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

Jisoo Hwang* Seonyoung Park† Donggyun Shin‡

November 26, 2015

PRELIMINARY. PLEASE DO NOT CITE OR CIRCULATE.

Abstract

The correlation between female labor force participation rate (FPR) and total fertility rate (TFR) across developed countries has switched from negative to positive. This paper provides a structural explanation of the historical pattern via changes in substitutability between mother's direct childcare and indirect market care. We construct a life-cycle model of female labor supply and fertility and estimate the model using Korean data. Simulations of our model show that FPR increases, whereas TFR is U-shaped with regards to substitutability. The dynamic relationship between FPR and TFR depends on the relative strength of behavioral and composition effects: greater childcare 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 two seemingly conflicting goals—increasing female labor supply and fertility rate.

JEL Codes: J11, J13, J22, D10
Keywords: female labor supply, total fertility rate, childcare substitutability

*Department of International Economics and Law, Hankuk University of Foreign Studies, 107 Imun-ro, Dongdaemun-gu, Seoul 130-791, Korea. Email: jhwang@hufs.ac.kr.

†Department of Economics, Alfred Lerner College of Business & Economics, University of Delaware, 421 Purnell Hall, Newark, DE 19716, U.S.A.. Email: ypark@udel.edu.

‡Department of Economics, Kyung Hee University, 26, Kyungheedae-ro, Dongdaemun-gu, Seoul, 02447, Korea. Email: dgshin@khu.ac.kr.

1 Introduction

Work and family have always been difficult to reconcile for married women with children. The long-run trend of rising female labor force participation rates (FPR) accompanied by falling total fertility rates (TFR) observed in most countries is an evident demonstration of the difficulty of achieving both, at the individual as well as the national level.

Thus it comes at a surprise that recent studies report a switch in the sign of the cross-country correlation between TFR and FPR among developed countries (e.g., Ahn and Mira, 2002; Bettio and Villa, 1998; Brewster and Rindfuss, 2000; Castles, 2003). Using data on OECD countries from 1970 to 1995, Ahn and Mira (2002) finds that the correlation, which was about -0.5 during the 1970s, turns positive in the mid-1980s, and reaches 0.5 in the 1990s (see Figure 1). That is, in some developed countries, women work more *and* have more children than in others. Understanding this historical pattern is key to finding the "one stone" that could achieve two seemingly conflicting goals—raising female labor supply while maintaining a population growth above the replacement level.

*** Figure 1 here ***

In this paper, we present a structural explanation of the change in the TFR-FPR correlation via increasing substitutability between mother's direct childcare and indirect market care (henceforth, substitutability). Using a model in which labor supply and fertility behaviors are endogenously determined in the process of optimizing a household's expected life-cycle utility, we show that women's labor supply increases with substitutability whereas TFR is U-shaped with regards to substitutability. Thus when substitutability improves over time, the TFR-FPR relationship evolves from negative in the decreasing phase of TFR to positive in the increasing phase of TFR.

To be more specific, the paper estimates a life-cycle model of married couples who get utility from consumption, disutility from work, and also care about childbirths and the human capital of their children. The model is estimated for the 1960s cohort in South Korea (hereafter, Korea). Korea is a particularly interesting case to study, because it has one of the lowest fertility rate and female labor force participation rate among OECD countries, and hence is desperately seeking for ways to enhance both measures. 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., the 1970s cohort in Korea and the 1950s cohort in the US).

Simulations of the estimated model reveal that the dynamic relationship of labor supply and fertility behaviors change as substitutability increases. While greater female labor supply is associated with lower fertility up to a certain level of substitutability, raising substitutability further beyond that level makes both FPR and TFR to increase at an increasing rate. The finding is robust to different cohorts.

Such patterns are explained by a combination of behavioral and composition effects. For higher-wage, more productive women who choose to work even with zero substitutability, an increase in substitutability gives incentive to supply more working hours (intensive margin), raise (per-child) expenditure on market care, and give more births. Enhanced substitutability, however, attracts additional lower-wage, less productive women from the non-market sector as well. While higher substitutability allows this group to supply more labor at both extensive and intensive margins, they trade childbirths for labor supply. The decreasing phase of TFR is thus driven by less productive women joining the labor force. As the elasticity of substitution exceeds some threshold level (of about 0.4), however, behavioral effects of working women begin to dominate composition effects, so that TFR increases with substitutability.

Our findings have some important implications. First, policies aimed to raise childcare substitutability to a sufficiently high level can help countries alleviate labor shortage problems due to population aging in both short- and long-run horizons. Greater FPR would increase the size of the labor force and greater TFR would slow down the speed of population aging altogether. Second, due to composition effects, changes in substitutability affects not only the total number but also the distribution of children across households. Even in the phase of decreasing TFR, new births are concentrated among relatively more productive women. It is worth noting that substitutability here, however, is not confined to the availability of market childcare services but encompasses its quality as well as social norms regarding childcare.

The paper contributes to the extensive literature on trends in female labor supply and fertility. Feyrer, Sacerdote and Stern (2008) explains that the gap between women's status in the workforce and the household can generate U-shaped TFR across developed countries. In the sociology literature, Brewster and Rindfuss (2000), argues that changes in institutional context which reduces the incompatibility between childrearing and female employment accounts for the reversal in TFR-FPR correlation. On the other hand, some papers focus on the role of technology. For example, Greenwood, Seshadri and Yorukoglu (2005) analyzes how the development of household appliances increases married women's labor force participation in a Beckerian framework, whereas Galor and Weil (1996) and Martínez and Iza (2004) examine the link between increases in capital per worker and the demographic transition in a general equilibrium overlapping generations model. Although similar in spirit, these papers cannot show using data, however, how work and fertility behaviors would simultaneously respond to changes in the exogenous variable of interest.

Thus we borrow from studies that employ structural methods. For example, Olivetti (2006) uses PSID data to demonstrate that the increase in women's marginal returns to experience accounts for most of the variation in married women's hours of work between the 1970s and 1990s. Attanasio, Low and Sanchez-Marcos (2008) calibrates a life-cycle model to explain the increase in labor supply of mothers between the 1940s and 1950s cohorts in the US; they find that a combination of reduction in the cost of children and the gender wage gap are needed.

There are also several papers that focus on the Korean case in particular. For instance, Eun (2003) and Lee (2009) document the fertility transition in Korea over the past few decades. Tsuya, Bumpass and Choe (2000) compares work-family balance in Korea, Japan, and the US. With growing concerns about populating aging and slower economic growth in Korea, recent research, for example Dao et al. (2014) and Kim, Park and Shin (2015), suggest possible policy measures to raise FPR and TFR.

The organization of the paper is 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 implications of our findings.

2 The Model

2.1 Economic environment

The economy consists of married couples, with or without children. Both a husband and a wife live J_T periods. Let $j \in \{j_1, j_2, ..., j_T\}$ denote a period (or "age") of the life-cycle, which includes five years of actual ages. Adults in the household start economic activity at j_1, and retire at j_R. In each period, the household makes decisions on the wife's labor supply and fertility, along with household consumption and savings. The husband always works with a fixed amount of (full time) hours. 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 nonworking period.

The household also chooses the number of new children in each period until the wife gets to j_I, after which she is considered to be infertile. 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. The children impose costs when the wife works. Key ingredients of the model are as follows.

2.1.1 Childcare costs

When the wife works, the household pays for childcare costs that depend on the number of children, ages of children, and the wife's labor income.

2.1.2 Wages and human capital

Both the husband's and wife's wages consist of deterministic and stochastic components. Their stochastic components are subject to permanent shocks. Since the husband always works, his deterministic wages depend on age. The wife's deterministic wages, however, depend on endogenously accumulated tenure at the current (or most recent job), overall experience, and most recent non-working periods. The husband's and the wife's deterministic wages are also affected by business cycle conditions, as represented by unemployment rates.

2.1.3 Preferences

Household gets utility from consumption and children and disutility from work. Each married couple also cares about not only the number of children but also their human capital in a way that allows a quantity-quality trade-off in childcare production.

A typical household's utility function is as follows:

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

where $u(\cdot)$ is the utility from consumption and disutility of work and $x(\cdot)$ represents utility from children. c denotes household size-adjusted (adult-equivalent) consumption, k is the number of children, n^w is wife's working hours, M is market childcare costs, and $\mathbb{I}(\cdot)$ denotes the indicator function.[1]

Following Caucutt, Guner and Knowles (2002) and Park (2014), $u(\cdot)$ and $x(\cdot)$ are specified, respectively, by

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

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

where γ is a coefficient of relative risk aversion of consumption and η the marginal disutility of work. Utility from children depends on the number (k) and age (j_c) of children, wife's childcare hours ($1 - n^w$), and market goods for childcare (M). δ is the weight on childcare

[1] We use the OECD-modified scale that assigns a value of 1 to the husband, .5 to the wife, and .3 to each child.

production. θ and λ concern utility from quantity and quality of children, respectively. ϕ governs the elasticity of substitution between 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 the relative share is allowed to vary depending on children's ages. For example, mother's direct care time becomes less important as children grow older (Olivetti, 2006).

