Parental Leave Policies, Fertility, and Labor Supply*

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Abstract

South Korea has been struggling with both low fertility rates and low female hours worked for several decades. Parental leave policies are often regarded as a government instrument to raise both. How successful would these policies be in achieving these objectives in a society featuring relatively strong social norms about the role of women within households and high monetary costs of children? We answer these questions using a quantitative heterogeneous-household life-cycle model in which couples jointly make decisions about fertility, childcare, labor supply, and savings with parental leave options. We calibrate the model to recent Korean cohorts to replicate various patterns of the key variables. We find that a longer duration of unpaid parental leave can raise both fertility and female labor supply in the baseline economy. Importantly, these favorable effects are substantially diminished when we either balance social norms that enforce unequal distribution of childcare responsibilities between genders or reduce the financial burden of private education expenses. Fertility could even decrease with parental leave duration in an economy with low demands for private education.

Keywords: Parental Leave, Birth Rates, Labor Supply, Gender Gaps, Social Norm, Private Education

JEL codes: E24, J22, D13, J13, J16.

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1. Introduction

South Korea (hereafter Korea) has been facing a significant challenge of low fertility rates. As of 2023, the total fertility rate is the world's lowest at 0.78, having remained below one since 2018. Moreover, Korea grapples with low female labor supply despite persistently low birth rates. According to the World Bank, the female labor force participation rate (of the female population aged 15 or above) has been slightly above 50% for the last two decades, as compared to the male counterpart of around 75% during the same period. The Korean government perceives parental leave as a major policy tool to address these challenges (Kim and Lundqvist, 2023), and began to encourage it in recent years.

How effective parental leave policies would be in enhancing fertility rates and increasing female labor force participation. What are the mechanisms behind the policy effects if successful or not? While there is quite a sizeable body of literature that empirically estimates the effects of parental leave policies on fertility (Dahl et al., 2016; Malkova, 2018; Farré and González, 2019; Raute, 2019) and female labor supply (Lalive and Zweimüller, 2009; Kleven et al., 2020) typically exploiting a specific reform in European countries, the literature lacks quantitative theoretical analysis on parental leave, as highlighted by Doepke et al. (2023). In this paper, we provide a structural analysis of parental leave policies that allows us to investigate these questions. In particular, our quantitative analysis is applied to Korea, an interesting and notable example of East Asian countries featuring high gender gaps and high monetary costs of children, due to private education expenditures (Kim et al., 2023), in contrast to European countries.

Our model explicitly allows couples to make joint decisions regarding labor supply and parental leave while considering their future career prospects in an otherwise standard lifecycle model of endogenous fertility. We distinguish and endogenize choices of husbands and wives to enable us to investigate the effects of parental leave on gender gaps while allowing males to also change their labor supply.[1] The fertility block of the model follows the tradition of Becker and Tomes (1976) such that parents value both the quantity and quality of children. As in Sommer (2016)'s lifecycle model of fertility, our model includes various features that allow fertility choices in the model to be in line with the data in terms of both timing of births and completed fertility. These include the childcare requirement for a newborn as well as parents' concern for the quality of children, both of which require monetary resources and time from parents. In particular, we would like our model to generate high demands for expensive private education, as observed in the data.

[1] In the data, male labor supply has been declining over time in Korea as in other countries (Boppart and Krusell, 2020). We are in line with the recent papers (Bick and Fuchs-Schündeln, 2017; Borella et al., 2022; Erosa et al., 2022; Guner et al., forthcoming) in highlighting the importance of modelling joint decision-making within a couple, despite heavy computational burdens.

A key decision we newly introduce to the model is the parental leave choice by a husband and a wife. We consider several key benefits and costs of parental leave that can be incorporated parsimoniously into the model. The key benefits include additional parental time that can be allocated for children subject to social norms about their unequal gendered division, which are more prevalent in East Asian societies (Hwang et al., 2019; Myong et al., 2021). Moreover, parental leave provides job security by allowing the parent to maintain the match-specific productivity shock when returning from the leave. On the other hand, we model the costs of taking parental leave (on top of having various costs of a child per se, as specified above) in two ways. First, since there are dynamic returns to current labor supply in the spirit of Imai and Keane (2004), parents expect that career prospects will be adversely affected when taking a longer duration of parental leave. Second, labor income is reduced although this reduction is mitigated by the replacement benefits of parental leave.

We assume dual labor markets with two types of jobs (permanent versus temporary) (e.g., Guner et al., 2023) and assume that the option of parental leave is only available to workers who hold a permanent job. Permanent jobs offer multiple advantages such as better wages, job security, and promotion opportunities, as compared to temporary jobs. However, these jobs are costly to enter and importantly require long hours worked, unlike temporary jobs. Our model also includes borrowing constraints and incomplete asset markets, as young and relatively low-income households often face borrowing constraints (Caucutt and Lochner, 2020), which may hinder fertility choices especially when potential parents anticipate high monetary costs of having children.[2]

We calibrate the model using longitudinal data from women born between 1965 and 1974 and their family members in the Korean Labor and Income Panel Study (KLIPS) survey data. Our calibrated model successfully replicates observed patterns in wages, job types, and fertility choices over the life-cycle for both female and male members of households. Most notably, social norms with help of the estimated gender gaps in career dynamics endogenously lead to a positive gender wage gap even among the young females without any child, which is comparable to the data counterpart, in the absence of other exogenous female-specific wage penalties.

We find that a longer duration of unpaid parental leave can raise both fertility and female labor supply. For example, the presence of maximum two quarters of unpaid parental leave raises female labor supply by 3.4% while reducing male labor supply by 1.7%, thereby closing the gender gap in labor supply. The positive effect on labor supply is much more pronounced among the young women (a 4.4% increase) but it fades out for the older women

[2]Choi (2017) also highlights the importance of asset heterogeneity for fertility decisions. As such, our quantitative approach is different from Yamaguchi (2019) who estimates a discrete choice model of female labor supply and parental leave take-up, yet abstracts from a joint decision of couples, wealth heterogeneity through savings and government budget constraints—the key ingredients of our model framework.

(a 2.1% increase). The completed fertility rate would increase also by 1.2%.

We then conduct the same policy experiments in the economy where we remove social norms about unequal gender division of childcare. We find that the above positive effects in the baseline economy are much dampened. For example, with two maximum quarters of unpaid parental leave, gender gaps in labor supply is closed by 0.8 percentage points (as compared to 2.7 percentage points in the baseline economy), and the fertility increases only by 0.3%. We also investigate the role of high demands for costly private education by re-running the policy exercises in the economy which features less demands for private education. We find that the positive effects of parental leave duration on female labor supply are considerably mitigated also in this case. More notably, we find that the fertility would actually decline in response to a longer parental leave duration in this economy. The above findings are interesting since Kleven et al. (2020) find that substantial changes in family policies such as parental leave have had little effect on the convergence of gender gaps in Austria, a country with more equal societal perception on women's roles and lower demands for private education.

