estimated equations (6) and (7) are used to estimate the stochastic components of couple’s wages. Following [Attanasio et al. \(2008\)](#), we allow only the permanent component in the error term, which follows an AR(1) process with permanent wage shocks.

$$\begin{aligned}\nu^w &= \rho^w \nu_-^w + \xi^w, \\ \nu^h &= \rho^h \nu_-^h + \xi^h.\end{aligned}$$

A couple’s permanent shocks have the following joint distribution:

$$\begin{aligned}\xi &= (\xi^w, \xi^h) \sim N(\mu_\xi, \sigma_\xi^2), \\ \mu_\xi &= \left(-\frac{\sigma_{\xi^w}^2}{2}, -\frac{\sigma_{\xi^h}^2}{2}\right), \quad \text{and} \quad \sigma_\xi^2 = \begin{pmatrix} \sigma_{\xi^w}^2 & \rho_{\xi^w \xi^h} \sigma_{\xi^w} \sigma_{\xi^h} \\ \rho_{\xi^w \xi^h} \sigma_{\xi^w} \sigma_{\xi^h} & \sigma_{\xi^h}^2 \end{pmatrix}.\end{aligned}\tag{8}$$

\*\*\* Table 2 here \*\*\*

Table 2 reports the estimation results of couple’s wage process, based on the KLIPS. The husband’s and wife’s permanent wage shocks appear to be almost uncorrelated.<sup>13</sup>

***Other externally determined parameters*** We set the per-period interest rate to 0.07, which corresponds to 0.014 of the annual interest rate. The annual interest rate equals the average real return on annual T-bills in Korea from 2000 to 2013. The per-period discount factor is set to 0.935, which corresponds to an annual discount rate of 0.987. It implies that the discount rate is the same as the interest rate so that households save only to smooth consumption against wage uncertainty.

<sup>12</sup>Estimated coefficients of the unemployment rate show that real wages are more procyclical for women than men in Korea, confirming [Park et al. \(2017\)](#)’s finding based on the Occupational Wage Survey data. Although this finding is also consistent with women’s experience of greater real wage reduction in the US during the Great Recession ([Elsby et al., 2016](#)), several other studies report men’s greater wage procyclicality in the US during the 1970s and 1980s (e.g., [Blank, 1989](#); [Solon et al., 1994](#)).

<sup>13</sup>Using the Panel Study of Income Dynamics data, [Hyslop \(2001\)](#) finds a positive correlation between couple’s permanent wage shocks in the US. Compared to US evidence (e.g., [Heathcote et al., 2010](#)), permanent wage shocks are much less persistent in the Korean labor market.

### 3.3 Internally Determined Parameters

**Parameters in the utility function** There are ten parameters in the utility function to be estimated by the model: the relative risk aversion of household consumption ( $\lambda$ ), the marginal disutility of wife’s work ( $\eta$ ), and the eight parameters governing childcare production ( $\delta, \theta, \phi, \lambda, g^1-g^4$ ).

**Parameters in the childcare cost function** The KLIPS releases information about each household’s average monthly expenditure on childcare services for children at all ages, from birth to high school. Expenditure categories include school tuition as well as costs of daycare centers, babysitters, after-school activities, cram schools, and tutoring lessons. Using this information, we estimate the childcare cost function as specified by Ribar (1992, 1995), among others,

$$m_{i,t} = c_0 + c_1 k_{i,t}^1 + c_2 k_{i,t}^2 + c_3 k_{i,t}^3 + c_4 k_{i,t}^4 + \epsilon_{i,t}, \quad (9)$$

where the dependent variable,  $m_{i,t}$ , is annual expenditure on market childcare services divided by labor income of wife  $i$  in year  $t$ .<sup>14</sup>  $\epsilon_{i,t}$  is an *iid* random variable with mean 0 and variance  $\sigma_\epsilon^2$ , which allows for uncertainty on market childcare costs in the model. The total household childcare expenditure is computed by the product of the predicted  $m_{i,t}$  and wife’s labor income ( $w^w n^w$ ):  $M = m w^w n^w$ .

\*\*\* Table 3 here \*\*\*

Table 3 reports estimation results of the childcare cost function. For brevity, only estimated coefficients are reported along with their standard error estimates. As in the wage function, OLS estimates of the coefficients of equation (9) are biased and inconsistent, as the fertility decisions are endogenously made in the model. As before, we estimate equation (9) by OLS using the KLIPS data, include the estimates in the set of target moments, and then determine the coefficients of equation (9) by solving the model.

**Other parameters in the wage function** Except for the coefficient on the unemployment rate, other coefficients on experience-related variables in wage equation (7) are internally determined in the model.

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<sup>14</sup>This normalization is based on our specification that childcare expenditure increases in wife’s working hours. Results, however, remain similar when the expenditure is divided by household income or not normalized.

### 3.4 Estimation Results

Put together, there are twenty structural parameters to be estimated by the model: ten in the utility function, five in the childcare cost function, and five in the wage function. Since the model does not have any closed-form solutions for the moments, these twenty structural parameters are jointly estimated by the Simulated Method of Moments (SMM) estimation, which effectively minimizes the distance between the parameter values and the twenty five target moments presented in Table 4.<sup>15</sup> (See Appendix A for details of the SMM and the computation algorithm.)

\*\*\* Table 4 here \*\*\*

\*\*\* Table 5 here \*\*\*

Results in Table 4 show that the target values are generally well-matched with corresponding model-generated moments, implying that the current model explains not only life-cycle labor supply but also fertility-related behaviors of the 1960s cohort to a reasonable degree. Table 5 summarizes estimated structural parameters for the 1960s cohort. Numbers in parentheses are estimated standard errors obtained by SMM, suggesting that all the estimated parameters are statistically significant. The relative weight placed on mother’s direct care against market care decreases in children’s ages. The estimated substitution parameter ( $\phi$ ), which plays a central role in explaining the changing TFR-FPR correlation, is about 0.14, which is much smaller than the corresponding estimate of 0.66 for the 1960s cohort in the US, suggested by Park (2015).

Estimates in the childcare cost function show that childcare becomes more costly as children grow older ( $c_1 < c_2 < c_3 < c_4$ ), which is expected as Korea has one of the highest private education expenditures among OECD countries.<sup>16</sup> Estimates in the wage equation suggest that a work interruption is associated with a substantial wage penalty (in addition

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<sup>15</sup>Following the literature on structural modeling of married women’s labor supply behavior, we use per capita employment as a measure of labor supply (e.g., Attanasio et al., 2008). First, a typical structural model assumes that an individual chooses between the paid-market and the non-market sector. Second, existing studies repeatedly report that unemployment and out of labor force are not distinct states (e.g., Clark and Summers, 1982; Gönül, 1992). Lastly, according to the official statistics available via the Korean Statistical Information Service, little difference is observed between the labor force participation rate and per capita employment in their life-cycle profiles as well as trend and cyclical movements. Thus, we use the two terms interchangeably throughout.

<sup>16</sup>According to *Education at a Glance 2014*, for example, 73 percent of spending on tertiary education in Korea came from private sources in 2011 (e.g., cram schools and tutoring lessons), compared with an OECD average of 31 percent. The share of private expenditure at all levels of education is ranked 2nd among 33 OECD countries. Thus, the increasing costs with children’s age in Korea are driven by the human capital component of childcare spending.

to forgone wages). Wages are reduced in a nonlinear fashion during the non-working period with a large initial drop. Estimates suggest that for a married woman who was out of the labor force for a total of five years, an additional year of non-work leads to a fall in real wages by about 6 percent. As previously mentioned, this type of “motherhood penalty” affects the entire post-interruption wages.

