

# The Fertility Race Between Technology and Social Norms

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## Abstract

Fertility rates are declining worldwide, creating challenges for many countries. We document that fertility falls more rapidly in economies undergoing fast structural changes. Furthermore, this correlation is stronger in societies with rigid social norms. To explain these facts, we develop a quantitative model of child bargaining, where equilibrium fertility reflects a tug-of-war between technological progress and social norms of childcare. A novel modeling ingredient is that social norms evolve endogenously, shaped by the opinions of all cohorts, which in turn depend on the childcare choices in the past. Calibrated to South Korean data, our model shows that intense social pressure and the reluctance of older cohorts to adapt delay equitable childcare adjustments, amplifying fertility declines and entrenching rigid norms. We predict a slow but eventual fertility recovery as social norms gradually converge to the new steady state. Policies promoting gender-equal childcare could accelerate this process.

**JEL classification:** J12, J13, O11

**Keywords:** Fertility, Structural Change, Social Norm

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# 1. Introduction

The rapid decline in global fertility rates poses an imminent challenge for major economies over the coming decades, threatening fiscal sustainability and economic growth (Jones 2022). This trend is especially pronounced in nations “getting old before getting rich” where low fertility imperils economic stability and catching-up prospects. Uncovering the causes of low fertility, forecasting its path, and pinpointing effective policy solutions are thus critical questions for researchers and policymakers.

In this paper, we document that countries undergoing rapid structural change experience a more pronounced decline in fertility rates. This relationship is particularly evident in societies with stringent social norms. Specifically, our cross-country regression analysis reveals that a one-percentage-point increase in the pace of service sector expansion is associated with an annual fertility decline of 3%. This correlation is 50% stronger in societies exhibiting above-median cultural rigidity, as measured by the tightness/looseness index from Uz (2015). This pattern persists even after accounting for GDP per capita growth and remains consistent when we substitute agricultural sector decline as a measure of structural change.

These observations motivate us to construct a quantitative model in which fertility emerges from the interplay between technological progress and evolving childcare norms. In this model, fertility decisions require mutual agreement of both parents, who negotiate childcare responsibilities and consumption within a bargaining framework with limited commitment, following Doepke and Kindermann (2019). Since parents cannot pre-commit to how consumption will be divided after childbirth, the allocation of childcare duties—something they can agree upon—becomes pivotal in shaping each parent’s welfare and, consequently, their willingness to have children. Parents determine the childcare allocation by balancing the opportunity costs of childcare against the psychic costs of straying from the prevailing social norm. For example, in a society with traditional gender expectations, assigning more childcare to men might lower costs if women earn higher wages, yet it could provoke social disapproval, adding psychic costs. Thus, social norms create a gap between the actual childcare arrangement

and the one that would minimize opportunity costs alone. As a result, these norms significantly influence fertility, labor supply, and gender welfare disparities in the model.

Different from prior studies that treat social norms as exogenously given, our key contribution is to explicitly model how social norm is endogenously formed. Informed by the insights from the sociology insights (e.g., [Brooks and Bolzendahl 2004](#)), we hypothesize that the prevailing norm reflects a weighted average of the opinions expressed by the other members in the society. These opinions, in turn, depend on the current economic conditions and the childcare practices that these members adopted in the past. Therefore, the evolution of the social norm in the economy stems from two sources. On the one hand, when new cohorts enter the economy and adopt childcare practices that are different from the past, they shift future norms, reflecting *between-cohort effects* (also known as cohort replacement effects). On the other hand, older cohorts re-evaluate the current situation and weigh it against their past practices. As a result, changing economic conditions affect the opinions expressed by older cohorts, reflecting *within-cohort effects* (also known as social structural effects). Furthermore, the influence of the two effects depends on the population weight of the corresponding cohort, which in turn depends on past fertility choices.