As highlighted by Doepke et al. (2023), the literature lacks quantitative theoretical analyses of parental leave. Erosa et al. (2010) is an exception who focuses on welfare implications with the bargaining aspects of parental leave being the key mechanism. Our quantitative focus on mechanisms highlighting couples' joint labor supply and career concerns over the life-cycle (Borella et al., 2022; Guner et al., forthcoming) and various dimensions of parental leave policies is new and thus distinguish our work from Erosa et al. (2010). As key decision variables are fertility and labor supply, our paper is also related to quantitative studies that employ rich structural models of endogenous fertility and labor supply, yet without parental leave decisions (see e.g., Kitao and Nakakuni (2023) and Guner et al. (2023) for recent papers and Doepke and Tertilt (2016); Doepke et al. (2023) for literature reviews).

Along the way to the convergence of gender gaps (Goldin, 2014), many developed countries have introduced family-friendly policies, including parental leave (Olivetti and Petrongolo, 2017). However, empirical evidence on the effects of such policies on gender gaps in labor markets and fertility is somewhat mixed (see e.g., Lalive and Zweimüller (2009); Dahl et al. (2016); Malkova (2018); Farré and González (2019); Raute (2019); Kleven et al. (2020) and also Doepke et al. (2023) for an overview on the literature). This might be because the channels behind the policy effects could depend on societies' prominent characteristics such as social norms and education fever in East Asia (Kim and Lundqvist, 2023). Thus, our rich theoretical framework can shed light on the empirical uncertainty by providing economic mechanisms that are important in shaping fertility and labor supply effects of parental leave.

This paper is organized as follows. Section 2 presents a quantitative life-cycle model. In Section 3, we explain how we parameterize and calibrate the model, and present the model fit. Section 4 conducts quantitative exercises. Section 5 concludes the paper.

Table 1: Model Period and Household (HH) Structures

Age	25	27	...	43	45	...	55	57	...	79
$j =$	1	2	...	10	11	...	16	17	...	28
Note:	Fertile (stochastic)				Infertile			Retire (no endog. LS)		
	Live with children				Children may leave			No children in HH		

2. Quantitative Model

This section presents the life-cycle model that we use to conduct quantitative exercises.

2.1. Model Environment

The model introduces a dual labor market system, consisting of permanent and temporary jobs, with parental leave options available exclusively to permanent jobholders. Parental leave is seen as a way to alleviate childcare constraints and financial burdens, encouraging parents to have children. In Korea's relatively rigid labor market for middle-aged and older individuals, parental leave also provides the option to return to the same job after the leave, preventing potential future wage losses. The model accounts for dynamic returns to current labor supply, especially for female concerned about their future careers, and considers parents' concerns about the quality of their children's education, influenced by social norms regarding within-household childcare responsibilities. These features allow for a comprehensive analysis of the impact of parental leave policies on fertility and labor supply choices, with a focus on the Korean context.

Households, preference, and period. A household, or a married couple, is composed of a women and a men, indexed by $g = f$ and m, respectively. The household enjoys having children and cares about the number and quality of their children.

Households enter the model at the model age $j = 1$, which corresponds to age 25. A period corresponds to two years, and the overview of the age structure is shown in Table 1. Before retirement at $j = 17$, each member of households makes a joint decision on work choices: job types (s_f, s_m) which can be a permanent P or temporary T job. Depending on the job, the choice set for hours differs as detailed below. Given the labor supply choice (h_f, h_m), households then make a standard consumption-savings choice. In the retirement periods (i.e., for all $j \geq 17$), both members do not work. At the beginning of each period $j = 1, 2, ..., 10$, households can choose to increase their number of children by one or not if they turn out to be fertile, which is governed by the probabilities π_j (details are provided below).

Parents allocate their time to their children, and the amount of parental time they can provide decreases as their working hours increase. However, it increases with both non-infant children (n) and infant children ($\tilde{n} - n$), where $\tilde{n}$ denotes the total number of children in the household. This allocation can be expressed as:

$$\lambda_g(\bar{h} - h_g)n^{1-\psi} + \lambda_g(\bar{h} - h_g)(\tilde{n} - n), \tag{1}$$

where $\bar{h}$ represents the time endowment, and h_g represents the hours worked by parent g. In the first part of the equation, the parameter ψ governs the returns to scale in parenting non-infant children, with values between 0 and 1 indicating the presence of scale economies. Consequently, the parental time allocated per non-infant child is given by $\lambda_g(\bar{h} - h_g)/n^{\psi}$. In the second part of equation, the number of infant children ($\tilde{n} - n$) is 0 or 1 in our model, implying that childcare time per infant child is $\lambda_g(\bar{h} - h_g)$ when the household has a newborn in a period. This equation captures how parents' allocation of time to childcare depends on various factors, including the number of children, their age, and parental working hours.

Additionally, we incorporate social norms in equation (1). The parameter λ_g represents societal norms related to parenting children. The condition $\lambda_m \leq \lambda_f$ indicates that these norms dictate that mothers typically allocate more time to parenting compared to fathers. This reflects the influence of societal expectations on gender roles in childcare responsibilities.

Per-period utility also increases with household consumption ($u(\cdot)$), the number of non-infant children, and their quality ($\phi(\cdot, \cdot)$), but it decreases with hours worked and parental time for each member, captured by the function $v_g(\cdot)$:

$$u(c/\Lambda(\tilde{n})) + \phi(n, q) - \sum_g v_g(\tilde{h}_g), \tag{2}$$

where q represents the (average) quality of non-infant children. The working and parental time is $\tilde{h}_g = h_g + \lambda_g(\bar{h} - h_g)[n^{1-\psi} + (\tilde{n} - n)]$. The utility increases with the total household consumption c divided by the household equivalence scale, denoted as $\Lambda(\tilde{n})$.

Careers: Jobs and Promotion/Demotion. In our model, a fundamental distinction lies in the choice between permanent and temporary employment, a pivotal factor that shapes household decisions and life-cycle outcomes. In each period, non-retired couples face a critical decision: whether to participate in the workforce and, if so, which job type to pursue (s_g)—permanent (P) or temporary (T) (e.g., see Guner et al., 2023).

The permanent job ($s_g = P$) requires long working hours, denoted as $\mathcal{H}_P = \{\underline{h}_P, .., \bar{h}\}$, but offers a wage premium relative to the temporary job. At the end of each period, there is a probability of promotion/demotion, which increases with the current level of labor supply, following the approach similar to Jang and Yum (2022). Individuals who receive promotions

($\chi_g = 2$ from $\chi_{g,-1} = 1$) reap the benefits of higher wages in the subsequent period. It is essential to note that the option of parental leave is exclusively available to those engaged in permanent employment, and we will discuss this in more detail.