2.2 Household's Decision Problem

In each period, a 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, and are denoted by $i \in \{1, 2, ..., 6\}$: i=1 if 0 children, i=2 if 1 child, all the way up to 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, wife's labor supply is eliminated from the choice set as well.

Let $\Omega = \{a, j, v^h, v^w, k^1_-, k^2_-, k^3_-, k^4_-, X, X^n_-, t\}$ be a set of state variables for the household's decision problem, where v^h and v^w represent the husband's and wife's permanent wage shocks, respectively. k^1_-, k^2_-, k^3_-, and k^4_- represent the number of children in the prior period, 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 X^n_- are tenure and most recent non-employment period, respectively. t is the calendar year.

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

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

and the value function of each case is defined by

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

subject to

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

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

$$a = 0 \ if \ j = j_1 \ or \ j = j_T, \ a' \geq \underline{\text{a}},$$

where β is the discount factor, and $\underline{a}$ is a natural borrowing constraint.

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

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

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

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 Ω. In solving the model, a potential nonconcavity problem arises because of the nature of the discrete choice associated with changes in the new number of children in the future period. With enough uncertainty, however, it will be smoothed out, leaving the expected value function concave (Attanasio, Low and Sanchez-Marcos, 2008).

3 Model Estimation

3.1 Externally Determined Parameters

3.1.1 Basic model setup

Individuals live ten periods (j_T=10), starting their lives at age j_1 as adults and ending at age $j_{(T+1)}$. Each period (or "age") consists of five years of actual ages, with j_1 representing actual ages of 25–29, ..., and j_T representing 70–74. Wives become infertile from j_I (40–44). Both husbands and wives retire at j_R (65–69). Newborn children are assumed to be attached to the household for four periods.

3.1.2 Childcare costs

Using the Korean Labor Income Panel Survey (KLIPS), we estimate the childcare cost function, as specified by Park (2014).[2]

$$m_{i,t} = c_0 + c_1 k^1_{i,t} + c_2 k^2_{i,t} + c_3 k^3_{i,t} + c_4 k^4_{i,t} + \epsilon_{i,t}, \tag{6}$$

[2] In each survey, the KLIPS releases information about each household's average monthly expenditure on private and public childcare services. The private childcare cost is defined by the total expenditure on all kinds of childcare-related services except for formal education. The expenditure on public childcare is the amount spent on formal education of children in elementary to high school, including tuition and related expenses. Total childcare costs are computed as sum of the two.

where the dependent variable, $m_{i,t}$, is annual expenditure on market childcare services divided by labor income of wife i in year t. The total household childcare costs are computed by the product of the predicted $m_{i,t}$ and wife's labor income ($w^w n^w$): $M = mw^w n^w$.

*** Table 1 here ***

Table 1 reports estimation results of the childcare cost function. For brevity, only estimated coefficients are reported along with their standard error estimates. Estimates show that childcare becomes more costly as children grow older in Korea ($c_1 < c_2 < c_3 < c_4$).[3]

3.1.3 Wages and wage shocks

As in most existing studies (e.g., Olivetti, 2006; Attanasio, Low and Sanchez-Marcos, 2008), husbands are assumed to work all the time so that their wage depends only on age:

$$lnw^h_{i,t} = \alpha_0 + \alpha_1 j_{i,t} + \alpha_2 j_{i,t} + \alpha_3 u_t + \nu^h_{i,t}, \tag{7}$$

where $w^h_{i,t}$ represents the real monthly earnings of husband i in year t, $j_{i,t}$ his age, u_t unemployment rate in year t, and $\nu_{i,t}$ is the error term in the husband's wage equation.

The wife's wage function is specified as follows:

$$lnw^w_{i,t} = \beta_0 + \beta_1 X_{i,t} + \beta_2 X^2_{i,t} + \beta_3 T_{i,t} + \beta_4 T^2_{i,t} + \beta_5 NX^n_{i,t} + \beta_6 (NX^n_{i,t})^2 + \beta_7 u_t + v^w_{i,t}, \tag{8}$$

where $w^w_{i,t}$ represents the real monthly earnings of wife i in year t, $X_{i,t}$ overall experience, $T_{i,t}$ tenure at the current (or most recent) job, $NX^n_{i,t}$ the most recent non-employment duration, and $\nu^w_{i,t}$ the error term.[4] Married women experience wage losses during a non-working period caused by childbearing or rearing among others, and labor market conditions, as measured by unemployment rates, affect labor supply through wage changes.

[3]The relationship between child's age and childcare cost need not be the same across countries. For example, Park (2014) finds that childcare becomes less costly over the age of children in the US.

[4]In the current model, hours adjustment represents changes in the number of employment months over a five-year period. First, the wage setting system in Korea makes the monthly pay more appropriate as the measurement of price of labor than the hourly wage rate, as many establishments adopt the "comprehensive pay system." Under the system, both the monthly pay and "average" monthly hours are set through collective bargaining over a certain period of time. Second, the labor force share of hourly workers is much lower in Korea, relative to, say, the US. The KLIPS data shows that the proportion of hourly workers among the entire wage and salary workers is far less than ten percent in the 2000s. Our analysis of the Current Population Survey data over a similar period produces a comparable figure of over 40 percent in the US. Third, and perhaps more importantly, the average hourly earnings variable (commonly used in previous studies as a measure of the hourly wage rate) suffers from measurement errors associated with monthly hours collected from surveys. That said, little change is made to the findings of this paper even when the average hourly earnings are used instead of monthly pay.

Some econometrics issues arise in estimating equation (8). First, wages are observed only when wives are employed. If the effects of the wage determinants for those who are not employed differ systematically from those for employed wives, then Ordinary Least Squares (OLS) of the equation leads to biased and inconsistent estimates of the regression coefficients. To correct for such sample selection, we employ the conventional two-step estimation methods suggested by Heckman (1979). With the selection term included as an additional regressor in the second-step estimation, identification of coefficients requires at least one variable excluded from the wage equation, but included in the selection term. Following prior studies in the literature, we use the number of children and husband's income as those excluded variables (e.g., Olivetti, 2006).

Second, the error term in each of the wife's or the husband's equation is likely to be cross-sectionally correlated because different individuals' error terms share common year effects. Neglecting this would bias the estimated standard error of the estimated cyclical effect downward. To obtain appropriate standard error estimates, we conduct White's standard error estimation that is robust with respect to within-year clustering.

*** Table 2 here ***

On the basis of the KLIPS data, Table 2 reports estimation results of the husband's and the wife's wage functions.[5] Estimated coefficients are generally significant, and their signs coincide with conventional ones. Results show that real wages are more procyclical for men than women. Although this finding is in contrast to women's experience of greater real wage reduction in the US during the Great Recession (Elsby, Shin and Solon, forthcoming), several studies (e.g., Blank, 1989; Solon, Barsky and Parker, 1994; Tremblay, 1990) report men's greater wage procyclicality in the US during the 1970s and 1980s.

Lastly, residuals from estimated equations (7) and (8) are used to estimate stochastic components of couple's wages. Following Attanasio, Low and Sanchez-Marcos (2008), we allow only the permanent component in the error term, which follows an AR(1) process with permanent wage shocks. A couple's permanent shocks have the following joint distribution:

$$\nu^w = \rho^w \nu^w_- + \xi^w,$$
$$\nu^h = \rho^h \nu^h_- + \xi^h,$$

[5]Although test results support endogenous selection of working wives, current findings remain valid even when the OLS results are used for estimating the model without correcting for selection.

$$where \quad \xi = (\xi^w, \xi^h) \sim N(\mu_\xi, \sigma^2_\xi), \tag{9}$$

$$\mu_\xi = (-\frac{\sigma^2_{\xi_w}}{2}, -\frac{\sigma^2_{\xi_h}}{2}), \quad and \quad \sigma^2_\xi = \begin{pmatrix} \sigma^2_{\xi^w} & \rho_{\xi^w\xi^h}\sigma_{\xi^w}\sigma_{\xi^h} \\ \rho_{\xi^w\xi^h}\sigma_{\xi^w}\sigma_{\xi^h} & \sigma^2_{\xi^h} \end{pmatrix}.$$

Table 3 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. While Hyslop (2001) finds positive correlations between couple's permanent wage shocks based on the Panel Study of Income Dynamics data, the estimated correlation becomes smaller in the 2000s (.15) than in 1970s (.57). Compared to U.S evidence (e.g., Heathcote, Storesletten and Violante, 2010; Park and Shin, 2015), permanent wage shocks are much less persistent in the Korean labor market.