The model suggests that strong social pressure and older cohorts' reluctance to re-evaluate the situation impose rigid constraints on young parents' choices, fostering cultural inertia. If technological advancements necessitate a shift in childcare allocation, this inertia prevents adjustment, increasing the burden on one side of the parents and making childbearing costlier for them. Given that fertility requires both parents' consent, this added cost can sharply reduce fertility rates, a pattern consistent with our empirical evidence.

Our model also predicts a non-monotonic trajectory: an initial drop followed by a recovery as norms adapt to economic realities. More importantly, it also offers predictions about the timing of this recovery and the pace of norm evolution, driven by both within- and between-cohort effects.

To evaluate the model's quantitative predictions, we calibrate the model to South Korean data from 1999 to 2014. Gender-specific wage paths are set to align with trends

in total factor productivity and gender wage gaps. Preference parameters are adjusted to match fertility trends, while the substitutability of childcare between genders reflects the initial allocation. The strength of social pressure is calibrated to fit gender disparities in childcare time from the Korean Time Use Survey (KTUS), yielding estimates consistent with prior research (e.g., [Myong et al. 2021](#)). The weight that old cohorts put on their past childcare practices when they re-evaluate the current condition is calibrated to match the share of within-cohort changes in driving the overall social norm evolution, calculated using data from the Korean General Social Survey (KGSS).

Using the calibrated model, we conduct four counterfactual experiments. In the first, we adjust the pace of structural change in the economy. We find that faster structural change accelerates the fertility decline, aligning with empirical evidence. However, the transition paths of childcare and social norms remain largely unchanged, as strong social pressure limits shifts in childcare allocation during this transformation. In the second counterfactual, we vary the intensity of social pressure while holding the structural change constant. Here, economies with weaker social pressure exhibit a smaller fertility drop and a faster social norm transition toward a new steady state, consistent with our empirical findings. In the third counterfactual, we vary the weight that older cohorts put on their past childcare practices when they re-evaluate the current situation. We find that a smaller weight accelerates the social norm convergence towards the new steady state and raises fertility rates along the transition path. Finally, we assess a hypothetical government policy that promotes a more egalitarian childcare norm. This policy also accelerates the social norm transition to the new steady state. Although its initial impact on fertility is modest initially, the pro-fertility effects strengthen over the transition, yielding significant differences in fertility along the transition path. This experiment underscores the need to account for dynamic effects in policy evaluations.

To summarize, this paper establishes that faster structural change or more rigid social norms exacerbates fertility decline, a fact we explain with a novel model of endogenous norms and household bargaining. Calibrated to South Korea, it matches observed trends, delivers new predictions—non-monotonic fertility and policy-driven recovery—and enriches the fertility literature with dynamic theory and actionable insights for a

pressing global issue.

### *Related Literature*

This paper contributes to the growing body of literature examining the effects of technological change on fertility and female labor supply. The most closely related studies in this domain are [Goldin \(2024\)](#), [Doepke and Kindermann \(2019\)](#), and [Myong et al. \(2021\)](#).

The work by [Goldin \(2024\)](#) demonstrates that countries with “lowest low” fertility rates experienced rapid growth in GNP per capita alongside slowly evolving traditions, resulting in both generational and gendered conflicts that precipitate a sharp decline in the total fertility rate. Our paper aligns with this perspective, positing that fertility rates emerge from a dynamic interplay between technological advancements and social norms. However, unlike [Goldin \(2024\)](#), which directly assumes gender-specific desired fertility levels, we derive fertility choices and bargaining dynamics between women and men from microeconomic foundations. Furthermore, we propose a model of social norms incorporating both within- and between-cohort effects, enabling all economic agents to adapt to shifting economic conditions rather than adhering rigidly to traditions. Finally, while [Goldin \(2024\)](#) posits that men prioritize inherited traditions more than women, leading to a higher desired number of children, we assume homogeneous preferences across genders and explain gaps in desired fertility through the negotiation of childcare responsibilities.