In contrast, the temporary job ($s_g = T$) imposes no minimum working hour requirements, allowing flexibility within the range $h_g \in \mathcal{H}_T = 0, .., \bar{h}$. Regrettably, parental leave is off the table, and the prospects of job promotion are non-existent; individuals in temporary roles invariably maintain $\chi_g = 1$. Temporary workers also grapple with the uncertainty of a match-specific shock z_g, where z_g is log-normally distributed with parameters $(0, \sigma^2_{z,e})$. On the other hand, permanent workers carry over a match-specific shock ($z_{g,-1}$) from the previous period with a certain probability, denoted as $\varrho \in (0, 1]$. With probability $1 - \varrho$, they draw a new match-specific shock z_g and face uncertainty. For convenience, we introduce the match quality shock $\tilde{z}_g$ and m_g by

$$\tilde{z}_g = \mathcal{I}(s_{g,-1} = s_g = P) \left[m_g z_{g,-1} + (1 - m_g) z_g \right] + \left[1 - \mathcal{I}(s_{g,-1} = s_g = P) \right] z_g \tag{3}$$

where m_g is a Bernoulli random variable representing the chance that a worker can keep their job quality $z_{g,-1}$ when they work a permanent job consecutively ($m_g = 1$). The level of ϱ reflects job security, with higher values indicating greater job stability.

While the permanent job offers the potential for promotion, job security, a wage premium, and eligibility for parental leave, temporary workers must pay entry costs to transition into a permanent job. At the beginning of each period, Moreover, temporary workers enjoy a degree of flexibility when it comes to choosing their working hours, a distinction from their permanent counterparts.

Children. At the beginning of each period, fertility shocks are realized. Fertile period households have a chance to have an additional child with probability π_j depending on age. With probability $1 - \pi_j$, they cannot have a new child while their age is between 25 and 43 (fertile period). At the end of each non-fertile period, non-infant children leave household stochastically.

There are two types of costs related to having a child. First, during the infant stage, childcare requires parental time contributions from parents ($\sum_g \lambda_g(\bar{h} - h_g)$), that can be non-perfectly substituted by market goods (x_b, i.e., childcare monetary spending) with constant elasticity. When there are n non-infant children in a household, the cost of caring for a newborn child is given by:

$$\eta \leq \left\{ \nu \left(x_b \right)^{\rho} + (1 - \nu) \left[\sum_g \lambda_g (\bar{h} - h_g) \right]^{\rho} \right\}^{\frac{1}{\rho}} \tag{4}$$

where the parameter η represents a degree of childcare burden.

Children are also costly beyond the infant stage. In particular, Korean students attend various after-school private education programs that are quite expensive with the participation rate being very high (at around 75%, Kim et al., 2023). To capture the financial and time burdens on the parents, the quality per non-infant child is an increasing function of education expenditure (x_q) and parental time per non-infant child. This is described by the following equation:

$$q = \underline{q} + x_q^{\alpha} \left[\sum_g \frac{\lambda_g(\bar{h} - h_g)}{n^{\psi}} \right]^{1-\alpha}, \tag{5}$$

where the parameter $\underline{q}$ represents the minimum quality of a child's education, indicating the baseline quality level that can be achieved without any additional education spending.

Parental leave. We introduce three government policy variables: maximum parental leave lengths ($\bar{l}_g$), the wage replacement rate (θ), and the cap on benefits ($\bar{\Theta}$).

In our model, individuals gain several advantages when they opt for parental leave from an individual perspective. First, it allows them to reduce the burden of childcare by working fewer hours. Second, parental leave provides employment protection. During a fertility period, taking parental leave helps individuals maintain their current permanent job position. In our model, parental leave reduces the required working hours for permanent jobs, specifically $\underline{h}_P$ of $\mathcal{H}_P = \underline{h}_P, \ldots, \bar{h}_P$. Consequently, it enables permanent job workers to spend more time with their infant child, enjoy a wage premium in the current period, and avoid entry costs associated with transitioning to a permanent job in the future.

However, despite the benefits mentioned above, parental leave comes with its challenges. It necessitates working full-time in the last year, and the monetary compensation during leave is lower than the full salary (depending on the replacement rate, $\theta \in [0, 1]$, and cap $\bar{\Theta} \in [0, \infty)$) in the current period. Additionally, taking parental leave can have long-term implications for an individual's career, including reduced probabilities of promotion and increased probabilities of demotion in the future.

2.2. Recursive Problems

Fertile periods. In model periods $j = 1, ..., 10$, fertility is a choice variable provided that fertility shock (π_j) is favorably realized. Denote the value of having a new-born and of no additional child by $\bar{N}(a, n, \mathbf{s}_{-1}, \chi, \mathbf{z}_{-1}, \mathbf{e}, j)$ and $\bar{V}(a, n, \mathbf{s}_{-1}, \chi, \mathbf{z}_{-1}, \mathbf{e}, j)$, respectively, which depend on a household's asset (a), number of non-infant children in household (n), current job situation ($s_g \in \{T, P\}$), last-period job match quality ($\tilde{z}_{g,-1}$), and education ($e_g \in \{1, 2\}$, 2 means high education and 1 low education). Note that the current job situation was determined by the previous period. We express the choice problem by the following value function:

$$W(a,n,\mathbf{s_{-1}},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) = \pi_j \max\left\{\underbrace{\bar{N}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j)}_{\text{value of having a new-born}}, \underbrace{\bar{V}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j)}_{\text{value of no additional child}}\right\} + (1-\pi_j)\bar{V}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j). \tag{6}$$

The value of having another child is

$$\bar{N}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) = \mathbb{E}_\xi \max_{\mathbf{s}} \left\{\bar{N}_{\mathbf{s}}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) - \sum_g \xi_g \mathcal{I}(s_g = T, s_g = P)\right\}_{s_g\in\{T,P\},g=f,m}, \tag{7}$$

which depends on the previous and current job choices: $s_{g,-1}$ and $s_g \in \{T,P\}$. Equivalently,

$$\bar{N}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) = \mathbb{E}_\xi \max\left\{\begin{array}{l} \bar{N}_{PP}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) - \sum_g \xi_g \mathcal{I}(s_{g,-1}=T), \\ \bar{N}_{PT}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) - \xi_f \mathcal{I}(s_{f,-1}=T), \\ \bar{N}_{TP}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) - \xi_m \mathcal{I}(s_{m,-1}=T), \\ \bar{N}_{TT}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) \end{array}\right\}. \tag{8}$$