Various tests are conducted to check the robustness of the model. First, we re-estimate the current life-cycle model for the 1970s cohort in Korea, and find that the model also matches their observed labor supply and fertility behaviors very well. Second, we expand the current model by dividing the entire workers into wage or salary workers and the self-employed, and find that all our analytical results survive the new exercise.<sup>17</sup>

\*\*\* Figure 1 here \*\*\*

More importantly, we examine how the estimated model performs in dimensions *not* directly targeted in the estimation. In particular, we examine how the model-generated employment dynamics before and after first childbirth matches the observed profiles from the KLIPS data. The black and grey solid lines in Figure 1 represent observed employment dynamics for the 1960s and 1970s cohorts, respectively, where year  $t$  represents the year of first childbirth. Compared to the 1960s cohort, the 1970s cohort worked more before first childbirth but less upon childbearing. Five years after first childbirth, per capita employment of the 1970s cohort begins to increase at a faster rate, catching up to the employment level of the 1960s cohort by ten years after first childbirth. These between-cohort differences in observed birth-employment dynamics are replicated by the estimated model, as shown by the (model-generated) dotted lines.

## 4 Explaining the Effect of Substitutability on Female Labor Supply and Fertility

### 4.1 Baseline Simulations

How do female labor supply and fertility rates respond to changes in childcare substitutability? Figure 2 plots the average age at first birth and the total fertility rate by the substitutability parameter,  $\phi$ ,  $-\infty$  and in increments of 0.2 from  $-1$  to  $1$ . Age at first birth is inverted U-shaped, and the TFR is U-shaped. As  $\phi$  increases from  $-\infty$  to  $0.4$ , married

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<sup>17</sup>The population share of the self-employed is relatively large in Korea among OECD countries, at about 25 percent in the 2000s. All results are available from the authors upon request.

women, on average, delay the timing of childbearing to a later stage of the life-cycle and reduce the total number of childbirths at a decreasing rate. Once  $\phi$  becomes greater than 0.4, the TFR (age at first birth) increases (decreases) at an increasing rate. Note that because the fertile period is fixed and both the number of children and the timing of births are determined endogenously within the model, age at first birth follows the opposite pattern of the TFR. In order to have more children, one's first childbirth would have to occur at a younger age.

\*\*\* Figure 2 here \*\*\*

Figures 3 and 4 depict how a married woman adjusts her life-cycle labor supply to childcare substitutability on the extensive and intensive margins, respectively. At each stage of the life-cycle, the fraction employed increases monotonically as  $\phi$  goes up from  $-\infty$  to 1. As in the fertility-substitutability profile, however, labor supply responds to  $\phi$  in a nonlinear fashion. Roughly speaking, labor supply appears to be a convex function of  $\phi$  over the range of 0 and 1. A careful examination of Figure 3 also indicates that labor supply responses to increased substitutability are particularly large at earlier stages of the life-cycle, the period of childbearing.

Hours of work also increase with  $\phi$ , except among women in their twenties and early thirties (Figure 4). Women cannot increase their working hours monotonically with  $\phi$  at this stage because the number of childbirths increases with  $\phi$  and young children require mother's time (refer to Figure 2).<sup>18</sup> When substitutability is high, women choose to have more children knowing that once the children are old enough, they will be able to take advantage of market childcare. During the first few years when market childcare has a relatively limited role, however, female labor supply on the intensive margin falls inevitably.

\*\*\* Figure 3 here \*\*\*

\*\*\* Figure 4 here \*\*\*

Put together, Figures 2–4 reveal an interesting labor supply-fertility dynamics over the values of  $\phi$ . When  $\phi$  increases from  $-\infty$  to about 0.4, women on average choose to supply more labor, delay childbearing, and reduce the number of childbirths. As  $\phi$  becomes greater than 0.4, however, additional increments of childcare substitutability make women increase both labor supply and fertility at an increasing rate and give births at earlier stages of the

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<sup>18</sup>The number of childbirths at each life-cycle stage in response to different values of the substitutability parameter is available from the authors upon request.

life-cycle. The finding is observationally equivalent to the over-time change in within-country and cross-country TFR-FPR correlation mentioned earlier.

To check the robustness of the results, we re-estimate the current model for the 1970s cohort in Korea and examine whether the changing dynamic correlation of the TFR and the FPR over substitutability remains valid. The results are virtually identical to those for the 1960s cohort: the TFR-FPR correlation switches from negative to positive as the estimated substitution parameter exceeds 0.4 (see Appendix B). We confirm this pattern again for various cohorts (1950s, 1960s, and 1970s) in the United States. For brevity, only results for the 1950s cohort in the US are reported in Appendix C.<sup>19</sup> A minor difference is that the TFR-FPR correlation turns from negative to positive at a slightly higher level of  $\phi$ , 0.6, in the US.

It is interesting to note that  $\phi$  is estimated to be 0.14, 0.25, and 0.66, for the 1960s cohort in Korea, 1970s in Korea, and the 1950s cohort in the US, respectively. These estimates suggest that the measured degree of substitutability has increased from the 1960s to 1970s cohort, with the change being statistically significant. They also imply that the US has already entered the phase of the positive TFR-FPR relationship, whereas Korea is approaching the threshold level of 0.4.

## 4.2 Decomposition

The increase in female employment with substitutability is perhaps intuitive. With the option of using market childcare, more of the mother’s time would be freed up for work in the labor market. How the TFR evolves with substitutability, however, is not as straightforward. Why do women decrease then increase the number of children as substitutability improves? Do all women respond in this way, or is there selection? If there is selection, which group is driving the results?

In this section, we provide a structural explanation of the patterns generated by the model by teasing out composition effects from behavioral effects. For simplicity, we choose to divide women into two groups according to their labor market productivity—“more productive” and “less productive.” More productive women are defined as those who work from their twenties even when  $\phi$  is  $-\infty$ , and comprise about 20 percent of the 100,000 simulated women. Less productive women include all others. We emphasize that the categorization of women into these two groups is for expositional purpose only and does not imply that there are two different types of women.

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<sup>19</sup>Estimation results of the model for the 1970s cohort in Korea and the 1950s cohort in the US are available from the authors upon request.

\*\*\* Figure 5 here \*\*\*

Let us first understand the characteristics of the two groups by plotting their average wage in Figure 5. After dividing women into more or less productive groups according to the definition above, we simulate the wage schedules of the employed, normalizing the husbands' average wage rate to 1. By construction, average wage of more productive women is the same across all values of  $\phi$  (panel (b)). Because this group consists of a fixed group of women who choose to work even in the most unfavorable condition ( $\phi = -\infty$ ), there is no change in its composition by  $\phi$ —they continue to work. Hence, this group allows us to observe behavioral effects absent composition effects.

On the other hand, Figure 5 panel (c) indicates that the average wage of less productive women decreases with  $\phi$ . That is, there is selection into the labor market. Lower-ability women who used to stay out of the labor force newly enter as substitutability increases, depressing the average wage of the group.<sup>20</sup> Thus, when all women are considered in panel (a), we again observe a negative relationship between substitutability and average wage. As more women decide to work, the average quality of the female labor force inevitably falls.

\*\*\* Figure 6 here \*\*\*

Keeping this in mind, we study how each group's fertility decision is affected by substitutability. Figure 6 plots age at first childbirth and the TFR by  $\phi$ , separately for more and less productive women (panels (a) and (b), respectively). The TFR increases with  $\phi$  in all ranges for the more productive group but is U-shaped with  $\phi$  for the less productive group. Age at first childbirth, again, has the mirror image of the TFR.

To distinguish the role of behavioral and composition effects, it is convenient to focus on the difference in the TFR between  $\phi = -\infty$  and  $\phi = -1$ . The difference between these two points is solely due to behavioral effects among the more productive women and solely due to composition effects among the less productive women. This is because all women continue to work in the former whereas some women newly enter the labor market in the latter from an initial pool of housewives.