*** Table 3 here ***

3.1.4 Other externally determined parameters

We set the per-period interest rate to .07, which corresponds to .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 .935, which corresponds to an annual discount rate of .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.

3.2 Internally Determined Parameters

The remaining set of model parameters are internally determined to match a set of population characteristics described by data (henceforth, target values) with the population characteristics generated by the model. The set of the structural parameters to be estimated includes the relative risk aversion of household consumption (λ), marginal disutility of wife's work (η), and a set of parameters governing childcare production (δ, θ, ϕ, λ, g^1-g^4). Since the model does not have any closed-form solutions for the moments, these ten structural parameters are jointly estimated by the Simulated Methods of Moments (SMM) estimation, which effectively minimizes the distance between the parameter values and the fifteen target moments (empirical moments) presented in Table 4.

*** Table 4 here ***

Formally, let $\boldsymbol{\beta} \equiv \{\gamma, \eta, \delta, \theta, \phi, \lambda, g^1\text{-}g^4\}$. Given internally determined parameters, we obtain 100,000 households for the 1960s cohort, use the model to simulate their life-cycle profiles, and generate the moments which is denoted by $M_m(\boldsymbol{\beta})$. Define $g(\boldsymbol{\beta}) = M_d - M_m(\boldsymbol{\beta})$, where M_d and $M_m(\boldsymbol{\beta})$ are the empirical and the simulated moments, respectively. The SMM minimizes the following function:

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

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

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

where $\hat{G} = \frac{\partial}{\partial\beta} g(\boldsymbol{\beta})|_{\boldsymbol{\beta}=\hat{\boldsymbol{\beta}}}$, and Ω is the variance matrix of the empirical moments. (See Appendix A for the computation algorithm.)

In general, the target values are well-matched with corresponding model-generated moments, implying that the current model explains not only cohort-specific labor supply but also fertility-related behaviors of the 1960s cohort to a reasonable degree.

Various tests are conducted to check robustness of the estimated model. First, following Park (2014), we examine how the estimated model performs in dimensions not directly targeted in the estimation. In particular, we examine how the estimated model explains employment dynamics before and after first childbirth. The results, though not reported for brevity, show that the model-generated employment dynamics and observed dynamics from the KLIPS data are well-matched. Second, we re-estimate the current life-cycle model for the 1970s cohort, and find that the current life-cycle model also explains both labor supply and fertility behaviors of the 1970s cohort. Lastly, we expand the current model by dividing the entire workers between wage and salary workers and the self-employed, and find that all the following analytical results still survive the new exercise.[6]

*** Table 5 here ***

Table 5 summarizes estimated structural parameters. Numbers in parentheses are estimated standard errors, 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 (ϕ) is about .13, which is smaller than the corresponding figure of .7 for the US, suggested by Park (2014).

[6]All these results are available from authors upon request. The population share of the self-employed is particularly large in Korea among OECD countries, at about 25 percent in the 2000s.

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 total fertility rate by the substitutability parameter, ϕ, at values $-\infty$ and in increments of 0.2 from -1 to 1. Age at first birth is inverted U-shaped and TFR is U-shaped. As ϕ increases from minus infinity to 0.4, a typical married woman delays the timing of childbearing to a later stage of the life-cycle and reduces the total number of childbirths at a decreasing rate. Once ϕ becomes greater than 0.4, TFR (age at first birth) increases (decreases) at an increasing rate. Note that because both the number of children and the timing of births are determined endogenously within the model, age at first birth follows the opposite pattern from 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 typical married woman adjusts her life-cycle labor supply to childcare substitutability in the extensive and intensive margins, respectively. In each stage of the life-cycle, per capita employment increases monotonically as ϕ goes up from minus infinity to one. As in the fertility-substitution profile, however, labor supply responds to ϕ in a nonlinear fashion. Roughly speaking, labor supply appears to be a convex function of ϕ 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 increases with ϕ, except among women in their twenties and early thirties. Because of the increase in number of children and the direct care that young children require, women cannot increase their labor hours monotonically with ϕ at this stage.

*** Figure 3 here ***

*** Figure 4 here ***

Put together, Figures 2–4 reveal an interesting labor supply-fertility dynamics over the values of ϕ. When ϕ increases from negative infinity to about 0.4, women on average choose to supply more labor, delay childbearing, and reduce the number of childbirths. As ϕ becomes greater than 0.4, however, additional increase in substitutability between direct and indirect childcare makes women increase both labor supply and fertility at an increasing rate, while giving births at earlier stages of the life-cycle. The finding is observationally equivalent to the change in correlation between female labor force participation and fertility rates observed across countries (refer to Figure 1).

To check for robustness, we re-estimates the current model for the 1970s cohort in Korea and examine whether the changing dynamic correlation of TFR and 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 substitutability exceeds 0.4 (see Appendix B). We confirm this pattern again, using an earlier cohort (1950s) by reproducing Park (2014)'s estimated model for the US sample (Appendix C).[7] A minor difference is that the TFR-FPR correlation turns from negative to positive at a slightly higher level of substitutability, 0.6, in the US.[8] It is also interesting to note that ϕ is estimated to be 0.13, 0.26, and 0.7, for the 1960s cohort in Korea, 1970s in Korea, and the 1950s cohort in the US, respectively. Thus it seems that the US has already entered the phase of positive TFR-FPR relationship, whereas Korea is approaching the threshold level.

4.2 Decomposition

The increase in female employment with substitutability is quite intuitive. With the option of using market childcare, more of mother's time would be freed up for work in the labor market. How 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? And 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 divide women into two groups according to ability—more productive and less productive. More productive women are defined as those who work from their twenties even when ϕ is negative infinity and comprise about 20 percent of the sample, whereas less productive women include all others.

*** Figure 5 here ***

[7] Park (2014)'s model is slightly different from the current one in that her model divides the entire paid market to full-time and part-time sectors. As previously stated, however, we also extend the current model by dividing the paid market to wage workers and the self-employed, and find little difference in the results.

[8] Estimation results of the model for the 1970s cohort in Korea and the 1950s cohort in the US available from authors upon request.

Let us first understand the characteristics of these two groups by observing their average wage (see Figure 5). By construction, average wage of more productive women is the same across all values of ϕ (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 ϕ—they continue to work. Hence, this group allows us to observe behavioral effects absent composition effects. On the other hand, panel C indicates that the average wage of less productive women decreases with ϕ. 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.[9] 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 TFR by ϕ, separately for more and less productive women (panels A and B, respectively). TFR increases with ϕ in all ranges for the more productive group but is U-shaped with ϕ for the less productive group. Age at first childbirth, again, has the mirror image of TFR.

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

The behavioral effect is positive (Figure 6 panel A). 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 and are thus unaffected by changes in substitutability, the sharp decline in TFR from $\phi = -\infty$ to $\phi = -1$ in panel B is attributable to these compliers who trade childbirths for labor supply.

Once ϕ exceeds -1, however, both behavioral and composition effects coexist within the less productive group, and the shape of TFR is determined by the relative strength of the two effects. At low levels of ϕ, composition effects dominate and hence, TFR falls with

[9] Note that average wage is calculated for working women only.

substitutability. At higher levels of ϕ, however, behavioral effects begin to dominate and hence, TFR increase with substitutability. Thus, 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 TFR at low levels of substitutability while raising 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 is the same. Greater substitutability decreases TFR of women selecting into the labor force and increases TFR of women already in the labor force. Consequently, TFR falls then rises as the size of the female labor supply expands.

*** Figure 7 here ***

To examine the specific trade-offs that accompany fertility decisions, we 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 shows that mother's time per child decreases continuously with ϕ at all stages of the life-cycle. 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 difference in mother's time by ϕ is particularly salient among women in their twenties (i.e., mothers of young children). Panel C shows that for ϕ larger than 0, less productive women also decrease per-child mother's time with ϕ. For lower levels of ϕ, however, an increase in substitutability actually increases mother's time per child. This is related to the fact that at lower levels of ϕ, less productive women decrease their number of children with ϕ.