[Doepke and Kindermann \(2019\)](#) find that countries with more equitable childcare practices exhibit fewer discrepancies between men and women regarding desired fertility, resulting in higher birth rates. They explain this pattern with a bargaining model with limited commitment. We extend their framework by incorporating the influence of social norms and modeling the norms’ endogenous evolution. This addition allows our model to address how economies adjust to technological changes over time.

The study by [Myong et al. \(2021\)](#) explores fertility and marriage patterns in East Asian societies, analyzing the effects of two social norms: one related to the stigma of out-of-wedlock births and another concerning the gender division of childcare. Estimating

their model with South Korean data, they conclude that the latter norm exerts a stronger influence on fertility outcomes. This finding inspires our focus on the childcare social norm, abstracting from marriage considerations. While [Myong et al. \(2021\)](#) treat social norms as exogenous and estimate them empirically, we micro-found the endogenous formation of these norms. Consequently, our approach enables predictions about future fertility trends and facilitates counterfactual analyses based on structural parameters of norm formation.

Our research also complements studies investigating social learning as a mechanism driving the rise of female labor force participation amid technological changes, such as [Fernández and Fogli \(2009\)](#), [Fogli and Veldkamp \(2011\)](#), and [Fernández \(2013\)](#). These works emphasize individuals' learning about the impact of female labor force participation on child outcomes and the intergenerational transmission of such knowledge. In contrast, we examine the role of social norms surrounding childcare responsibilities, exploring how these norms are shaped by both within- and between-cohort adjustments.

Lastly, our study resonates with sociological perspectives on norm evolution. For instance, [Brooks and Bolzendahl \(2004\)](#) decompose post-World War II social norm changes in the United States into within- and between-cohort effects. We integrate this insight into an economic framework of fertility bargaining, tracing the evolution of social norms back to technological advancements.

The remainder of the paper is structured as follows. Section 2 presents the motivating empirical evidence. Section 3 outlines the theoretical model. Section 4 details the calibration strategy and results. Section 5 conducts the primary counterfactual exercises. Section 6 evaluates the model's robustness. Finally, Section 7 offers concluding remarks.

## 2. Motivating Facts

This section presents cross-country evidence on the relationship between fertility, structural change, and social norms, drawing data from multiple sources. We document the following two empirical regularities:

**Fact 1:** Economies experiencing faster structural change exhibit more rapid fertility declines.

**Fact 2:** The relationship between structural change and fertility is stronger in societies with more stringent social norms.

To examine these relationships, we combine different sources of data. Data on total fertility rate is obtained from the United Nations Population Division. Sectoral employment data are from the Groningen Growth and Development Centre (GGDC) 10-Sector Database (Timmer et al., 2015). This database offers long-term, internationally comparable data on value added and employment across ten sectors for more than 40 economies, including both developing and developed ones.<sup>1</sup> Data on gross national product (GDP) is collected from the Penn World Table 10.01. Lastly, we follow the literature on sociology and cultural studies in measuring the stringency of social norms. In particular, we obtain the tightness/looseness index from Uz (2015), where the author measures the tightness of social norms using the dispersion of opinions. The motivation of this measure is that in a tight culture, people's values, norms, and behavior are similar to each other because deviations are sanctioned. The merged sample includes 23 countries from all levels of economic development, with observations from the 1950s to 2010.

To construct the speed of fertility change for country  $i$ , we run the regression

$$\log(\text{tfr})_{i,\text{year}} = \alpha_i^{\text{tfr}} + \text{speed\_tfr}_i \times \text{year} + u_i \quad (1)$$

where  $\text{speed\_tfr}_i$  measures the average annual growth rate of the total fertility rate for country  $i$  during the sample period.