The behavioral effect, as presented in Figure 6 panel (a), is positive. Simply put, more productive, working women have more children now that they no longer need to quit their careers with childbirth. The composition effect, on the other hand, is negative (Figure 6 panel (b)). At  $\phi = -\infty$ , no woman in the less productive group participate in the labor market. At  $\phi = -1$ , a subgroup of less productive women—let us call them “compliers”—newly enter the labor force. Because housewives are assumed to use only direct childcare

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<sup>20</sup>Note that average wage is calculated for working women only.

and are thus unaffected by changes in substitutability, the sharp decline in the TFR from  $\phi = -\infty$  to  $\phi = -1$  in panel (b) is attributable to these compliers who trade childbirths for labor supply.

Once  $\phi$  exceeds  $-1$ , however, both behavioral and composition effects would coexist within the less productive group, and the shape of the TFR is determined by the relative strength of the two effects. Obviously, the significance of behavioral effects depends on the size of the female workforce. As more women participate in the labor market with increasing substitutability, the changes in the behavior of currently working women become more important than the changes in composition between working and non-working women. Consequently, at low levels of  $\phi$  where most women are not working, composition effects dominate and the TFR falls with substitutability. At higher levels of  $\phi$  where most women are already working, behavioral effects begin to dominate and the TFR increases with substitutability. Altogether, the TFR among less productive women is U-shaped with regards to substitutability.

The same logic applies when we combine more and less productive women. Behavioral effects among more productive women help alleviate the rapid fall in the TFR at low levels of substitutability while raising the TFR further up at high levels of substitutability, but the overall U-shaped pattern remains. In fact, regardless of how we define more or less productive women, the basic intuition remains the same. Greater substitutability decreases the TFR of women selecting into the labor force, increases the TFR of women already in the labor force, and increases female labor supply, which in turn amplifies the behavioral effects further on. In short, the TFR falls then rises as the size of the female labor supply expands with substitutability.

\*\*\* Figure 7 here \*\*\*

To examine the specific trade-offs that accompany these fertility decisions, we now depict the two inputs required for child quality—time and money. We normalize both measures by the number of children to capture parental inputs per child. Figure 7 panel (b) indicates that mother’s time per child  $((1 - n^w)/k)$  decreases continuously with  $\phi$  at all stages of the life-cycle among more productive women. That is, when market care becomes substitutable with mother’s direct care, mothers with high productivity choose to pay the costs of market care instead of giving up their time in the labor market. The stark difference in mother’s time by  $\phi$  among women in their twenties and early thirties is related to the number of children these women choose to have at each  $\phi$ . As aforementioned, more productive women increase childbirths with substitutability and as a result, per-child mother’s time falls. Panel (c) shows that for  $\phi$  larger than 0, less productive women also decrease per-child mother’s

time with  $\phi$ . For lower levels of  $\phi$ , however, an increase in substitutability actually increases mother’s time per child. This is due to the composition effect: at lower levels of  $\phi$ , less productive women decrease their number of children with  $\phi$ .

\*\*\* Figure 8 here \*\*\*

Figure 8 is the other side of the coin—market care expenditure per child ( $m/k$ ). As mentioned in Section 3, childcare costs rise with child’s age in Korea because of private education. How market care expenditure changes with  $\phi$ , however, depends on women’s productivity. It increases with  $\phi$  for more productive women (panel (b)), but decreases with  $\phi$  for less productive women (panel (c)). As substitutability improves, more productive mothers trade money for work time, particularly when their children are old enough to take advantage of market care. In the less productive group, there is again, selection. Recall that market care is used only by working women. Thus, as lower-ability women enter the labor force and begin to use market care, their relatively lower expenditure dampens the average of this group. As a result, we observe the seemingly counterintuitive relationship of decreasing per-child market care expenditures at greater levels of childcare substitutability (panel (a)).

A seemingly puzzling observation among more productive women may be that their market care expenditure does not increase much with substitutability when they are in their twenties and early thirties. That is, their reduction of per-child direct care is not matched one-to-one with an increase in per-child market care (Figures 7 and 8 panel (b)). This behavior can be explained by a combination of two factors. First, as reported in Table 5, mothers place the greatest weight on direct childcare at the youngest stage of their children (ages 0–4), and hence there is a limited role for market care at this stage even when substitutability is high. Second, households value the number of children as well as their quality. Thus, when substitutability increases, couples maximize their lifetime utility by having more children (even at the cost of temporarily lower per-child quality), because children’s quality can be later improved via market care. To have more children, women give first birth in their twenties or early thirties.

In sum, the fall and rise of the TFR with regard to childcare substitutability is not a representation of a “typical” woman’s fertility response, but rather a combination of behavioral and composition effects. As direct and indirect care become more substitutable, working women can have more children by investing in child quality via market care expenditure (behavioral effect). At the same time, however, housewives who choose to enter the labor force have fewer children than before because they reallocate some of mother’s time to the labor market (composition effect). The former, positive, behavioral effect on the TFR

becomes greater than the latter, negative, composition effect on the TFR as the size of the female labor force expands with substitutability.

## 5 Discussion

How can we increase substitutability to achieve higher FPR and TFR as predicted by the model? Although evaluating specific government programs is not the goal of the paper, we discuss the implications of our results by providing examples of what would, and would not, constitute an increase in  $\phi$ . We also discuss cases in which there would be limited effects, even when policies are in the direction of increasing substitutability.

First, substitutability incorporates the quality of market childcare. Recall that  $\phi$  is a parameter in the household utility function (equation (3)), not the budget constraint. Thus, policies that only focus on the quantity of market childcare while sacrificing its quality will have limited efficacy, because parents need to actually consider it as being comparable to mother’s direct care. For instance, increasing the number of private daycare centers by relaxing required qualifications may not produce desired effects on FPR and TFR. Expanding high-quality public (pre)schools, training caregivers and teachers, frequently inspecting related facilities on their compliance to hygiene and safety standards, are few examples of policies that would help increase substitutability (e.g., [Blau and Currie, 2006](#)).

Second, substitutability is related to not only market conditions but also social norms regarding childcare. According to the 2010–2014 waves of the World Value Survey, more than 55 percent of Koreans agreed to the statement “When a mother works for pay, the children suffer.” The statistic is similar in Hong Kong (65 percent) and Singapore (43 percent) and considerably lower in the US (25 percent) and Sweden (32 percent). Childrearing culture invoking “mother’s guilt” constrains parents from exploiting market childcare even when it is available ([Borck, 2014](#)). Thus, policies aimed at promoting gender equality at home as well as the labor market can also help enhance substitutability.

Third, substitutability does not have equal effects throughout the life cycle; its effects can be limited when children are very young. Our simulations indicate that women do not reduce their per-child mother’s time or increase their per-child market care expenditure with substitutability when they are in their twenties or early thirties. Higher substitutability induces working women to have more children, but they still choose to reduce their working hours during the few years following childbirth. Thus, policies such as parental leave would still be necessary to keep women in the labor force until their children are old enough to take advantage of market childcare ([Lalive and Zweimüller, 2009](#)).<sup>21</sup>

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<sup>21</sup>Limited substitutability for very young children is consistent with studies on child outcomes. For exam-

Lastly, it is worth pointing out that raising substitutability may not lift up fertility rates in the short-run. As the TFR does not have a linear relationship with the degree of substitutability, increasing it to an “insufficient” level would actually result in the lowest TFR of all (the dip in the U-shaped curve). In this intermediate phase, more women join the labor force than before, but they have very few children because mother’s time cannot be replaced with market care. Developed countries in East Asia and Southern Europe with “lowest-low” fertility rates may be such examples. To enter the second, positive, phase of the U-shaped curve, substitutability must be sufficiently high.