*** Figure 8 here ***

Figure 8 is the other side of the coin—market care expenditure per child. As mentioned in Section 3, market care expenditure rises with women's age in Korea. How market care expenditure changes with ϕ, however, depends on women's productivity. It increases with ϕ for more productive women (Figure 8 panel B) but decreases with ϕ for less productive women (Figure 8 panel C). As childcare becomes increasingly substitutable, productive mothers trade money for work time. 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 into the labor force, their relatively lower market care expenditure dampens the average of this group. That is, even if the behavioral effect of increasing the use of market care when it becomes more substitutable is the same across all women, the composition of women who use market care in the first place changes by ϕ. As a result, we observe the seemingly counterintuitive result of decreasing per-child market care expenditures at greater levels of childcare substitutability (Figure 8 panel A).

5 Implications

There are several important implications that we can draw from the findings. First and foremost, a sufficiently high level of substitutability between direct and indirect childcare can be the "one stone" that kills two birds—TFR and FPR. With population aging and slower economic growth, many developed countries are seeking for measures that can help increase both female labor force participation and fertility rates. The limitation of many existing policy schemes, however, is perhaps in that these two goals are considered separately when household's work and fertility decisions are not. Once it becomes clear that childbirth need not accompany substantial reallocation time away from the labor market, married women would pursue both family and career.

Second, enhancing substitutability may have positive effects on marriage rates. Although we only analyze married couples in this paper, a significant portion of the decline in TFR in developed countries is known to be due to the decline in marriage rates. Particularly in countries like Korea, marriage and fertility decisions are difficult to separate out because cohabitation is rare and out-of-wedlock childbirths comprise less than 2 percent of all childbirths. The (career) costs of childbirth being one of the reasons for avoiding and delaying marriage, increasing substitutability would then help raise TFR through both the intensive (among married couples) and extensive (increasing married couples) margins.[10]

Lastly, notice that the evolution of TFR is not just an increase in the number of children in an average household, but a change in the composition of households that have children. When the elasticity of substitution is low, most productive women do not have children. Increases in substitutability raises the relative portion of children that are born into more productive mothers. If we are concerned about not only the number but also the distribution of children across households, such shifts in composition may be desirable. The fall in women's age at first childbirth at higher levels of ϕ also suggests better health for both mothers and children.

It is thus crucial to understand what the substitutability parameter entails and how it can be increased. As defined in Section 2, ϕ governs the elasticity of substitution be-

[10] Korea's marriage rate has been declining, particularly among highly educated women. Hwang (2015) explains that traditional norms, including placing almost all of the burden of childcare and housework on women, is partly attributable for such phenomenon in developed Asian countries.

tween mother's childcare time and expenditure on market childcare in the household utility function. This means that having many daycare centers is only one component of high ϕ. Because households need to actually consider indirect childcare as being substitutable with mother's time, both quantity and quality of market care matters. Compliance to hygiene and safety standards, qualifications and training of childcare workers, design of early education curriculum, are all examples of the aspects of quality of childcare services.

Furthermore, norms regarding childcare would affect whether mother's time is replaceable with other inputs. According to the most recent 2010–2014 wave 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). Of course, such responses may simply reflect the availability of market childcare per se, but it is also true that most societies still consider the mother to be responsible for childcare. Such family norms invoking mother's guilt constrain mothers from exploiting market childcare even when it is available.

In this context, policies designed to promote gender equity at home and at work can have positive spillovers on childcare substitutability, and thus, FPR and TFR. Although not in the current model, recall that there is another potential provider of childcare—fathers. Family-friendly policies that are more gender-neutral would help alleviate the disproportionate burden of childcare on women by increasing substitutability between mother's and father's time in addition to market care substitutability. Parental leave systems that allow both mother and father to take turns child rearing (rather than "maternity" leave) is one such example. Even in the case in which an increase in mother's working hours is offset by of a reduction in father's working hours, the result would not be zero-sum; fertility rates would increase.

References

Ahn, Namkee, and Pedro Mira. 2002. "A note on the changing relationship between fertility and female employment rates in developed countries." *Journal of Population Economics*, 15(4): 667–682.

Attanasio, Orazio, Hamish Low, and Virginia Sanchez-Marcos. 2008. "Explaining changes in female labor supply in a life-cycle model." *The American Economic Review*, 1517–1552.

Bettio, Francesca, and Paola Villa. 1998. "A Mediterranean perspective on the breakdown of the relationship between participation and fertility." *Cambridge Journal of Economics*, 137–171.

Blank, Rebecca M. 1989. "Disaggregating the effect of the business cycle on the distribution of income." *Economica*, 56: 141–163.

Brewster, Karin L, and Ronald R Rindfuss. 2000. "Fertility and women's employment in industrialized nations." *Annual Review of Sociology*, 271–296.

Castles, Francis G. 2003. "The world turned upside down: below replacement fertility, changing preferences and family-friendly public policy in 21 OECD countries." *Journal of European Social Policy*, 13(3): 209–227.

Caucutt, Elizabeth M, Nezih Guner, and John Knowles. 2002. "Why do women wait? matching, wage inequality, and the incentives for fertility delay." *Review of Economic Dynamics*, 5(4): 815–855.

Dao, Mai, Davide Furceri, Jisoo Hwang, Meeyeon Kim, and Tae-Jeong Kim. 2014. "Strategies for reforming Korea's labor market to foster growth." *IMF Working Paper 14/137*.

Elsby, Michael WL, Donggyun Shin, and Gary Solon. forthcoming. "Wage adjustment in the Great Recession and other downturns: evidence from the United States and Great Britain." *Journal of Labor Economics*.

Eun, Ki-Soo. 2003. "Understanding recent fertility decline in Korea." *Journal of Population and Social Security (Population)*, 1: 574–595.

Feyrer, James, Bruce Sacerdote, and Ariel Dora Stern. 2008. "Will the stork return to Europe and Japan? Understanding fertility within developed nations." *Journal of Economic Perspectives*, 22(3): 3–22.

Galor, Oded, and David N. Weil. 1996. "The gender gap, fertility, and growth." *The American Economic Review*, 86(3): 374–387.

Greenwood, Jeremy, Ananth Seshadri, and Mehmet Yorukoglu. 2005. "Engines of liberation." *Review of Economic Studies*, 72(1): 109–133.

Heathcote, Jonathan, Kjetil Storesletten, and Giovanni L Violante. 2010. "The macroeconomic implications of rising wage inequality in the United States." *American Economic Review*, 118(4): 672–681.

Heckman, James J. 1979. "Sample selection bias as a specification error." *Econometrica: Journal of the Econometric Society*, 153–161.

Hwang, Jisoo. 2015. "Housewife, "gold miss," and equal: the evolution of educated women's role in Asia and the US." *Journal of Population Economics*, DOI: 10.1007/s00148-015-0571-y.

Hyslop, Dean R. 2001. "Rising US earnings inequality and family labor supply: The covariance structure of intrafamily earnings." *American Economic Review*, 91: 755–777.

Kim, Nayoung, Seonyoung Park, and Donggyun Shin. 2015. "Effects of substitutability between mother's child care and market care service on life-cycle labor supply and fertility behavior." *Kukje Kyungje Yongu*, 21(2): 55–91 [in Korean].

Lee, Sam-Sik. 2009. "Low fertility and policy responses in Korea." *The Japanese Journal of Population*, 7(1): 57–70.

Martínez, Dolores Ferrero, and Amaia Iza. 2004. "Skill premium effects on fertility and female labor force supply." *Journal of Population Economics*, 17(1): 1–16.

Olivetti, Claudia. 2006. "Changes in women's hours of market work: The role of returns to experience." *Review of Economic Dynamics*, 9(4): 557–587.

Park, Seonyoung. 2014. "Recent stagnation of married women's labor supply: a life-cycle structural model." *University of Minnesota, Mimeo.*

Park, Seonyoung, and Donggyun Shin. 2015. "Welfare consequences of rising wage volatility: heterogeneity in risk preferences, self-section into risky jobs and effectiveness of insurance measures." *University of Delaware, Mimeo.*

Solon, Gary, Robert Barsky, and Jonathan A Parker. 1994. "Measuring the cyclicality of real wages: how important is composition bias?" *The Quarterly Journal of Economics*, 109(1): 1–25.

Tremblay, Carol Horton. 1990. "Wage patterns of women over the business-cycle." *Quarterly Review of Economics and Business*, 30(1): 90–101.

Tsuya, Noriko O, Larry L Bumpass, and Minja Kim Choe. 2000. "Gender, employment, and housework in Japan, South Korea, and the United States." *Review of Population and Social Policy*, 9: 195–220.

Table 1: Estimated Childcare Cost Function

Dependent variable: $M = \frac{Annual\ childcare\ costs}{Annual\ wife's\ income}$	
Coefficient	Estimate
Constant	.2178
	(.0055)
k^1	-.0117
	(.0069)
k^2	-.0102
	(.0052)
k^3	.0146
	(.0049)
k^4	.0466
	(.0054)
N of obs	5,066

Notes. Sample criteria: working mothers who spend between 5% and 100% of their labor income on market childcare.