Likewise, we measure the speed of structural change for country  $i$  using

$$\text{service share}_{i,\text{year}} = \alpha_i^{\text{ser}} + \text{speed\_ser}_i \times \text{year} + v_i \quad (2)$$

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<sup>1</sup>We follow Herrendorf et al. (2014) in the sector assignments. In particular, Agriculture corresponds to the sum of International Standard Industrial Classification (ISIC) sections A–B, Manufacturing corresponds to the sum of ISIC sections C, D, F, and Services correspond to the sum of ISIC sections E, G–P.

where service share measures the fraction of service employment, and

$$\text{agriculture share}_{i,\text{year}} = \alpha_i^{\text{agr}} + \text{speed\_agr}_i \times \text{year} + v_i \quad (3)$$

where agriculture share measures the fraction of agricultural employment. Therefore,  $\text{speed\_ser}_i$  and  $\text{speed\_agr}_i$  measures the average annual change of sectoral employment for country  $i$  during the sample period.

Figure 1a plots the correlation between  $\text{speed\_tfr}_i$  and  $\text{speed\_ser}_i$ . As can be seen, countries that have experienced faster expansion of the service sector, e.g., South Korea and Peru, also witnessed more rapid fertility declines. Similarly, Figure 1b indicates that countries that have experienced faster shrinkage of the agriculture sector, e.g., South Korea, China, and Mexico, also experienced more rapid fertility declines. The latter finding complements Ager et al. (2020) who document the relationship between agriculture decline and fertility transition in the American South.

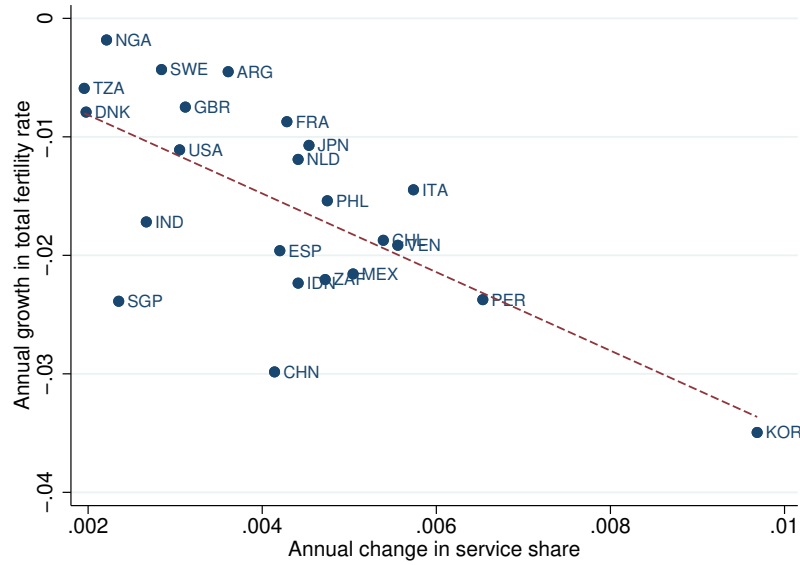
To examine the relationship between structural change and fertility decline more systematically, we run a set of OLS regressions where we regress  $\text{speed\_tfr}_i$  on  $\text{speed\_ser}_i$  and  $\text{speed\_agr}_i$ , after controlling for the growth rate of GDP per capita  $\text{speed\_gdp}_i$ . We also interact the speed of structural change with a dummy variable “tight”, which takes the value of 1 if the country’s opinion dispersion, measured by Uz (2015), is below the median.