## 6 Conclusion

With population aging and slower economic growth, many developed countries are seeking ways to enhance both female labor force participation and fertility rates. The change in the TFR-FPR correlation within and across countries sheds light on the possibility that the two goals can indeed be achieved. In this paper, we show how increasing substitutability between direct and market childcare can explain the trend in the TFR-FPR relationship, and be implemented to raise the TFR and the FPR in a given country. Analysis of a life-cycle model of married women’s labor supply and fertility decisions indicates that the FPR increases, whereas the TFR is U-shaped with regard to substitutability. As substitutability improves, behavioral effects of working women (who increase childbirths) begin to dominate composition effects of less productive women (who trade childbirths for labor supply).

Going back to the question we posed earlier, our findings imply that with sufficiently high childcare substitutability, women would be able to “have it all.” The increase in the TFR with substitutability comes with not just an increase in the number of children in an average household, but a change in the composition of households that have children: an increase in the relative portion of children born to more productive mothers. The rise in the TFR and the FPR brings about a transition from most women pursuing either “career *or* family” to “career *and* family” as described by [Goldin \(2004\)](#).

While our analysis focuses on married households and assumes that mothers are primary caretakers, the effects of substitutability may even be larger than our estimates if we take into account potential spillovers to marriage rates or fathers’ role in childrearing. The low TFR in developed Asian countries is known to be partly due to the decline in marriage, particularly among highly-educated women ([Jones, 2007](#); [Hwang, 2016](#)). Since out-of-wedlock childbirths are very rare in these countries and the career cost of childbirth is one of the

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ple, analyzing the universal childcare reform in Quebec, [Baker et al. \(2008\)](#) find that non-parental care has negative behavioral, social, and health consequences for children under age 3.

reasons for avoiding marriage, increasing substitutability could help raise the TFR through both the intensive (among married couples) and extensive (increasing the number of married couples) margins. Also, there is no doubt that mother's time with children is substitutable not only with market childcare but also father's time. The interaction between childcare substitutability, parental roles, and fertility is another interesting avenue for future research.

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Table 1: Estimated Wage Function: Deterministic Component

Coefficient	Estimate
<b>Panel A: Husband</b>	
Constant	5.2407 (0.0492)
Age	0.0498 (0.0043)
Age squared	-0.00112 (0.00011)
Unemployment rate	-0.0561 (0.0045)
N of obs	18,352
<b>Panel B: Wife</b>	
Constant	5.4820 (0.0490)
Cumulative work experience	0.0358 (0.0034)
Cumulative work experience squared	-0.00098 (0.00011)
Cumulative non-employment duration	-0.0792 (0.0024)
Cumulative non-employment duration squared	0.00203 (0.00009)
Unemployment rate	-0.0818 (0.0065)
N of obs	8989

Data source: The KLIPS work history file, 1998 to 2015. White's robust standard error estimates are in parentheses. Males are included in the sample if their ages are greater than or equal to 25 years and their monthly earnings are between 0.3 million won (about 300 dollars) and 20 million won (about 20,000 dollars) in terms of 2010 won.

Table 2: Estimated Joint Stochastic Wage Processes of Husbands and Wives

	Husband	Wife
$\rho^g$ (persistence of permanent wages)	0.7848	0.7795
$\sigma_{\xi^g}^2$ (variance of wage shocks)	0.2583	0.2753
$\rho_{\xi^w \xi^h}$ (correlation b/w husband's and wife's wages)	0.1739	

Notes: See notes to Table 1.

Table 3: Estimated Childcare Cost Function

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Dependent variable:  $m = \frac{\text{Annual childcare expenditure}}{\text{Annual wife's income}}$

Coefficient	Estimate
Constant	0.2144 (0.0050)
Number of children between ages 0 to 4	-0.0251 (0.0064)
Number of children between ages 5 to 9	-0.0166 (0.0048)
Number of children between ages 10 to 14	0.0093 (0.0045)
Number of children between ages 15 to 19	0.0425 (0.0049)
N of obs	5,311
Variance of residuals	0.0133

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Data source: The Korea Labor and Income Panel Survey (KLIPS), 1998 to 2015. Sample criteria: working mothers who spend between 5% and 100% of their labor income on market childcare.

Table 4: Model-Generated Moments vs. Empirical Moments

1960s cohort	Model	Data
Per capita employment for women whose ages are b/w <sup>a</sup>		
25–29	0.3646	0.3534
30–34	0.4198	0.4213
35–39	0.5575	0.5591
40–44	0.6142	0.6022
45–49	0.6230	0.6193
50–54	0.5861	0.6004
Per capita employment for women whose children's ages are b/w <sup>b</sup>		
0–4	0.2781	0.2998
5–9	0.3917	0.4007
10–14	0.4801	0.4957
15–19	0.5502	0.5506
Number of lifetime childbirths <sup>b</sup>		
Share of non-mothers <sup>b</sup>	0.0614	0.0437
Share of mothers who have their first birth before age 30 <sup>b</sup>	0.8377	0.8697
Share of mothers who have their first birth after age 34 <sup>b</sup>	0.0647	0.0464
Ratio of male to female labor income <sup>c</sup>	0.6033	0.5918
Childcare cost equation <sup>c</sup> :		
Constant	0.2241	0.2144
Number of children b/w ages 0–4	-0.0244	-0.0251
Number of children b/w ages 5–9	-0.0157	-0.0166
Number of children b/w ages 10–14	0.0106	0.0093
Number of children b/w ages 15–19	0.0427	0.0425
Wife's wage equation <sup>c</sup> :		
Constant	5.4601	5.4820
Cumulative work experience	0.0361	0.0358
Cumulative work experience squared	-0.00097	-0.00098
Cumulative non-employment duration	-0.0779	-0.0792
Cumulative non-employment duration squared	0.00198	0.00203

<sup>a</sup>Data source: The Economically Active Population Survey, January 1985 to December 2013. <sup>b</sup>Data source: The Korea Census, 1995, 2000, 2005, 2010. <sup>c</sup>Data source: The KLIPS, 1998 to 2015.

Table 5: Estimated Structural Parameters

	Parameter	Estimate
Relative risk aversion of consumption	$\gamma$	0.653 (0.061)
Disutility of wife's work	$\eta$	0.571 (0.021)
Weight on childcare production	$\delta$	0.262 (0.024)
Relative risk aversion of number of children	$\theta$	0.408 (0.023)
Relative risk aversion of quality of children	$\lambda$	0.290 (0.023)
Substitutability b/w mother's time and market care	$\phi$	0.143 (0.022)
Relative share of mother's time on childcare when children's ages are b/w		
0-4	$g^1$	0.567 (0.068)
5-9	$g^2$	0.381 (0.050)
10-14	$g^3$	0.289 (0.036)
15-19	$g^4$	0.244 (0.026)
Childcare cost equation:		
Constant	$c_0$	0.2198 (0.0189)
Number of children b/w ages 0-4	$c_1$	-0.0264 (0.0028)
Number of children b/w ages 5-9	$c_2$	-0.0168 (0.0027)
Number of children b/w ages 10-14	$c_3$	0.0102 (0.0025)
Number of children b/w ages 15-19	$c_4$	0.0414 (0.0030)
Wife's wage equation:		
Constant	$\beta_0$	5.4027 (0.0311)
Cumulative work experience	$\beta_1$	0.0357 (0.0042)
Cumulative work experience squared	$\beta_2$	-0.00098 (0.00017)
Cumulative non-employment duration	$\beta_3$	-0.0802 (0.0069)
Cumulative non-employment duration squared	$\beta_4$	0.00202 (0.00031)

Numbers in parentheses are standard error estimates obtained by the Simulated Method of Moments estimation (100,000 households).