The value of choosing the job choice ($\mathbf{s} = [s_f, s_m]$) before drawing the match quality shock $\tilde{z}_g$ (m_g and z_g) is

$$\bar{N}_{\mathbf{s}}(a,n,\mathbf{s}_{-1},\chi,\tilde{\mathbf{z}}_{-1},\mathbf{e},j) = \mathbb{E}_{\tilde{\mathbf{z}}} N_{\mathbf{s}}(a,n,\chi,\tilde{\mathbf{z}},\mathbf{e},j). \tag{9}$$

For given the job choice (s) after the realization of the match quality shock, the value of having another child is

$$N_{\mathbf{s}}(a,n,\chi,\tilde{\mathbf{z}},\mathbf{e},j) = \max_{\substack{c,a',x_b,x_q\geq 0 \\ l_g\in\{0,\ldots,\bar{l}_g\}\times\mathcal{I}(s_g=P) \\ h_g+l_g\in\mathcal{H}_{s_g}}} \left\{\begin{array}{l} u(c) - \sum_g v_g(\tilde{h}_g) + \phi(n,q) \\ +\beta\mathbb{E}_{n'}\sum_{\chi'}\pi_g(\chi'|\chi,\mathbf{s},\mathbf{l})W(a',n',\mathbf{s},\chi',\tilde{\mathbf{z}},\mathbf{e},j+1) \end{array}\right\} \tag{10}$$

subject to equations (4) and (5), as well as

$$c + x_q n + x_b + a' = (1-\tau)\sum_g w_g\left(h_g + l_g \max\{\theta, \bar{\Theta}/w_g\}\right) + (1+r)a + Tr \tag{11}$$

$$w_g = \omega_{e_g,g,j}\gamma_\chi \tilde{z}_g,\ g = f,m \tag{12}$$

$$n' \sim B(n+1,p), \tag{13}$$

where the parameter ς governs mother's penalty from birth in labor markets. Also, the total working and parental time is given by $\tilde{h} = h_g + \lambda_g(\bar{h} - h_g)(n^{1-\psi} + 1)$.

Non-fertile periods. In non-fertile periods, fertility is not a choice variable. In the beginning of the period, households decide whether to work a Permanent job (P) or Temporary (T) jobs. If they worked a Temporary job ($s_g = T$) in the previous period, but would like to work a Permanent job, they would need to pay an entry cost ξ_g:

$$\begin{aligned} &\bar{V}(a, n, \mathbf{s}_{-1}, \chi, \tilde{\mathbf{z}}_{-1}, \mathbf{e}, j) \\ &= \mathbb{E}_\xi \max_{\mathbf{s}} \left\{ \bar{V}_{\mathbf{s}}(a, n, \mathbf{s}_{-1}, \chi, \tilde{\mathbf{z}}_{-1}, \mathbf{e}, j) - \sum_g \xi_g \mathcal{I}(s_{g,-1} = T, s_g = P) \right\}_{s_g \in \{T,P\}, g=f,m} \end{aligned} \tag{14}$$

Similar to fertile periods, the expected value of both working the permanent job before drawing the shock $\tilde{z}_g$ is

$$\bar{V}_{\mathbf{s}}(a, n, \mathbf{s}_{-1}, \chi, \tilde{\mathbf{z}}_{-1}, \mathbf{e}, j) = \mathbb{E}_{\tilde{\mathbf{z}}} V_{\mathbf{s}}(a, n, \chi, \tilde{\tilde{\mathbf{z}}}, \mathbf{e}, j). \tag{15}$$

The value of working s_g job after realization of $\tilde{z}_g$ is

$$V_{\mathbf{s}}(a, n, \chi, \tilde{\mathbf{z}}, \mathbf{e}, j) = \max_{\substack{c, a', x_b, x_q \geq 0 \\ h_g \in \mathcal{H}_{s_g}}} \left\{ \begin{array}{l} u(c) - \sum_g v_g(\tilde{h}_g) + \phi(n, q) \\ + \beta \mathbb{E}_{n'} \sum_{\chi'} \pi_g(\chi' | \chi, \mathbf{s}) \bar{V}(a', n', \mathbf{s}, \chi', \tilde{\mathbf{z}}, \mathbf{e}, j+1) \end{array} \right\} \tag{16}$$

subject to equation (5) as well as

$$c + p_q x_q n + a' = (1 - \tau) \sum_g w_g h_g + (1 + r)a + Tr \tag{17}$$

$$w_g = \omega_{e_g, g, j} \gamma_\chi \tilde{z}_g, \ g = f, m \tag{18}$$

$$n' \sim B(n, p), \tag{19}$$

where $\tilde{h} = h_g + \lambda_g(\bar{h} - h_g)n^{1-\psi}$.

Retirement periods. The household optimization problem becomes simplified during retirement periods, specifically for $j = 19, ..., 28$, as there is no labor supply and no children in the household. The value after retirement can be expressed as:

$$R(a, \chi, \mathbf{e}, j) = \max_{c, a' \geq 0} \left\{ u(c) + \beta R(a', \chi, \mathbf{e}, j+1) \right\} \tag{20}$$

subject to

$$c + a' = \sum_g P(\chi_g, e_g) + (1+r)a, \tag{21}$$

where $P(\chi_g, e_g)$ represents pension income.

3. Parameterization and Calibration

We calibrate the model to the cohort of Korean households with female born between 1965 and 1974. The calibration proceeds in two steps. First, some parameter values are chosen externally based on direct data analogs, the literature, or simple normalization, as summarized in Table 2. Second, the remaining parameters are chosen to match relevant data moments. We also compare the model's predictions along several non-targeted dimensions.

We will begin with some preliminary information. We set the maximum number of children equal to three, which means that households can have either 0, 1, 2, or 3 children ($n \in \{0, 1, 2, 3\}$). This choice is based on the observation that the proportion of households with more than three children is very small.

For the discretization of working time, we use $h_g \in \{0, 1, 2, ..., 8\}$, where the maximum working time is $\bar{h} = 8$. This means that for $h_g = 1, 2, ..., 7$, the working time corresponds to $9 \times (h_g - 1, h_g]$ hours per week. In our model, the minimum required working time for a permanent job is $\underline{h}_P = 4$, implying that the permanent job requires more than 27–36 hours of work per week. Additionally, $h_g = 0$ represents no working, while $h_g = 8$ signifies working more than 63 hours per week.

We parameterize the components of wage as follows:

$$\omega_{o,e,g,j} = [1 + \tilde{\omega}_p \mathcal{I}(o = P)] [1 + \tilde{\omega}_e \mathcal{I}(e = 2)] \exp\left(\tilde{\omega}_1 (j-1) - \tilde{\omega}_2 (j-1)^2\right) \tag{22}$$

$$\gamma_\chi = 1 + \tilde{\gamma} \mathcal{I}(\chi = 2), \tag{23}$$

where we allow wage to depend on the job, education, age and promotion status. The match-specific shock is assumed to be drawn from a log normal distribution: $z_g \sim \log N(0, \sigma^2_{z,e})$.