Table 2: Estimated Wage Function: Deterministic Component

Coefficient	Estimate
Panel A: Husband	
α_0 (intercept)	5.3173
	(.05856)
α_1 (age)	.0553
	(.0049)
α_2 (age squared)	-.00139
	(.0001)
α_3 (unemployment rate)	-.0871
	(.0049)
N of obs	12,886
Panel B: Wife	
β_0 (intercept)	4.6750
	(.0231)
β_1 (experience)	.0102
	(.0036)
β_2 (experience squared)	-.00023
	(.00021)
β_3 (tenure)	.0432
	(.0034)
β_4 (tenure squared)	-.00071
	(.0002)
β_5 (non-employment duration)	-.0220
	(.0046)
β_6 (non-employment duration squared)	.00034
	(.00029)
β_7 (unemployment rate)	-.03636
	(.0057)
ρ	.0336
	(.0122)
N of obs	7,002

Notes. Data source: KLIPS (1998-2012) work history file. 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 (about 20,000 dollars).

Table 3: Estimated Joint Stochastic Wage Processes of Husbands and Wives

	Husband	Wife
ρ^g (persistency of permanent wages)	.7652	.7455
$\sigma^2_{\xi^g}$ (variance of wage shocks)	.1218	.1776
$\rho_{\xi^w \xi^h}$ (correlation b/w husband's and wife's wages)	.0734	

Notes. See notes to Table 2.

Table 4: Model-Generated Moments vs Empirical Moments

1960s cohort	Model	Data
Per capita employment for women whose ages are b/w[a]		
25–29	.3716	.3534
30–34	.4379	.4213
35–39	.5637	.5591
40–44	.6192	.6022
45–49	.6320	.6193
50–54	.5892	.6004
Per capita employment for women whose children's ages are b/w[b]		
0–4	.2811	.2998
5–9	.3864	.4007
10–14	.4937	.4957
15–19	.5411	.5506
Number of lifetime childbirths[b]	2.071	1.943
Share of non-mothers[b]	.0607	.0437
Share of mothers who have their first birth before age 30[b]	.8214	.8697
Share of mothers who have their first birth after age 34[b]	.0617	.0464
Ratio of male to female labor income[c]	.5728	.5918

Notes. [a]Data source: Economically Active Population Survey (1985.1 ∼ 2013.12). [b]Data source: Korean Census (1995, 2000, 2005, 2010). [c]Data source: Korea Labor and Income Panel Survey (1998-2012).

Table 5: Estimated Structural Parameters

	Parameter	Estimate
Relative risk aversion of consumption	γ	.621
		(.073)
Disutility of wife's work	η	.563
		(.023)
Weight on childcare production	δ	.254
		(.026)
Relative risk aversion of	θ	.406
number of children		(.011)
Relative risk aversion of	λ	.290
quality of children		(.023)
Substitutability b/w mother's time and market care	ϕ	.134
		(.021)
Relative share of mother's time on childcare		
when children's ages are b/w		
0–4	g^1	.563
		(.071)
5–9	g^2	.376
		(.052)
10–14	g^3	.283
		(.034)
15–19	g^4	.234
		(.029)

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

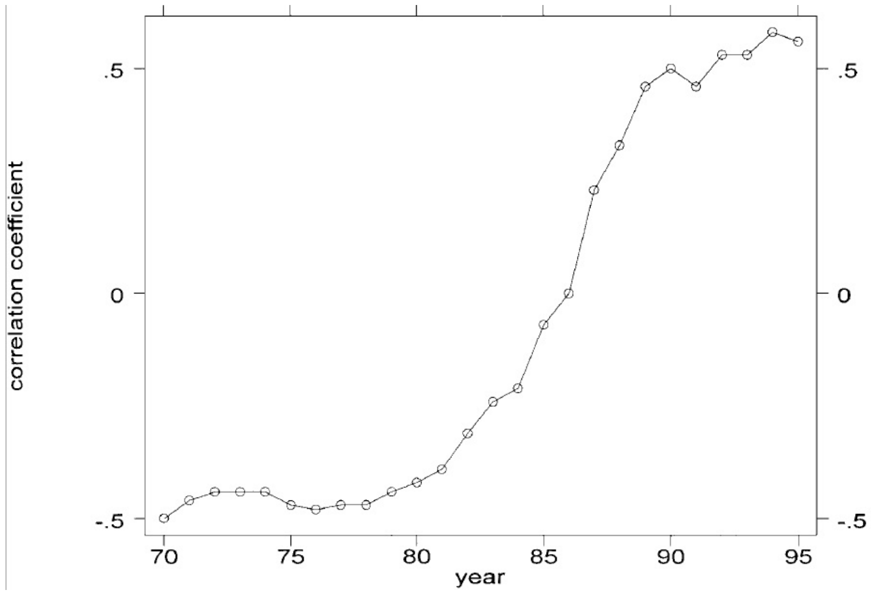


Figure 1: Cross-country Correlation between TFR and FPR

Source. Ahn and Mira (2002) Figure 2.