The regression results, presented in Table 1, reveal key insights. Column (1) shows that a one-percentage-point increase in the speed of service sector expansion corresponds to an annual fertility decline of 3%, a statistically and economically significant correlation. This relationship holds after controlling for GDP per capita growth in Column (2). In Column (3), we observe that the link between service sector expansion and fertility decline is predominantly driven by countries with rigid social norms. Specifically, countries with above-median cultural tightness exhibit a coefficient on service sector expansion speed nearly 50% larger than those below the median. Column (4) confirms that this heterogeneity persists even after adjusting for GDP per capita growth. Columns (5) through (8) replicate the analysis using the decline in agricultural employ-

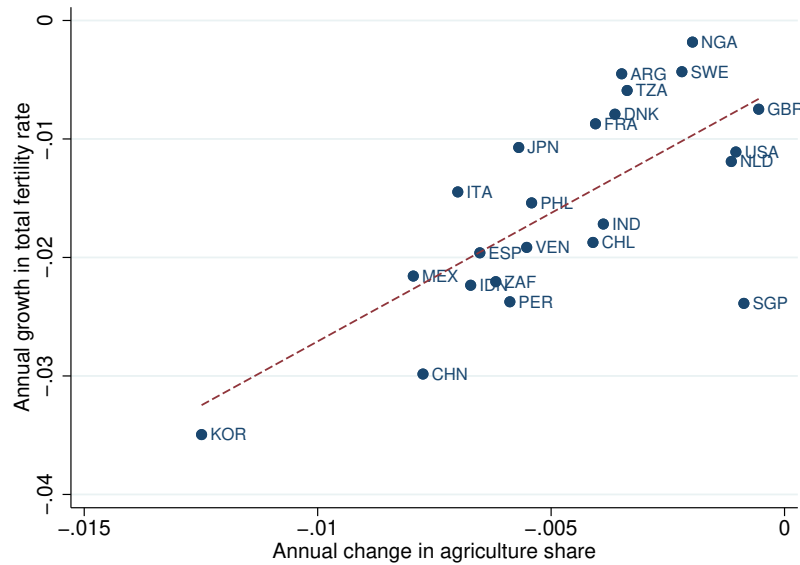


Figure 1: Fertility Change and Structural Change

(a) Service Expansion and Fertility Decline



(b) Agriculture Shrinkage and Fertility Decline



Notes: “speed\_tfr” is defined as the average annual percentage change in total fertility rate for each country in the sample period, using data from the United Nations Population Division. “speed\_ser” and “speed\_agr” are the average annual change in the fraction of employment in service and agriculture sectors respectively, using data from the Groningen Growth and Development Centre (GGDC).

ment as an alternative measure, yielding findings consistent with those for service sector expansion.

**Table 1:** Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: speed_tfr								
speed_ser	-3.32	-2.62	-2.32	-1.70				
	(0.80)	(0.84)	(0.98)	(0.97)				
tight $\times$ speed_ser			-1.03	-0.98				
			(0.62)	(0.59)				
speed_agr					2.17	1.78	1.58	1.30
					(0.47)	(0.47)	(0.59)	(0.57)
tight $\times$ speed_agr							0.74	0.64
							(0.48)	(0.46)
speed_gdp		-0.15		-0.14		-0.15		-0.14
		(0.08)		(0.07)		(0.07)		(0.07)
Observations	23	23	23	23	23	23	23	23

*Notes:* “speed\_tfr” is defined as the average annual percentage change in total fertility rate for each country in the sample period, using data from the United Nations Population Division. “speed\_ser” and “speed\_agr” are the average annual change in the fraction of employment in service and agriculture sectors respectively, using data from the Groningen Growth and Development Centre (GGDC). “speed\_gdp” is calculated as the annual change in GDP per capita in the sample period, using data from the Penn World Table. “tight” is a dummy variable that takes the value of 1 if the tightness index is above the sample median, reflecting stronger constraints imposed by social norms on individual behavior. The index is developed by [Uz \(2015\)](#).

To summarize, we find that countries that have experienced faster structural change, i.e., service expansion or agriculture decline, witnessed more rapid decline in fertility. Furthermore, this correlation is robust to controlling for the growth in GDP per capita, and is stronger in societies with rigid social norms. In the next section, we propose a structural model to understand these relationship.

### 3. Model

This section introduces an overlapping generations model where parents bargain over fertility and childcare responsibilities under the influence of social norm. Moreover, the prevailing social norm in the economy is endogenously determined by older cohorts' opinions which depend on past childcare practices.