3.1. Externally Calibrated Parameters

In our model, permanent job workers can experience either promotion ($\chi' = 2$ from $\chi = 1$) or demotion ($\chi' = 1$ from $\chi = 2$). Promotion and demotion are determined based on the two-year wage growth, where either a wage increase or decrease exceeding 25% triggers the corresponding event. The probabilities of promotion and demotion vary by gender and age. For individuals aged 27 to 44, the probability of promotion (demotion) is 5.85% (7.32%) for females and 11.45% (9.46%) for males. For those aged 45 to 56, the corresponding probabili-

Table 2: Externally Calibrated Parameters

	Value	Description
β	0.96^2	Two-year discount factor
r	0.08	Two-year interest rate
σ_c	2	Relative risk aversion
σ_h	1	Frisch elasticity
ζ_P	1.35	Logit regressions (25) and (26)
$\pi^u_{P,f,j}$	0.067	Fraction of wage growth$>$ 25% ($h = 5$, female young age 27–44)
$\pi^u_{P,m,j}$	0.161	Fraction of wage growth$>$ 25% ($h = 5$, male young age 27–44)
$\pi^u_{P,f,j}$	0.053	Fraction of wage growth$<$ -25% ($h = 5$, female old age 45–56)
$\pi^u_{P,m,j}$	0.105	Fraction of wage growth$<$ -25% ($h = 5$, male old age 45–56)
$\pi^d_{P,f,j}$	0.067	Fraction of wage growth$>$ 25% ($h = 5$, female young age 27–44)
$\pi^d_{P,m,j}$	0.037	Fraction of wage growth$>$ 25% ($h = 5$, male young age 27–44)
$\pi^d_{P,f,j}$	0.024	Fraction of wage growth$<$ -25% ($h = 5$, female old age 45–56)
$\pi^d_{P,m,j}$	0.042	Fraction of wage growth$<$ -25% ($h = 5$, male old age 45–56)
$\tilde{\gamma}$	0.4	Wage premium for promoted workers
ρ	0.59	(Infant) childcare elast. of substitution $(1-\rho)^{-1}$ (Bar et al., 2018)
ψ	0.33	Economies of scale (Doepke et al., 2015)
π_j	$0.96[1-\exp(-0.75(11-j))]$	Fertile probability (Taylor, 2003)
η	$(1-\nu)^{1/\rho}2\bar{h}$	Required total input for a newborn child
τ	0.2	Labor income tax rate
Tr	2.0	Transfers

ties are 5.09% (4.42%) for females and 9.75% (9.27%) for males.

The wage changes due to promotion and demotion result in an average wage change of around 40%. While these wage changes can differ by gender and age, the observed variations are not statistically significant. Specifically, for individuals aged 27 to 44, the wage change resulting from promotion is 37.8% for females and 41.8% for males, while the wage change due to demotion is –39.31% for females and –42.6% for males. For those aged 45 to 56, the corresponding wage changes are 35.5% for females and 38.7% for males in the case of promotion, and –35.2% for females and –38.3% for males in the case of demotion. Consequently, we set the wage premium parameter at $\tilde{\gamma} = 0.4$.

The transition matrix $\pi(\chi'|\chi, (P, P), \mathbf{h})$ is then calibrated. The probability of promotion increases with working hours, while the probability of demotion decreases with working hours. We express these probabilities using the following equation:

$$\Pi^{motion}_{P,g,j}(h_g) = \left[1 + \left(\frac{1}{\pi^{motion}_{P,g,j}} - 1\right)\exp\left(-\zeta^{motion}_P(h_g - 5)\right)\right]^{-1}, \tag{24}$$

where $motion$ represents either promotion (u) or demotion (d). The probability of promotion/demotion, conditional on $h_g = 5$ for each group, is denoted as $\pi^{motion}_{P,g,j}$.[3] We classify groups by two dimensions: gender and broad age group (27–44 and 45–56).

We estimate the parameter ζ^{motion}_P through logistic regression on discretized working hours with fixed effects (household by gender by broad age group) as follows. For promotion (u), the regression equation is:

$$\text{Prob}(\ln w_{i,g,t+1} - \ln w_{i,g,t} > 0.25 | h_{ig,t}) = \frac{\exp\left(\text{fe}_{i,g,j} + \zeta^u_P h_{ig,t}\right)}{1 + \exp\left(\text{fe}_{i,g,j} + \zeta^u_P h_{ig,t-1}\right)}, \tag{25}$$

where i indexes households. Similarly, for demotion (d), we have:

$$\text{Prob}(\ln w_{i,g,t+1} - \ln w_{i,g,t} < -0.25 | h_{ig,t}) = \frac{\exp\left(\text{fe}_{i,g,j} - \zeta^u_P h_{ig,t-1}\right)}{1 + \exp\left(\text{fe}_{i,g,j} - \zeta^d_P h_{ig,t-1}\right)}. \tag{26}$$

The estimated coefficients for ζ^u_P and ζ^d_P from regression equations (25) and (26) are 1.331 (0.081) and –1.372 (0.072), respectively, with standard errors in parentheses, clustered at the level of gender by broad age group. The estimated $\zeta^u P$ and $-\zeta^d P$ are both positive, but the difference is not statistically significant at the 1% level. Therefore, we set $\zeta^u_P = -\zeta^d_P$ to be $\zeta_P = 1.3$.

The utility functional forms used in our model are standard in macroeconomics and life-cycle literature. They are as follows:

$$u(c/\Lambda(\tilde{n})) = \frac{(c/\Lambda(\tilde{n}))^{1-\sigma_c}}{1-\sigma_c}$$
$$v_g(\tilde{h}_g) = \tilde{v}\frac{\tilde{h}_g^{1+\sigma_h}}{1+\sigma_h}$$
$$\phi(n, q) = \tilde{\phi}_n \log q,$$

where we set $\sigma_c = 2$ and $\sigma_h = 1$, which are commonly used values in the literature. Additionally, we define $\Lambda(\tilde{n}) = 1.5 + 0.3\tilde{n}$ based on the OECD modified equivalence scale. This scale assigns a value of 1 to the adult head, 0.5 to an additional adult, and 0.3 to each child aged under 14. The child preference parameter $\tilde{\phi}_n$ is essential for capturing observed fertility patterns and will be internally calibrated in the subsequent subsection.

The fertility probability ($j = 1, 2, ..., 10$) decreases as female age increases. We introduce the following functional form to capture this relationship:

$$\pi_j = 0.96 \times \left[1 - e^{-0.75\times(11-j)}\right], \tag{27}$$

[3]This specific working time level of $h_g = 5$ corresponds to the mode of the distribution for both female and male permanent job working hours.