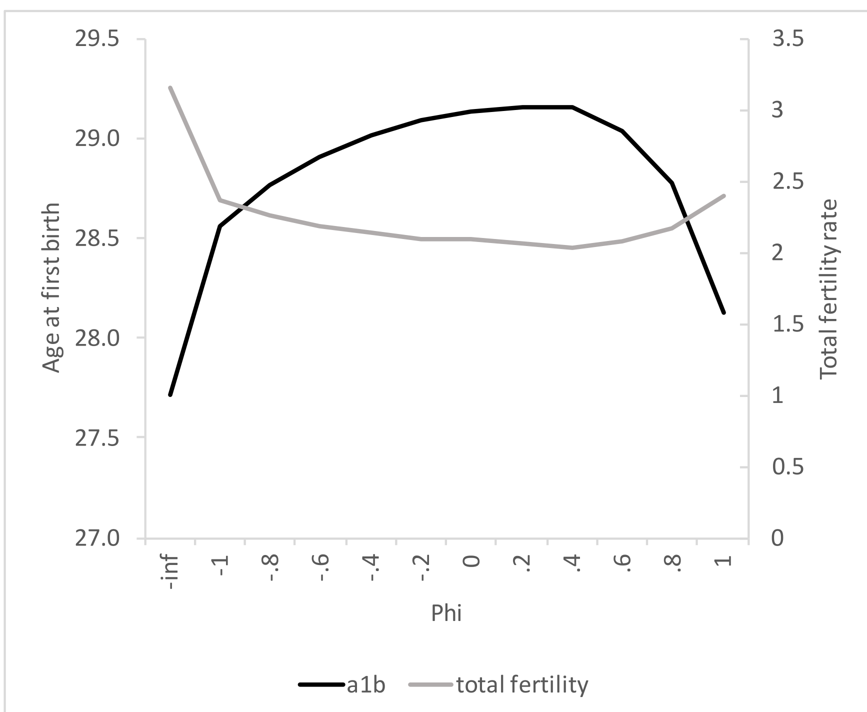


Figure 2: Fertility Behavior by Substitutability, All Women

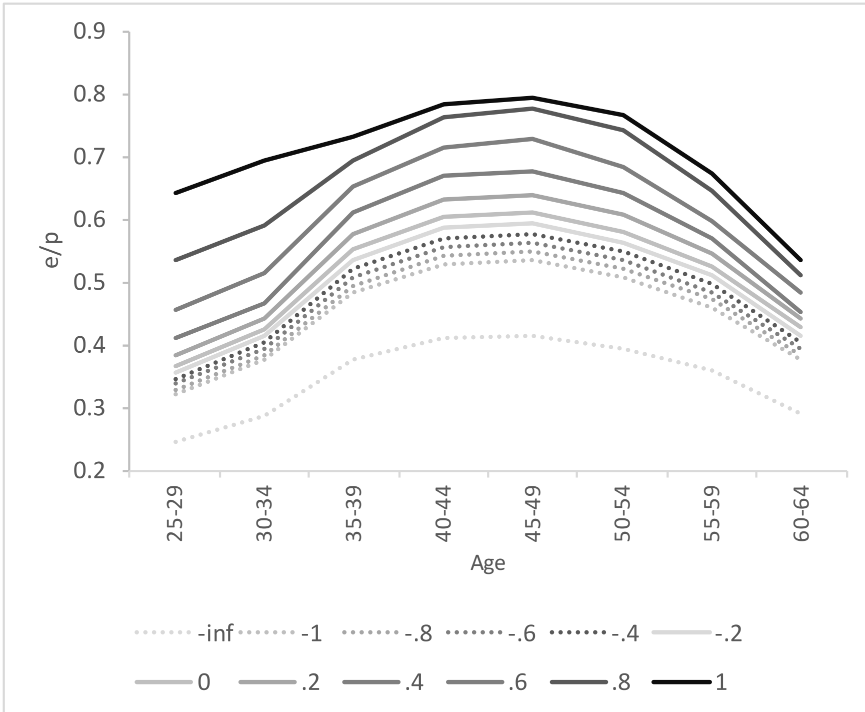


Figure 3: Employment Over the Life-cycle by Substitutability, All Women

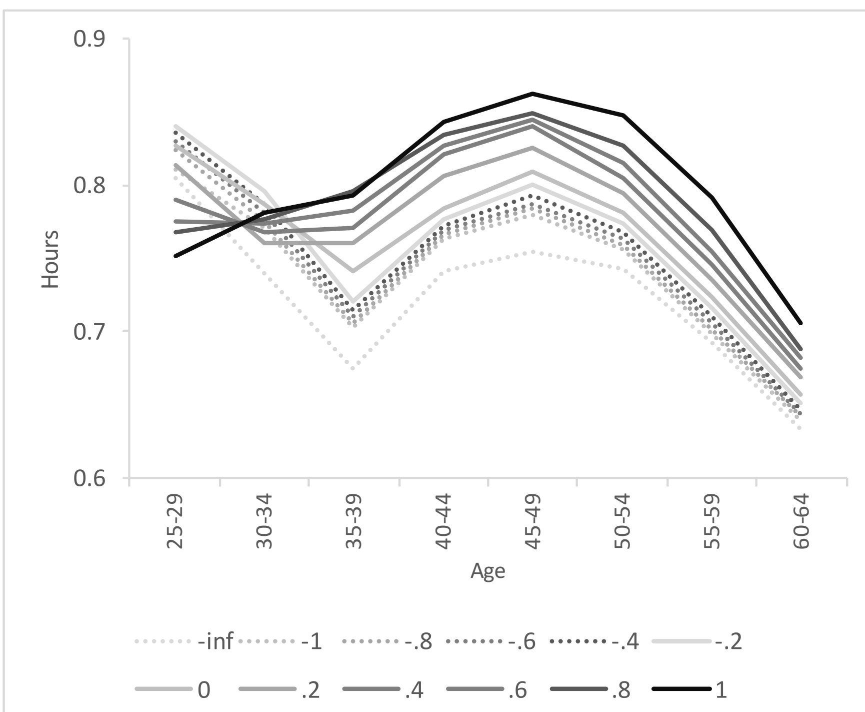
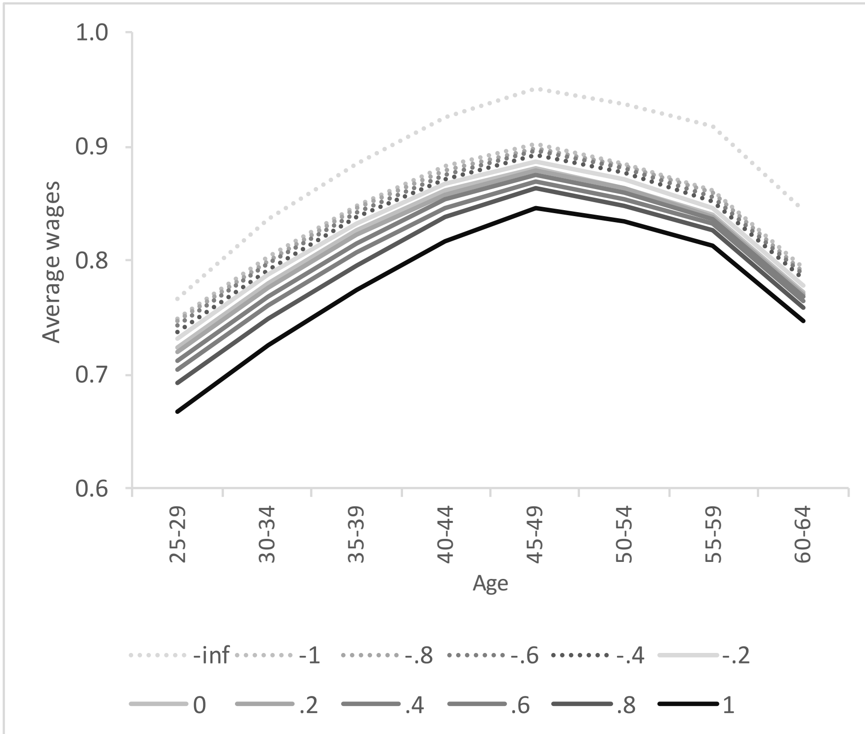
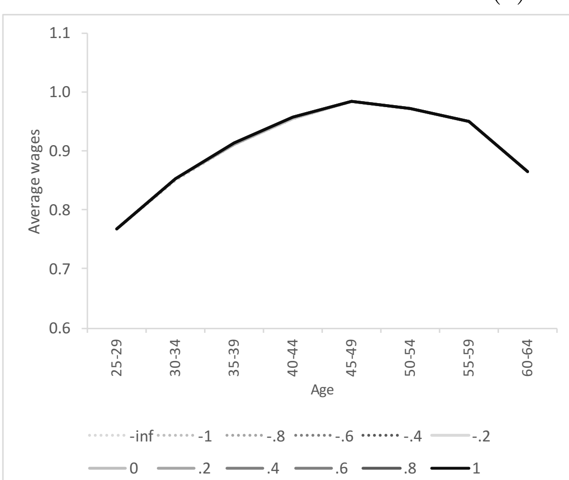


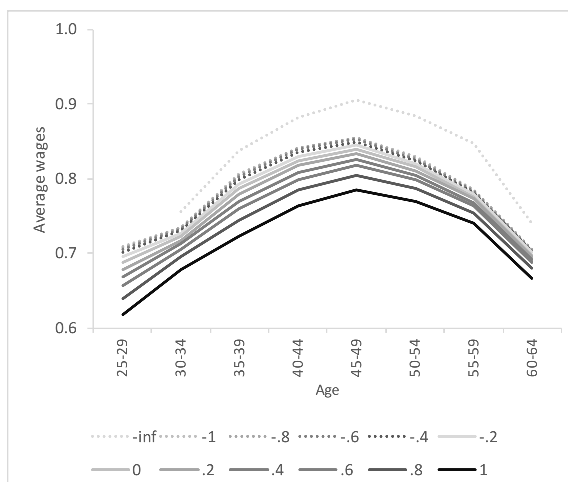
Figure 4: Hours of Work Over the Life-cycle by Substitutability, All Women