#### 3.1 Household Problem

We study an overlapping generations economy in which women and men live up to age  $J$ . To focus on fertility and childcare decisions, we assume individuals simply consume their labor income before and after age  $J_f$  – a period where individuals form couples and engage in a bargaining problem.

A couple comprises a woman and a man, indexed by gender  $g \in \{\varnothing, \sigma\}$ . They choose individual consumption  $c^g$ , childcare contributions  $l^g$ , and the number of children  $n$ , which is a household-shared decision. We use  $t$  to denote time. Gender-specific market wages, denoted  $w_t^g$ , are exogenous and reflect technological changes impacting labor demand differentially by gender (Ngai and Petrongolo 2017).<sup>2</sup>

Individual's preference over fertility and consumption are given by:

$$u^g(c^g, n) = c^g + \gamma \cdot \frac{n^{1-\rho} - 1}{1 - \rho} \quad \rho > 0 \quad (4)$$

where  $c^g$  represents personal consumption and  $n$  the number of children. The parameters  $\gamma$  and  $\rho$  control the weight and curvature of fertility  $n$  in the utility function, respectively.

Raising each child incurs a time cost  $\phi$ . Thus, to support  $n$  children, the couple must satisfy the childcare provision constraint:

$$n\phi = \left( (l^{\varnothing})^{\frac{\sigma-1}{\sigma}} + (l^{\sigma})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 1 \quad (5)$$

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<sup>2</sup>Alternatively, we could model structural change via time-varying, gender-specific labor demand, with equilibrium wages determined by market clearing. However, as this paper focuses on household-level fertility and childcare responses, we adopt the simpler exogenous wage approach.

where  $l^\varnothing$  and  $l^\sigma$  denote childcare time from the woman and man, respectively, and  $\sigma$  governs the substitutability of their contributions.

Following [Doepke and Kindermann \(2019\)](#), we assume that spouses bargain over fertility and childcare under partial commitment. The decision-making timeline is outlined below.

#### *First Stage: Childcare Arrangements*

The couple first determines a plan for childcare allocation, conditional on having  $n$  children, and commits to this decision post-childbirth.<sup>3</sup> For all  $n$ , the couple solves:

$$\min_{l^\varnothing, l^\sigma} w_t^\varnothing l^\varnothing + w_t^\sigma l^\sigma + \lambda \cdot w_t^\sigma \cdot \left( \frac{l^\varnothing}{l^\sigma} - \eta_t \right)^2, \quad (6)$$

subject to the childcare constraint (5). Here,  $w_t^\varnothing l^\varnothing + w_t^\sigma l^\sigma$  represents the opportunity cost of childcare in the units of consumption goods, while  $\lambda \cdot w_t^\sigma \cdot \left( \frac{l^\varnothing}{l^\sigma} - \eta_t \right)^2$  captures psychic costs from deviating from the prevailing social norm,  $\eta_t$ , which is taken as given by parents at time  $t$ . The parameter  $\lambda$  governs the intensity of these social pressure costs. We scale the psychic cost by  $w_t^\sigma$  so that what matters for the childcare allocation is the gender wage gap  $w_t^\varnothing / w_t^\sigma$  rather than the universal wage levels. The solutions to this cost-minimization problem, denoted  $l_t^\varnothing(n)$  and  $l_t^\sigma(n)$ , represent optimal childcare allocation under the influence of the social norm.

#### *Second Stage: Bargaining over Fertility*

Next, the couple negotiates the number of children,  $n_t$ . Only mutually agreed-upon fertility is realized, defined as:

$$n_t = \min\{n_t^\varnothing, n_t^\sigma\}, \quad (7)$$

where  $n_t^g$  is the fertility level that maximizes the ex-post utility of gender  $g \in \{\varnothing, \sigma\}$  in the third stage.