Figure 1: Fertile Probabilities by Age

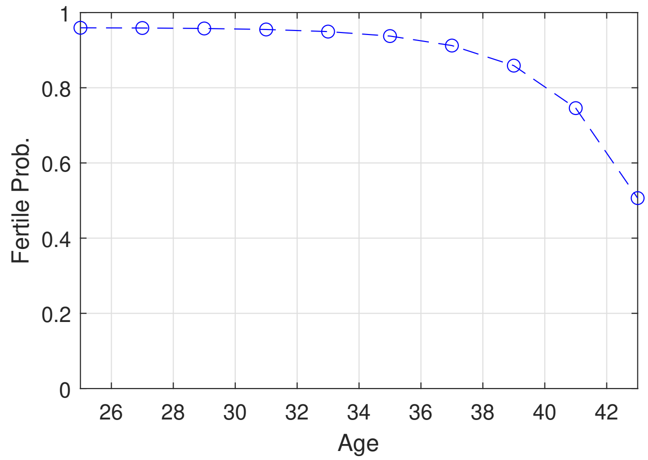

Table 3: Initial Distribution

		Male	
		Non-college	College
Female	Non-college	0.45	0.15
	College	0.05	0.35

where we have chosen these specific numerical values to align with the subfertility rate reported in Taylor (2003). This functional form helps us model the age-related changes in fertility probabilities realistically, as shown in Figure 1.

Finally, in equation (4), we set $\rho = 0.59$, which is consistent with the value used in Bar et al. (2018). The share parameter ν is internally calibrated to align with the average childcare spending and earning ratio. We normalize the degree of infant childcare burden by using $\eta = (1-\nu)^{1/\rho} 2\bar{h}$, which ensures that childcare costs are zero ($x_b = 0$) when both parents allocate all of their time endowment to parenting their newborn child. In our model, the maximum parenting time spending for an infant is given by $\sum_g \lambda_g \bar{h}$, which is less than the total time endowment $\sum_g \bar{h} = 2\bar{h}$. This implies that there will be a positive need for childcare monetary spending for an infant child.

We take the initial distribution of couples' education directly from the data, as summarized in Table 3, and their corresponding distribution of the number of children in each household, as reported in Table A1.

3.2. Internally Calibrated Parameters

We calibrate the remaining parameters to match the relevant target statistics obtained from our KLIPS cohort families. We summarize these in Table 4.

Notably, the calibrated social norm suggests that women would allocate twice as much as parental time relative to men to rationalize the gender gap in parental time which is threefold. This is because of the significance presence of gender gaps in labor supply in our baseline model, as observed in the data.

Table 4: Internally Calibrated Parameters

		Target Statistics		
	Value	Model	Data	Description
$\tilde{v}_f$	0.0088	2.12	2.11	Female avg. hours
$\tilde{v}_m$	0.0083	4.14	4.26	Male avg. hours
$\sigma_{z,1}$	0.33	0.505	0.514	Std. dev. wage (low educ. in P)
$\sigma_{z,2}$	0.40	0.531	0.536	Std. dev. wage (high educ. in P)
$\tilde{\xi}$	0.10	0.95–0.99	0.96	Permanent job persistence (male)
$\tilde{\phi}_1$	0.073	0.30	0.18	Share of households with one child
$\tilde{\phi}_2$	0.146	0.58	0.63	Share of households with two children
$\tilde{\phi}_3$	0.206	0.10	0.13	Share of households with three or more children
$\tilde{p}$	0.925	Figure 3		Avg. numbers of children by age 45-55
ν	0.22	0.17	0.20	Avg. childcare spending to income
$\underline{q}$	3.5	0.11	0.10	Avg. private educ. (per kid) to income
α	0.60	0.75	0.70	Cor(private educ.,income)
λ_f	0.31	2.05	2.28	Female avg. parental time with new born
λ_m	0.16	0.71	0.57	Male avg. parental time with new born
ϱ	0.52	0.65	0.65	Permanent job wage persistence
$\tilde{\omega}_P$	0.37	1.57	1.55	Observed job wage ratio (age 25-30, male)
$\tilde{\omega}_e$	0.30	1.27	1.30	Observed educ. wage ratio (age 25-30, n=0)
$\tilde{\omega}_1$	0.08	Figure 4		Avg. wage
$\tilde{\omega}_2$	0.0025	Figure 4		by age

3.3. Model Fit and Validation

Figure 2 shows the age profile of labor supply by gender. While we only targeted the average by gender only, as shown in Table 4, the model does a reasonably good job of matching the patterns over age. In particular, it is interesting to note that female labor supply increases with age when childbearing is getting over, as observed in the data.

Figure 3 displays the average number of children in a household by age, which contains information about timing of childbirth. It is noteworthy that the model statistics up to age 45 are very close to the data counterparts despite the fact that they are not directly targeted by calibration. The negative slop from age 45 is directly targeted to match the data.

Figure 4 plots the age profile of wage by gender, which is mostly disciplined by the internal calibration subject to the parsimonious parametric assumptions such as equation (22). Figure 5 shows the same graph for the share of permanent job workers relative to all workers. Currently, although this figure is completely not targeted, the model successfully generates the fact that most of male workers at around 80% hold a permanent job, whereas a considerably lower share of female workers (around a half) have a permanent job.