(a) All women

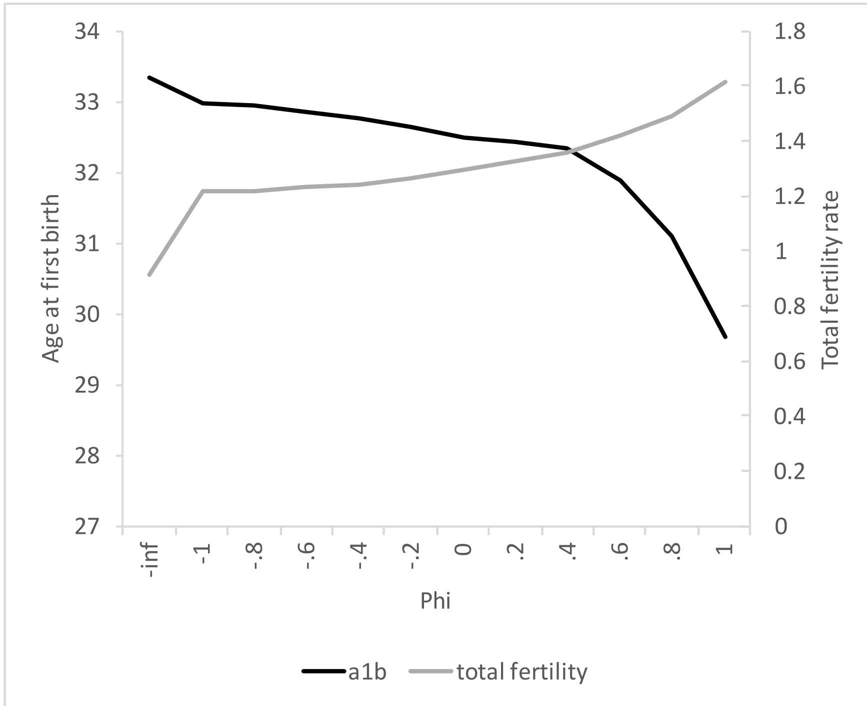


(b) More productive women

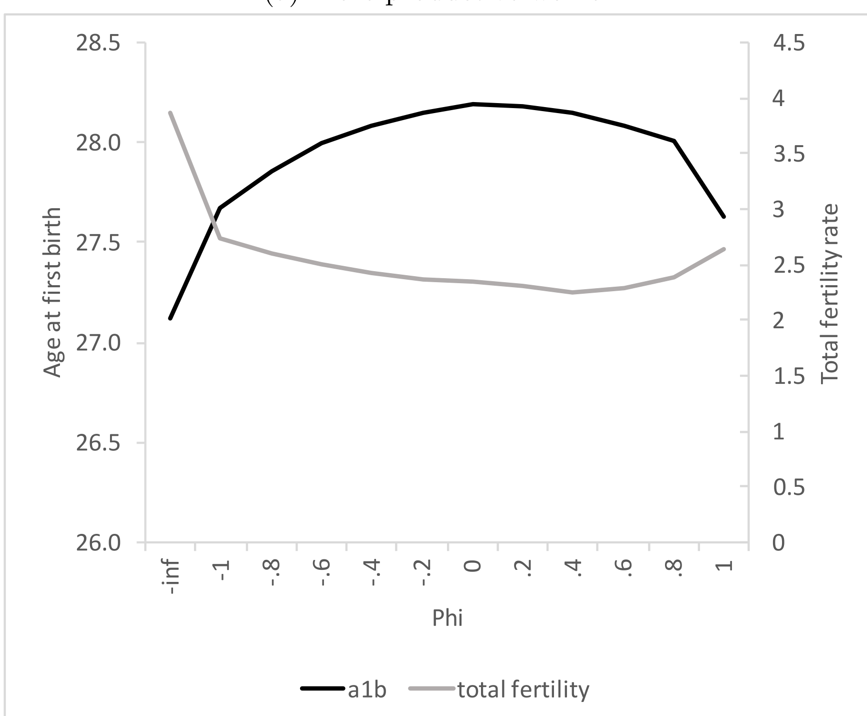


(c) Less productive women

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

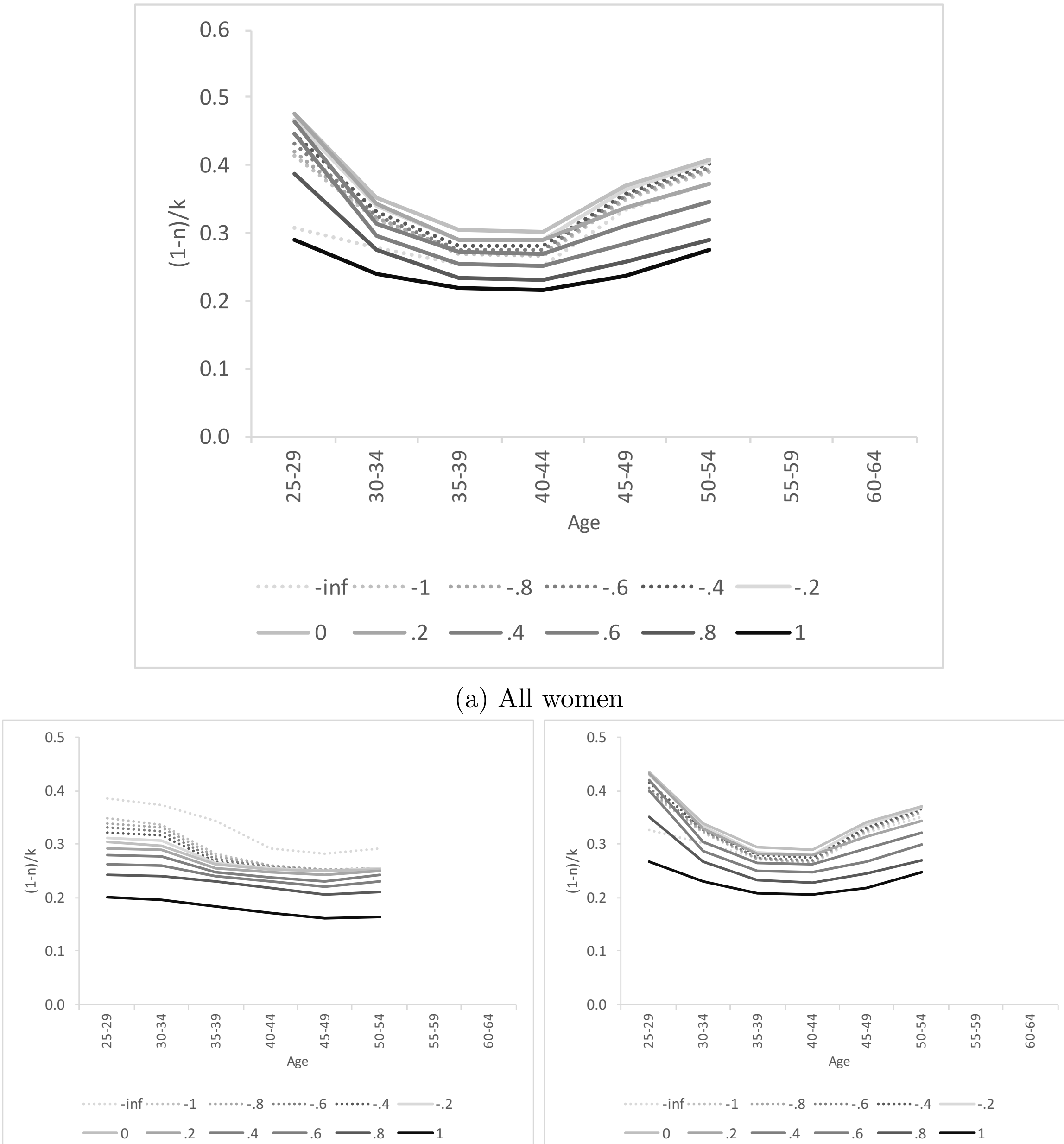


(a) More productive women



(b) Less productive women

Figure 6: Fertility Behavior by Substitutability

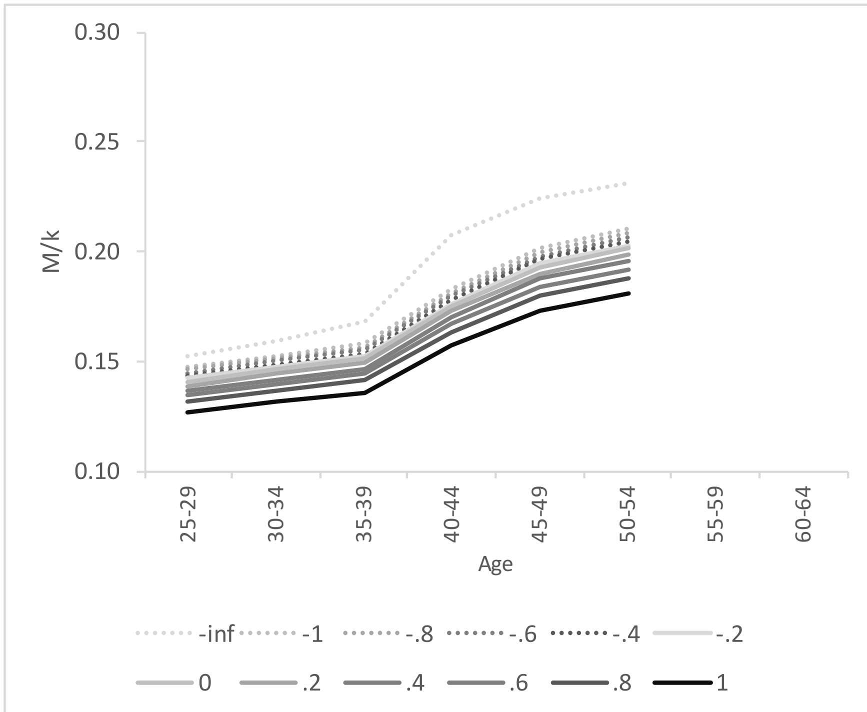


(a) All women

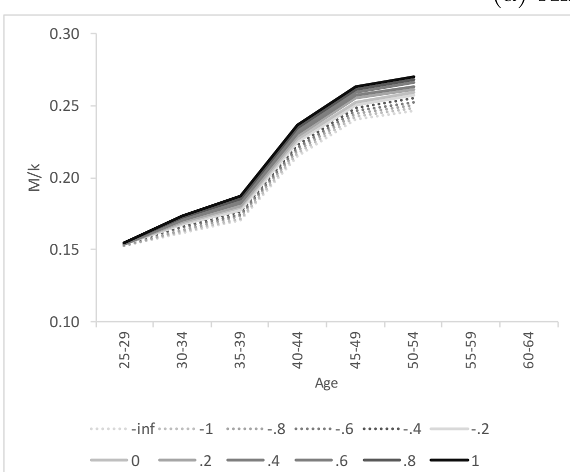
(b) More productive women

(c) Less productive women

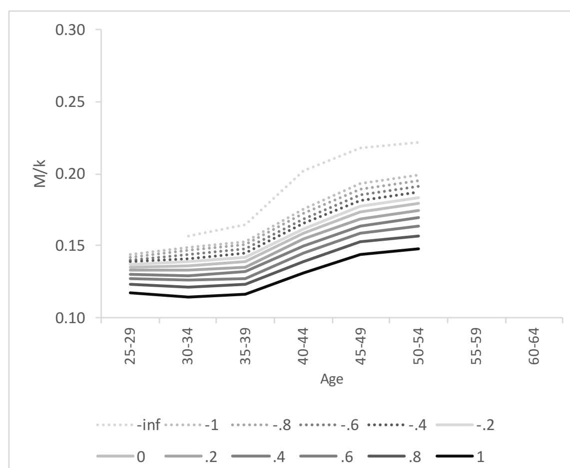
Figure 7: Mother's Childcare Hours Over the Life-cycle by Substitutability