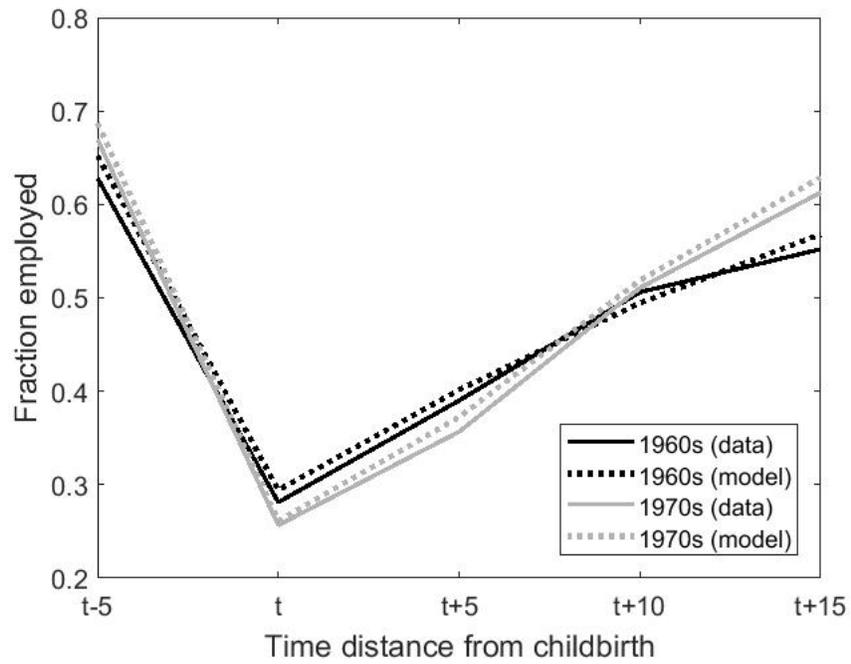


Figure 1: Employment Dynamics Before and After Childbirths

Notes: The solid lines represent the observed employment dynamics and the dotted lines represent the model-generated dynamics. The black lines (solid or dotted) are for the 1960s cohort and the grey lines are for the 1970s cohort. Year  $t$  represents the year of first childbirth.

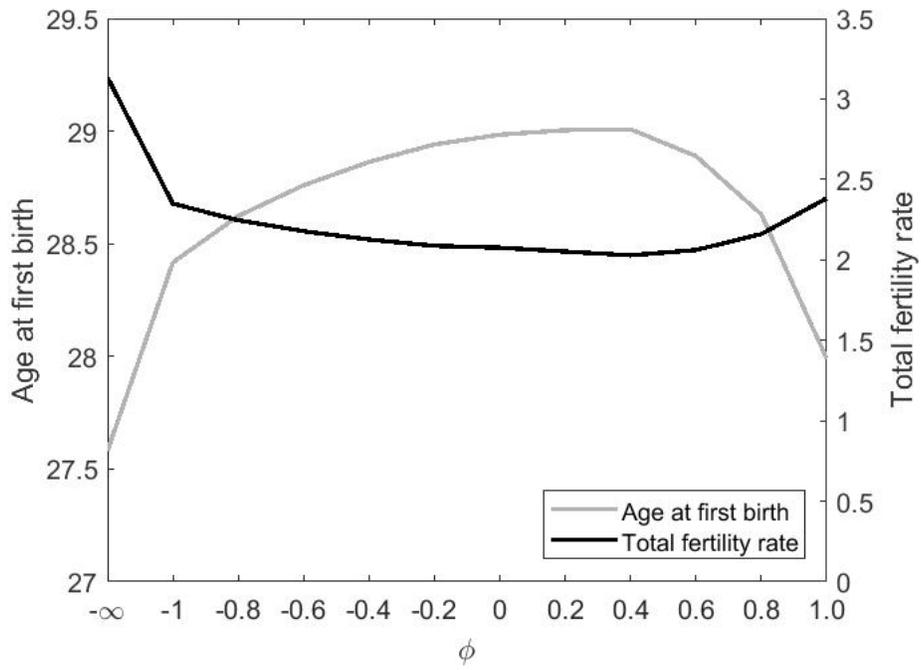


Figure 2: Fertility Behavior by Substitutability, All Women

Notes:  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.

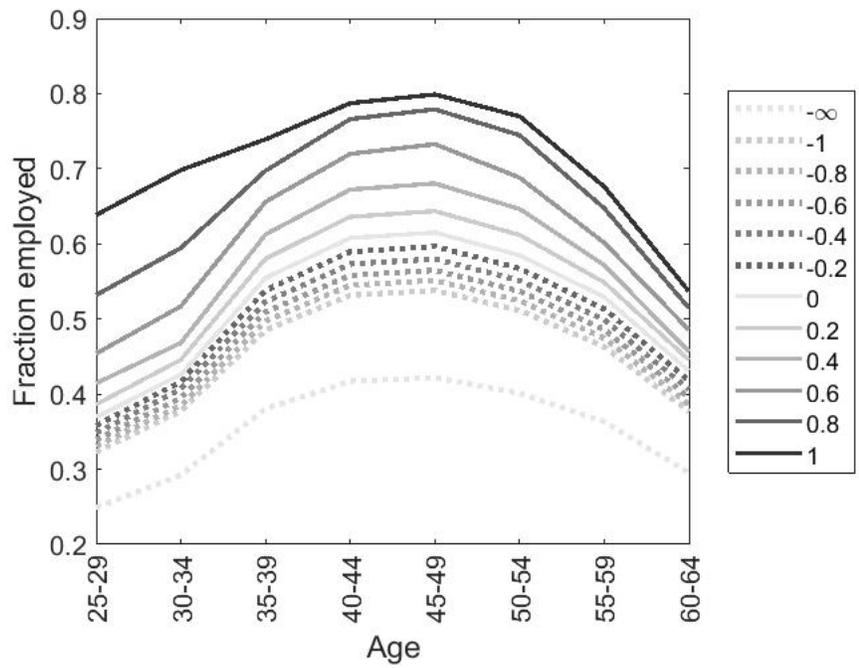


Figure 3: Employment Over the Life-Cycle by Substitutability, All Women

Notes: Fraction employed among all women.  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.