Figure 2: Labor Supply by Age and Gender

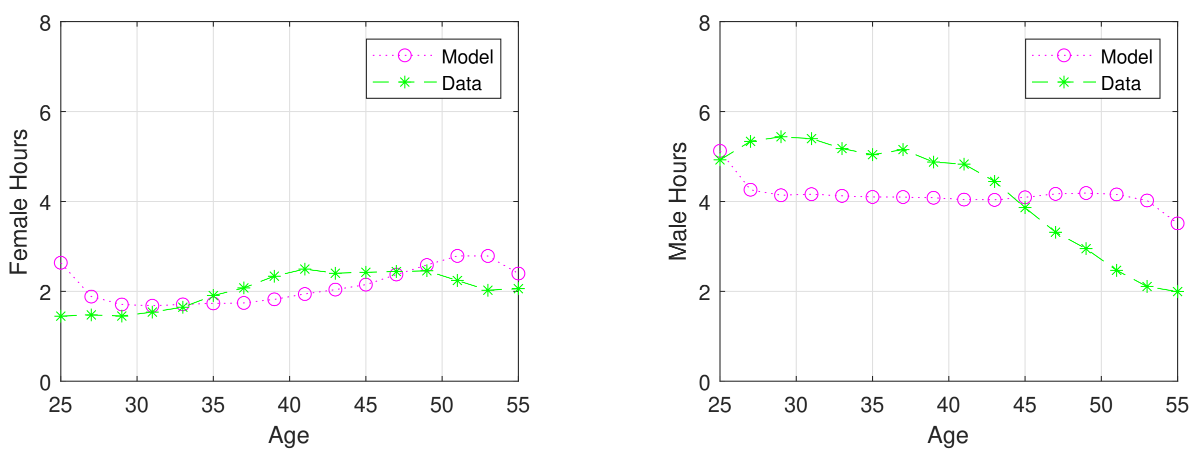

Figure 3: Children in Households by Age

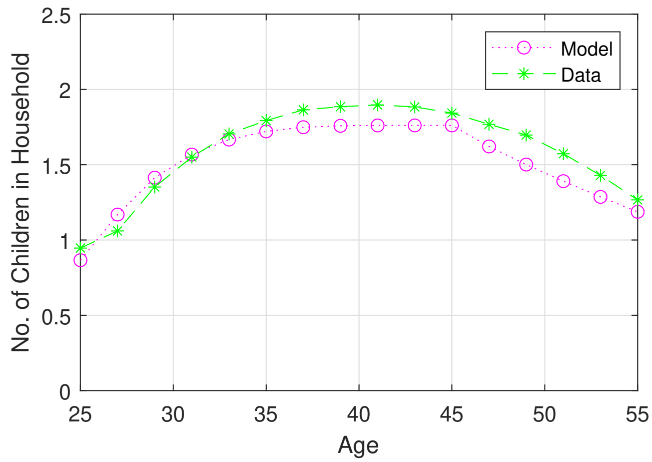

Figure 4: Wage by Age and Gender

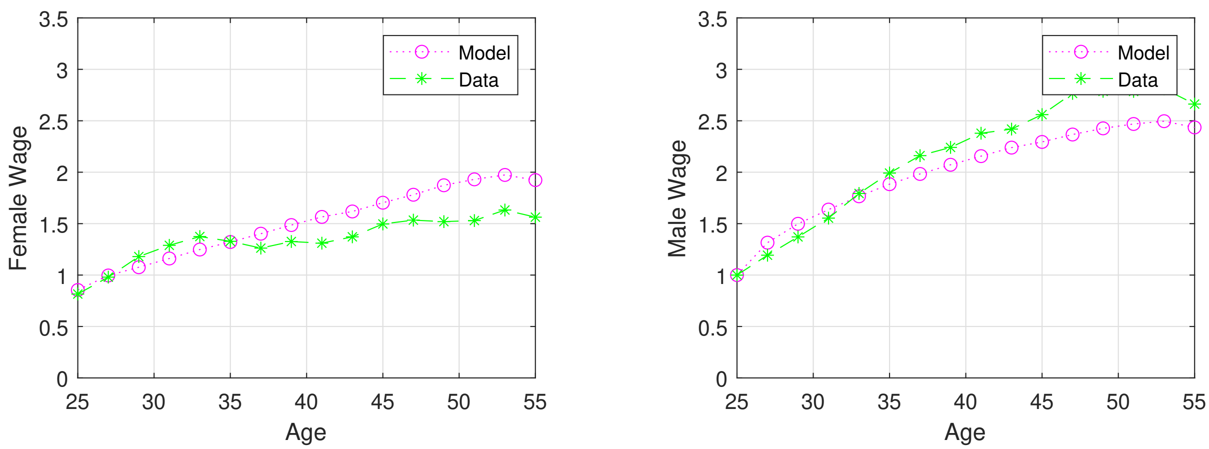

Figure 5: Job Shares by Age and Gender

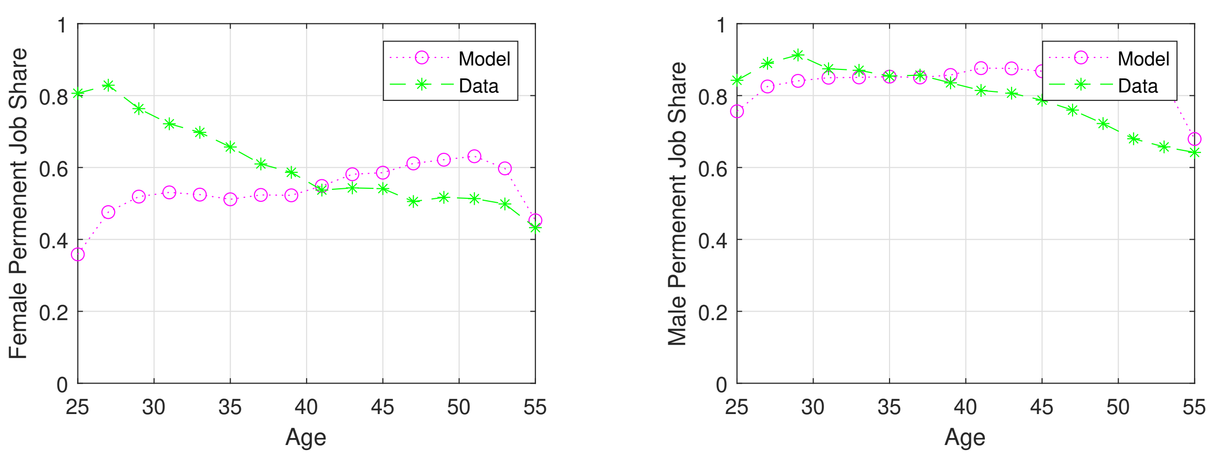

Table 5: Effects of of (Unpaid) Parental Leave (PL) Duration in Baseline Economy

	Labor Supply									
	Female			Male			% Gender Gap			
	Young	Old	All	Young	Old	All	Young	Old	All	**Fertility**
No PL	1.89	2.51	2.12	4.21	4.02	4.14	55.2%	37.5%	48.8%	1.76
Duration	Change relative to No PL									
1Q	2.1%	1.2%	1.7%	–0.9%	–0.7%	–0.8%	–1.4 p.p.	–1.2 p.p.	–1.3 p.p.	0.5%
2Q	4.4%	2.1%	3.4%	–2.0%	–1.2%	–1.7%	–2.9 p.p.	–2.1 p.p.	–2.7 p.p.	1.2%
3Q	6.4%	3.4%	5.0%	–2.6%	–1.7%	–2.3%	–4.2 p.p.	–3.2 p.p.	–3.9 p.p.	2.0%

Notes: "Young" households represent those in their fertile years (age 25–44), and "Old" households belong to the infertile age range (age 45–55). The % gender gap is calculated by 100 $\times$ (1-Female/Male).

4. Quantitative Results

This section provides main quantitative exercises exploring the impact of parental leave on labor supply, its gender gaps and fertility. We will demonstrate how the effects of parental leave policies may vary across space and time by considering two counterfactual economies where we remove two notable characteristics of the recent Korean economy: (i) social norms on the role of women and (ii) high demands for costly private education. As policy instruments, we will consider various dimensions of parental leave such as the maximum duration of parental leave and the generosity of benefits.