(a) All women



(b) More productive women



(c) Less productive women

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

Appendix

Appendix A Computation

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

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 wife's employment sector and 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 shock; and simulate their decision rules and choice for the wifes employment and fertility by approximating the solutions on a grid.

4. Compare the values of target moments in Table 4 generated in the model with the ones from data. 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

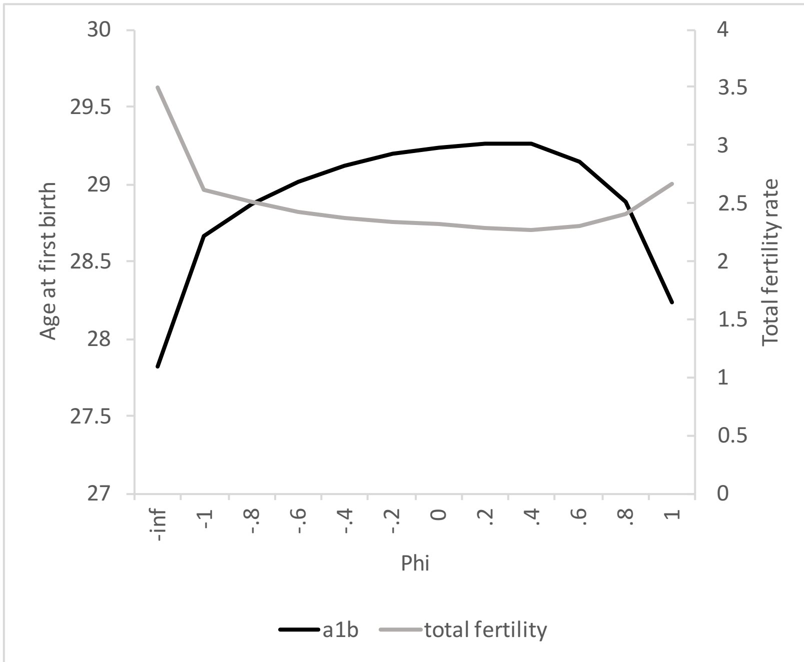


Figure B.01: Fertility Behavior by Substitutability, All Women

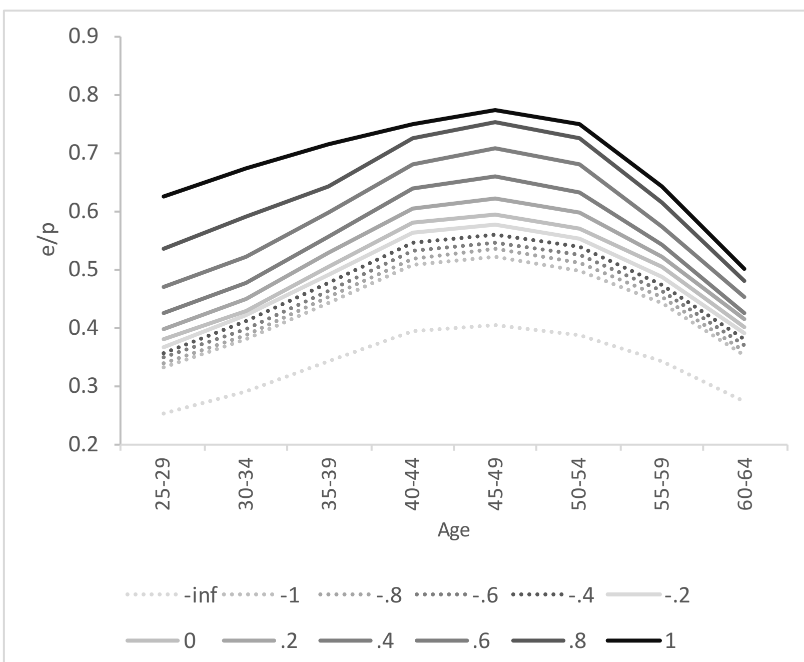


Figure B.02: Employment by Substitutability, All Women

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

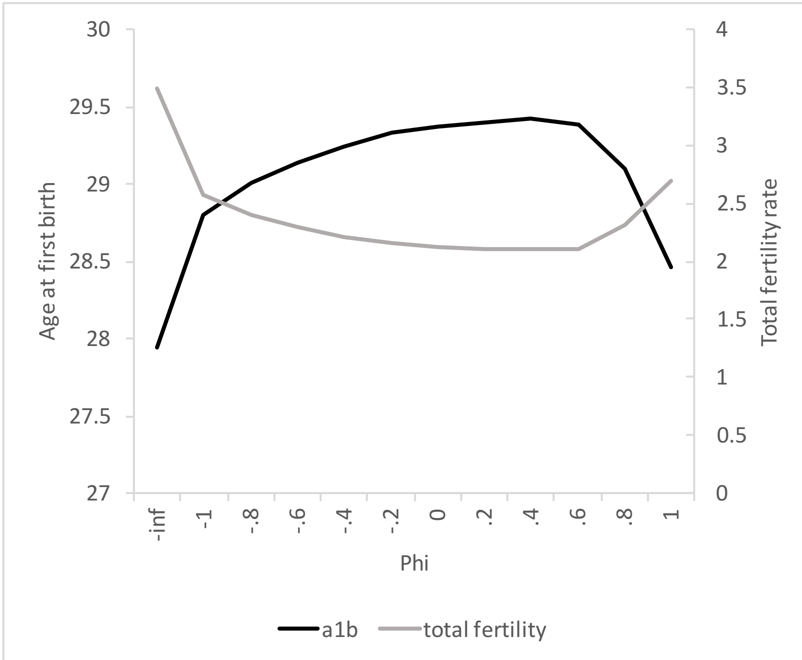


Figure C.03: Fertility Behavior by Substitutability, All Women

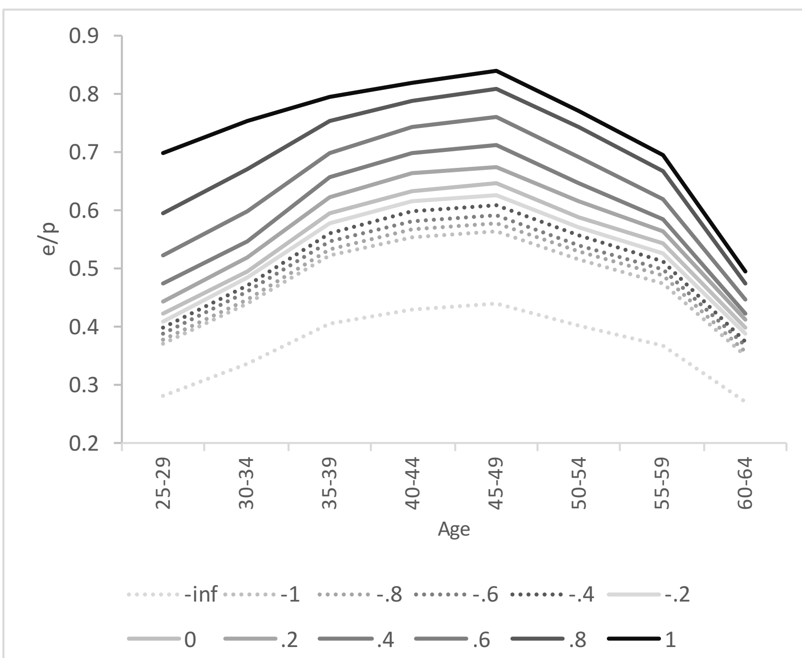


Figure C.04: Employment by Substitutability, All Women