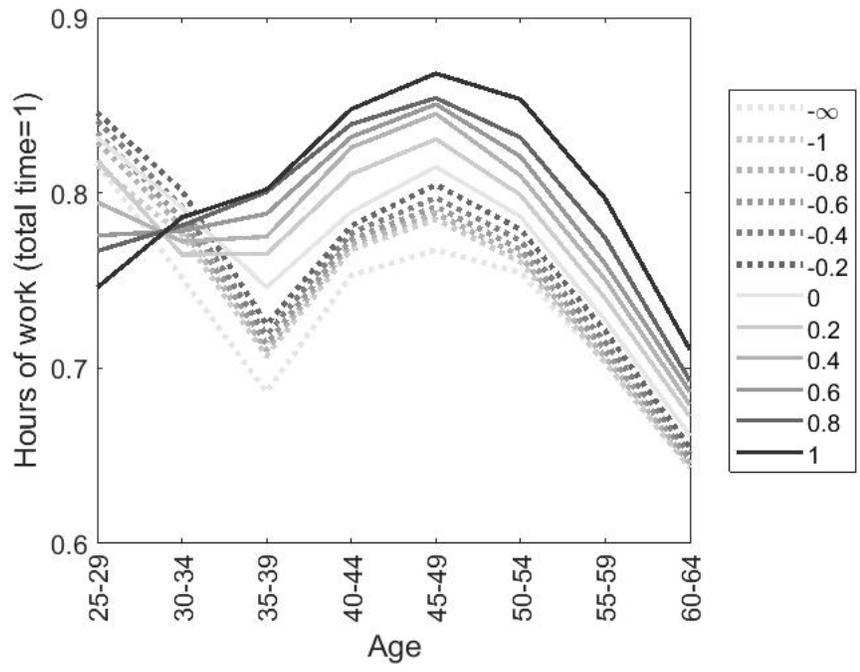
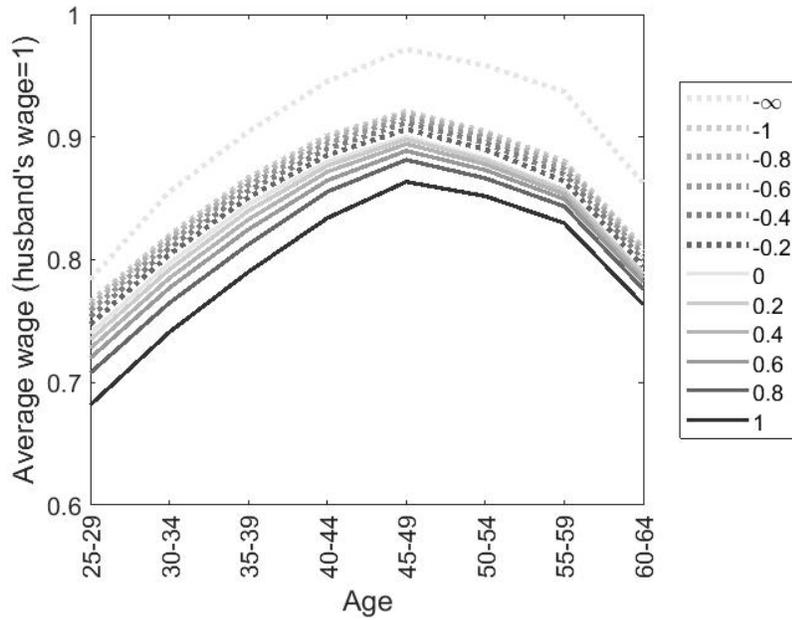
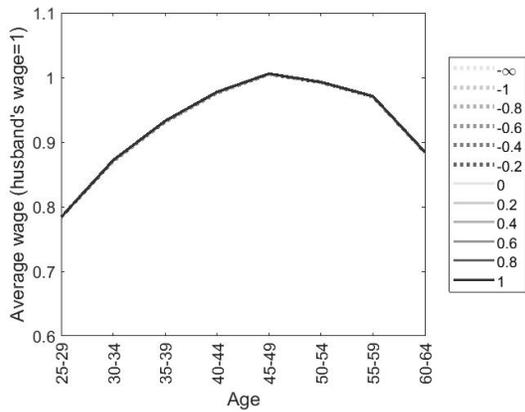


Figure 4: Hours of Work Over the Life-Cycle by Substitutability, All Women

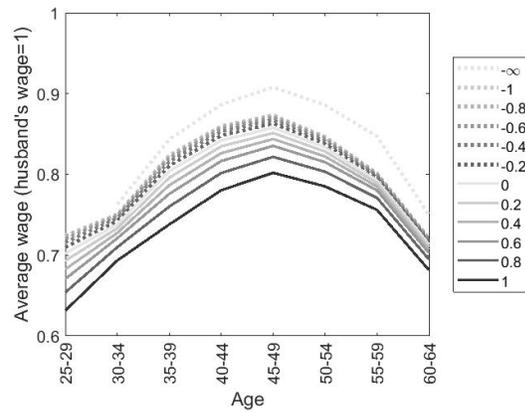
Notes: Women’s working hours ( $n^w$ ) when total time (and husband’s labor hours) is normalized to 1.  $\phi$  represents the parameter that governs the elasticity of substitution between mother’s direct care and indirect market care.



(a) All women



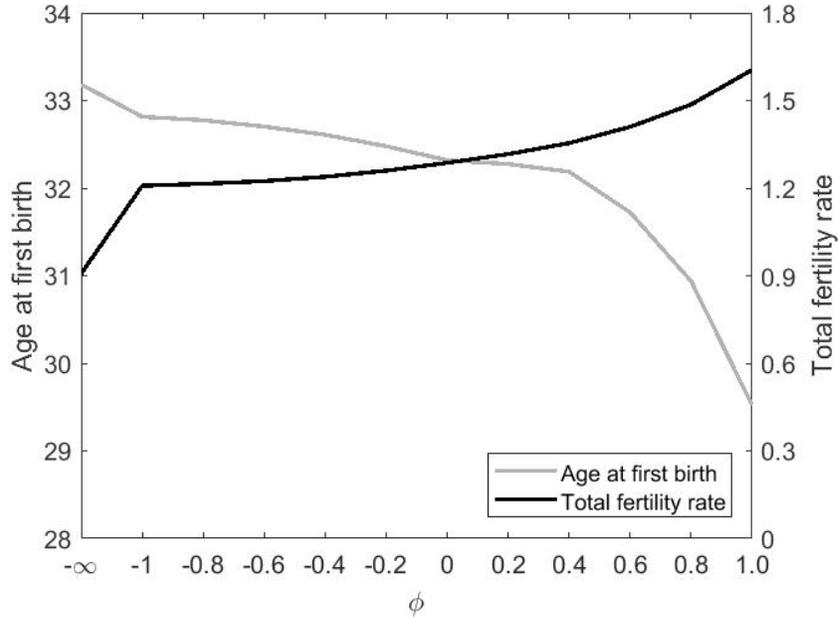
(b) More productive women



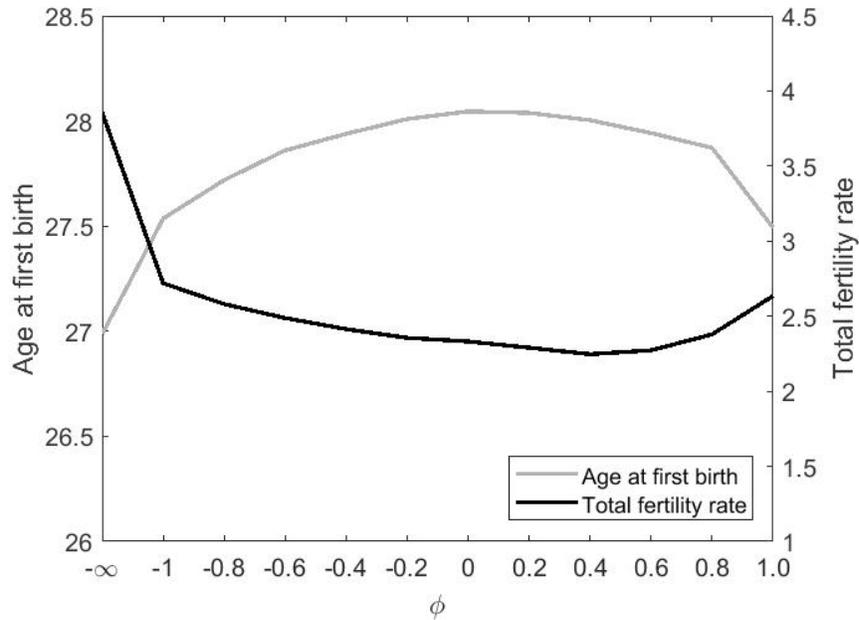
(c) Less productive women

Figure 5: Average Wage Over the Life-Cycle by Substitutability

Notes: Average wage of working women when husbands' average wage is normalized to 1.  $\phi$  represents the substitution parameter that governs the elasticity of substitution between mother's direct care and indirect market care.