4.1. Effects of Unpaid Parental Leave

This subsection first focuses on unpaid leave policies. That is, we assume that θ_g is still zero, but change the maximum duration of parental leave from one quarter to three quarters. We report labor supply effects for the young households (who are in their fertile periods), the old households (who are in their infertile periods), and all households, separately.

Table 5 summarizes the results. It is clear to note that a longer maximum duration of parental leave raises both fertility and female labor supply. On the other hand, male labor supply becomes lower instead. For example, the presence of maximum two quarters of unpaid parental leave increases female labor supply by 3.4%, yet reduces male labor supply by 1.7%. Therefore, it closes the gender gap in labor supply by 2.7 percentage points (p.p.). Note that the positive effect on labor supply is much more pronounced among the young women (by 4.4%) around the time when women take parental leave. However, this positive effects tend to fade out, increasing the labor supply of the older women in infertile periods (an 2.1% increase). The completed fertility rate would increase also by 1.2%.

Table 6: Effects of of (Unpaid) Parental Leave (PL) Duration in Economy with Equal Division of Childcare Time

	Labor Supply									
	Female			Male			% Gender Gap			
	Young	Old	All	Young	Old	All	Young	Old	All	**Fertility**
No PL	1.07	1.76	1.33	4.94	4.78	4.88	78.4%	63.1%	72.8%	1.95
Duration	Change relative to No PL									
1Q	2.6%	0.5%	1.5%	–0.6%	–0.1%	–0.4%	–0.7 p.p.	–0.2 p.p.	-0.5 p.p.	0.0%
2Q	3.9%	0.4%	2.1%	–1.2%	–0.1%	–0.8%	–1.1 p.p.	–0.2 p.p.	–0.8 p.p.	0.3%
3Q	7.9%	1.1%	4.5%	–1.9%	–0.2%	–1.3%	–2.1 p.p.	–0.5 p.p.	–1.6 p.p.	0.8%

Notes: Above exercises are conducted in the alternative economy where λ_f and λ_m are equalized at the average calibrated values in the baseline economy. See Table 5 for the definition of "Young" and "Old". The % gender gap is calculated by 100 $\times$ (1-Female/Male).

4.2. The Role of Social Norms on the Women for the Effects of Unpaid Parental Leave

Korea used to have a very strong social norm on the role of women until recently due to Confucianism (Myong et al., 2021). However, there has been a dramatic change in perceptions on the gender role in childcare over the last few decades, and the currently young generations have much more egalitarian views (Kim et al., 2023). Also, many European countries—which various empirical studies are based on—have much more equal views on the role of women. To answer how the effects of parental leave policies would change in such cases, we then conduct the same policy experiments in the economy where social norms about unequal gender division of childcare are balanced by imposing that λ_f and λ_m are equalized at the average calibrated values in the baseline economy.

Table 6 summarizes the results. Interestingly, it shows that the positive effects in the baseline economy are quantitatively much dampened. For example, with two maximum quarters of unpaid parental leave, gender gaps in labor supply is closed by 0.8 p.p. (as compared to 2.7 p.p. in the baseline economy), and the fertility increases only by 0.3%. This finding is interesting as Kleven et al. (2020) find that substantial changes in family policies such as parental leave have had little effect on the convergence of gender gaps in Austria, which has much more equal views on the role of women, compared to East Asian countries like Korea.

Table 7: Effects of of (Unpaid) Parental Leave (PL) Duration in Economy with Lower Demand for Private Education

	Labor Supply									
	Female			Male			% Gender Gap			
	Young	Old	All	Young	Old	All	Young	Old	All	**Fertility**
No PL	1.12	1.66	1.32	4.67	4.14	4.47	76.0%	60.0%	70.4%	1.95
Duration	Change relative to No PL									
1Q	1.3%	0.2%	0.8%	–0.4%	–0.3%	–0.3%	–0.4 p.p.	–0.2 p.p.	–0.3 p.p.	–0.4%
2Q	4.5%	0.5%	2.7%	–1.1%	–0.5%	–0.9%	–1.4 p.p.	–0.4 p.p.	–1.1 p.p.	–0.4%
3Q	8.8%	1.8%	5.5%	–2.0%	–1.2%	–1.7%	–2.7 p.p.	–1.2 p.p.	–2.2 p.p.	–0.3%

Notes: Above exercises are conducted in the alternative economy where α is set to be 50% of its calibrated value in the baseline economy. See Table 5 for the definition of "Young" and "Old". The % gender gap is calculated by 100 $\times$ (1-Female/Male).

4.3. The Role of High Demands for Costly Private Education for the Effects of Unpaid Parental Leave

Korea is a prominent example of East Asian countries with education fever (Kim et al., 2023), unlike European countries. To investigate the role of high demands for costly private education, we then repeat the policy exercises in the economy which features less demands for private education. Specifically, we assume that α is set to be 50% of its calibrated value in the baseline economy.

Table 7 shows that the positive effects of parental leave duration on female labor supply are considerably mitigated also in this case. More notably, we find that fertility would actually decline in response to a longer parental leave duration in this economy. As parents now are concerned less about the future costs of children in terms of private education expenditures, mothers are more able to focus on careers with fewer number of children in households. It is worth highlighting that the weak (or even negative) effects of parental leave on fertility are consistent with the empirical evidence from Austria where private education expenditures are much lower than East Asian countries.

4.4. Effects of Paid Parental Leave

We plan to assess the effects of paid parental leave policies. This would require us to consider their fiscal costs, thus we will introduce government budget constraints into the model.

5. Conclusion

(Work in progress - to be completed)

We are working on calibration to improve the fit of the model. We plan to demonstrate mechanisms behind the main policy results presented above.

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Appendix

A. Initial Distribution

Table A1: Initial Distribution of the Number of Children

Male education		Non-college	College	Non-college	College
Female education		Non-college	Non-college	College	College
		Panel A. Female head age ≤28			
No. of children	0	16.6%	20.6%	28.6%	37.3%
	1	39.4%	54.8%	42.9%	46.8%
	2	41.1%	24.7%	23.8%	15.9%
	3+	2.9%	0.0%	0.0%	4.8%
Average		1.31	1.04	1.10	0.79
No. of households		175	73	21	126
		Panel B. Female head age ≤26			
No. of children	0	25.7%	34.8%	44.4%	54.3%
	1	39.2%	52.2%	33.3%	31.4%
	2	33.8%	13.0%	22.2%	14.3%
	3+	1.4%	0.0%	0.0%	0.0%
Average		1.11	0.78	0.78	0.60
No. of households		74	23	9	35

Notes: The number of children in each household with a female head under the age of 26 (or 28) is determined by considering their complete fertility history up to that age. Specifically, if a household had new babies when its female head was, for instance, aged 20, 27, 29, and 35, then the number of children in that household would be two for Panel A (but one for Panel B), as it reflects the cumulative count of children born to that household up to the specified age of the female head.