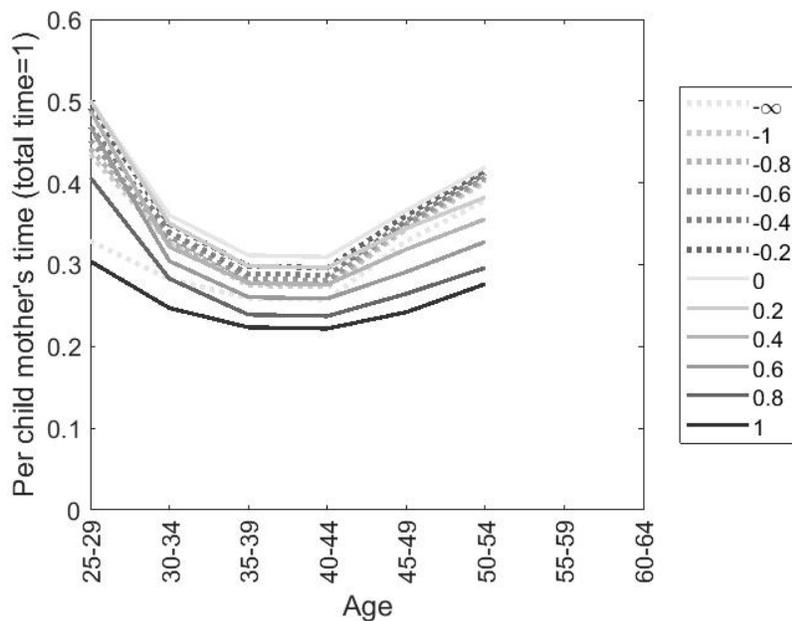
(a) More productive women



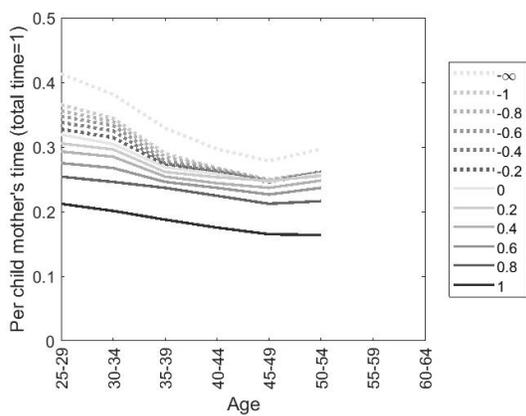
(b) Less productive women

Figure 6: Fertility Behavior by Substitutability

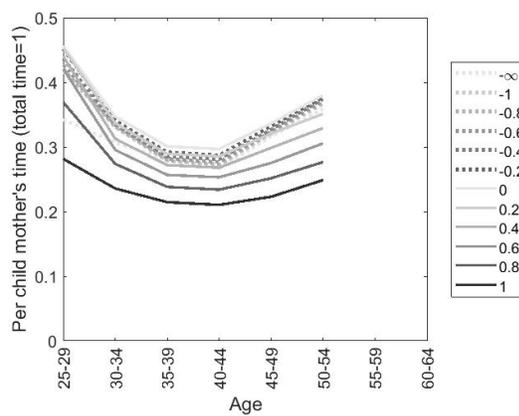
Notes:  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.



(a) All women



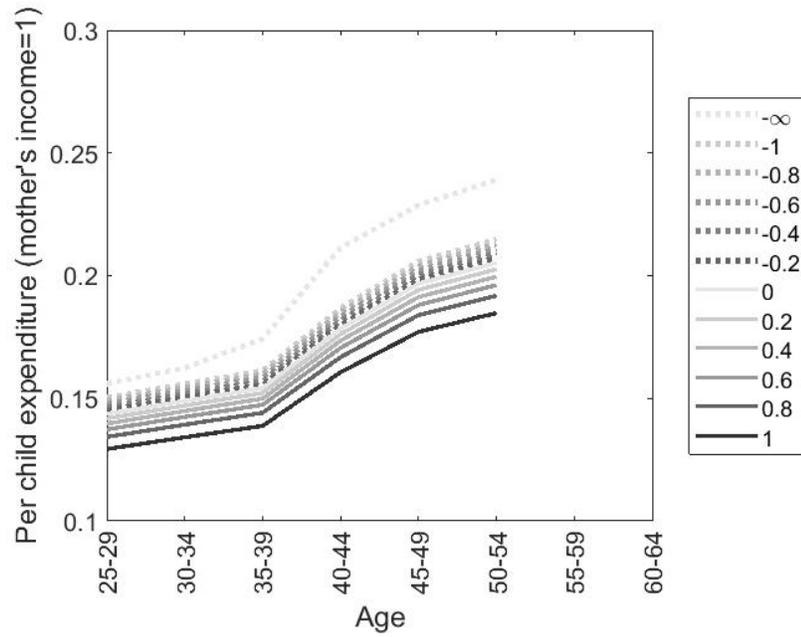
(b) More productive women



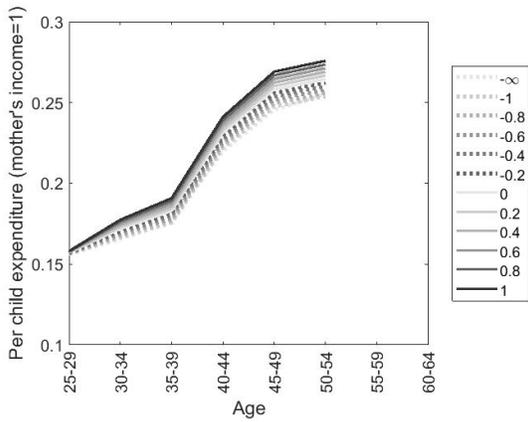
(c) Less productive women

Figure 7: Mother's Childcare Hours Over the Life-Cycle by Substitutability

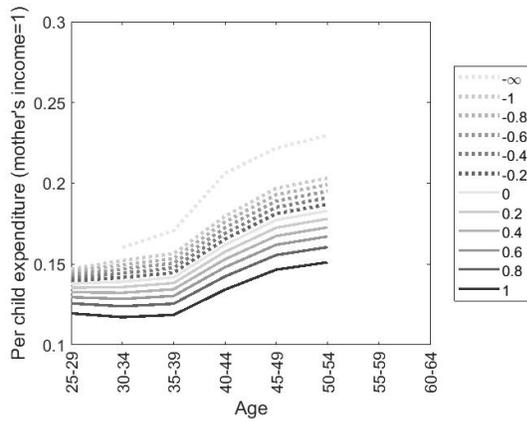
Notes: Mother's childcare hours per child  $((1 - n^w)/k)$  when total time is normalized to 1.  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.



(a) All women



(b) More productive women



(c) Less productive women

Figure 8: Market Care Expenditure Over the Life-Cycle by Substitutability

Notes: Market care expenditure per child ( $m/k$ ) among working women with children.  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.

# Appendix

## Appendix A

### A.1 Simulated Method of Moments (SMM) Estimation

Let  $M_d$  represent a vector of empirical moments that are computed from various data sources in Korea, as described in Table 4. There are twenty five target moments for the 1960s cohort that describe the wife' labor supply, fertility outcomes, wife's wages and indirect market childcare costs. Let  $\boldsymbol{\beta} \equiv \{\gamma, \eta, \delta, \theta, \phi, \lambda, g^1-g^4, c_0-c_4, \beta_0-\beta_4\}$  represent the model parameters to be estimated internally, including ten utility parameters, five parameters governing returns (penalties) to work (non-work) experience in the wife's wage equation, and five parameters in the childcare cost function. Given externally determined parameters, we obtain 100,000 households for the 1960s cohort, use the model to simulate their life-cycle labor supply and fertility profiles, and generate the moments analogous to the empirical moments, denoted by  $M_m(\boldsymbol{\beta})$ . Obviously, each of these model-generated moments is a function of  $\boldsymbol{\beta}$ . Define the vector of deviations between the empirical moments and the model generated-moments by  $g(\boldsymbol{\beta}) = M_d - M_m(\boldsymbol{\beta})$ . The Simulated Method of Moments (SMM) estimator chooses the value of  $\boldsymbol{\beta}$  that minimizes the weighted sum of the squared deviations between the empirical and model-generated moments.

$$\hat{\boldsymbol{\beta}}_{smm} = \arg \min_{\boldsymbol{\beta}} g(\boldsymbol{\beta})'Wg(\boldsymbol{\beta}),$$

where  $W$  is the optimal weighting matrix. The variance-covariance estimator is calculated by

$$\widehat{\Sigma}_{\hat{\boldsymbol{\beta}}} = (\hat{G}'W\hat{G})^{-1}\hat{G}'W\Omega W\hat{G}(\hat{G}'W\hat{G})^{-1},$$

where  $\hat{G} = \frac{\partial}{\partial \boldsymbol{\beta}}g(\boldsymbol{\beta})|_{\boldsymbol{\beta}=\hat{\boldsymbol{\beta}}}$ , and  $\Omega$  is the variance matrix of the empirical moments. We estimate the model with an optimal weighting matrix  $W = \Omega^{-1}$ .

### A.2 Computation

Given a set of model parameters,  $\boldsymbol{\beta} \equiv \{\gamma, \eta, \delta, \theta, \phi, \lambda, g^1-g^4, c_0-c_4, \beta_0-\beta_4\}$ ,

1. Generate a discrete grid over the state space.
2. Solve the households' problem to obtain optimal decision rules by backward recursion. The choice of the number of newborn children in  $j$  is determined by the maximum of the conditional value functions.
3. Generate the permanent shocks for 100,000 couples using the joint distribution of the couple's shocks; and simulate their decision rules and choice for the fertility by approximating the solutions on a grid.
4. Compare the empirical moments with the model generated moments as in Table 4. Update the set of parameters of  $\boldsymbol{\beta}$  and go back to (1). A minimization routine is constructed through the Nelder-Mead simplex algorithm.

## Appendix B Baseline Simulations for the 1970s Cohort in Korea

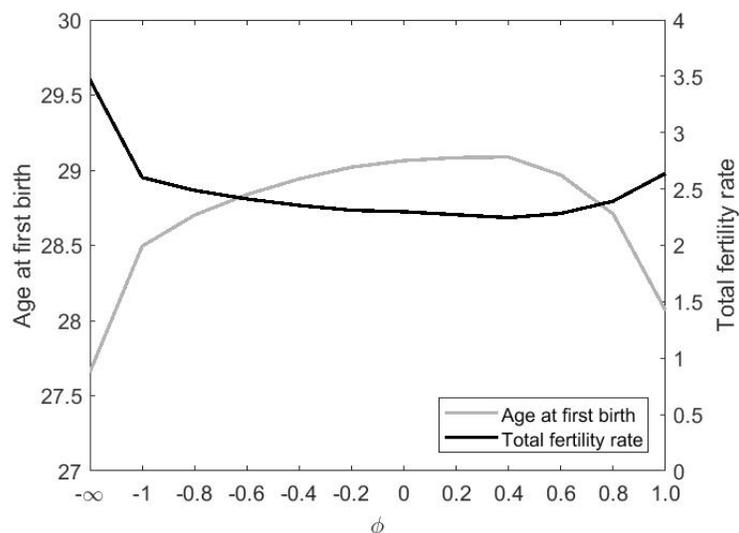


Figure B.01: Fertility Behavior by Substitutability, All Women

Notes:  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.

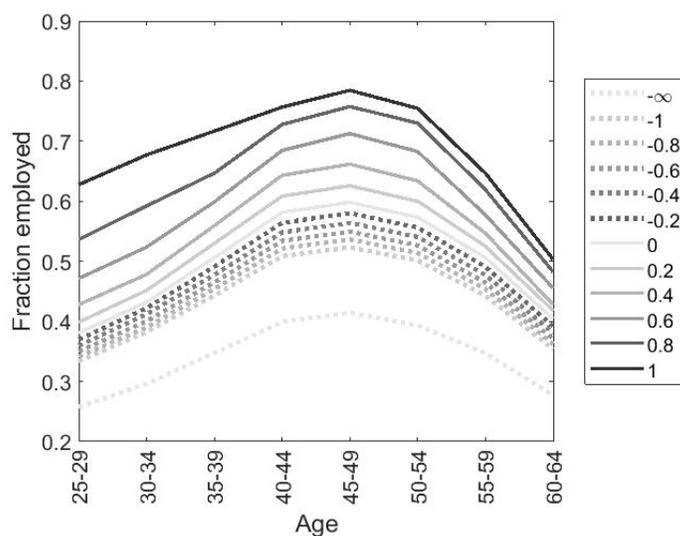


Figure B.02: Employment Over the Life-Cycle by Substitutability, All Women

Notes:  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.

## Appendix C Baseline Simulations for the 1950s Cohort in the US

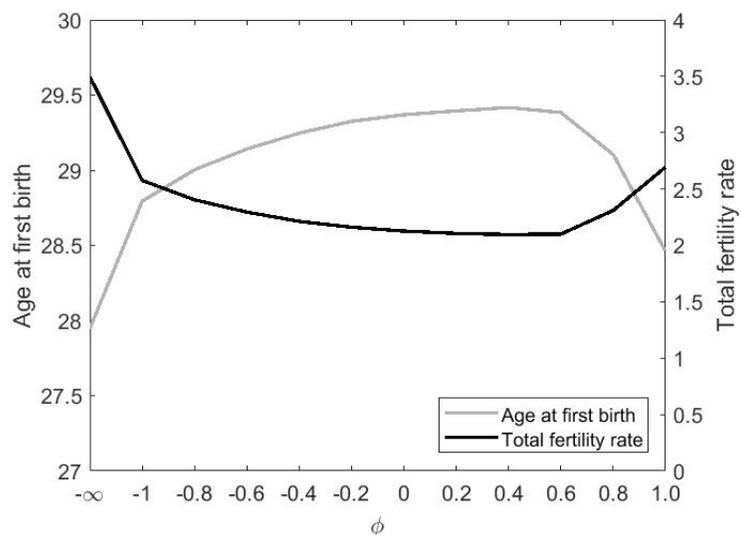


Figure C.03: Fertility Behavior by Substitutability, All Women

Notes:  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.

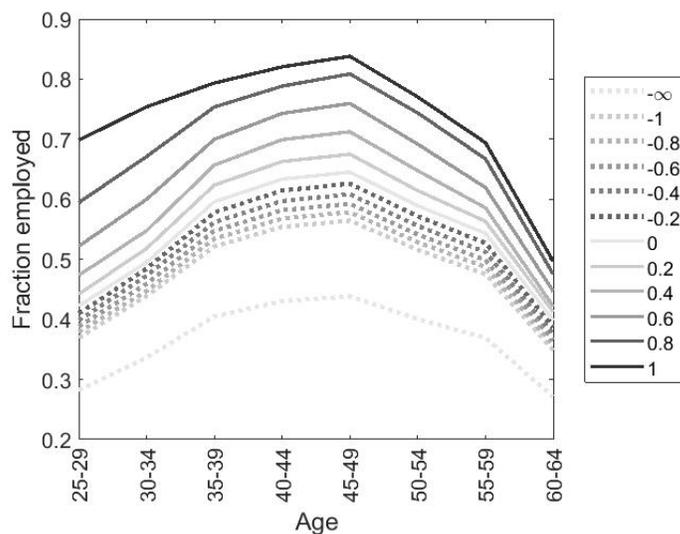


Figure C.04: Employment Over the Life-Cycle by Substitutability, All Women

Notes:  $\phi$  represents the parameter that governs the elasticity of substitution between mother's direct care and indirect market care.