#### *Third Stage: Bargaining over Consumption*

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<sup>3</sup>[Doepke and Kindermann \(2019\)](#) justifies this commitment by noting that childcare decisions involve significant switching costs and advance planning (e.g., securing daycare slots before birth) and interact with persistent choices like residential location, which affects childcare availability.

Post-childbirth, the couple implements the agreed childcare arrangement  $l_t^g(n)$  and bargains over consumption  $c^g(n)$ . If the couple ends up having  $n$  children, each gender's outside option in the non-cooperative case is:

$$\bar{u}^g(n) = w_t^g(1 - l_t^g(n)) + \gamma \cdot \frac{n^{1-\rho} - 1}{1 - \rho}, \quad \rho > 0, \quad (8)$$

reflecting consumption of residual labor income after childcare.

If they cooperate, the Nash bargaining problem is:

$$\max_{c^\varnothing, c^\sigma} \left( u^\varnothing(c^\varnothing, n) - \bar{u}^\varnothing(n) \right)^{1/2} \cdot \left( u^\sigma(c^\sigma, n) - \bar{u}^\sigma(n) \right)^{1/2}, \quad (9)$$

subject to the budget constraint:

$$c^\varnothing + c^\sigma = (1 + \alpha) \cdot [w_t^\varnothing(1 - l_t^\varnothing(n)) + w_t^\sigma(1 - l_t^\sigma(n))], \quad (10)$$

where  $\alpha$  captures economies of scale from cooperation. Following [Doepke and Kindermann \(2019\)](#), we assign each spouse equal bargaining power (one-half).

### 3.2 Endogenous Social Norm

A novel feature of this model is that the prevailing social norm is endogenously determined. Unlike exogenous social norm assumption used in the literature, we posit that the social norm at time  $t$ , denoted  $\eta_t$ , emerges as a weighted average of the *opinions* expressed by the other members in the society, which in turn depends on the childcare practices in the past. This dynamic process ties current norms to historical household decisions, capturing both social pressure and reevaluation by older cohorts.

Specifically, the prevailing social norm at time  $t$  is defined as:

$$\eta_t = \sum_{j=1}^{J-J_f} \phi_{J_f+j,t} \cdot \tilde{\eta}_{J_f+j}, \quad \sum_{j=1}^{J-J_f} \phi_{J_f+j,t} = 1, \quad (11)$$

where  $\tilde{\eta}_{J_f+j}$  represents the opinions of childcare allocation expressed by the cohort at

age  $J_f + j$  at time  $t$ , and  $\phi_{J_f+j,t}$  is the weight assigned to that cohort's influence. This weight reflects the share of households aged  $J_f + j$  at time  $t$  among the subpopulation older than  $J_f$ , calculated as:

$$\phi_{j,t} = \frac{\pi_{j,t}}{\sum_{k=J_f+1}^J \pi_{k,t}}, \quad (12)$$

where  $\pi_{j,t}$  denotes the population share of the cohort aged  $j$  at time  $t$ . These weights ensure that the influence of past decisions is proportional to the relative size of each cohort.

We assume that older cohorts form opinions by solving the following minimization problem:

$$\tilde{\eta}_{J_f+j} = \arg \min_{\eta} w_t^{\circ} \cdot \eta + w_t^{\sigma} + \psi \cdot \left( \eta - \frac{l_{t-j}^{\circ}}{l_{t-j}^{\sigma}} \right)^2. \quad (13)$$

where  $\frac{l_{t-j}^{\circ}}{l_{t-j}^{\sigma}}$  measures the childcare practice adopted by these agents  $j$  periods ago.

This minimization problem reflects changes in social norms within cohorts, where older generations re-evaluate the situation given the prevailing market wage, and choose the opinion they express to the current parents. Parameter  $\psi$  governs the utility costs of deviating from their own past choice, i.e., stubbornness. If they are perfectly altruistic towards the current parents, they would simply discard their own past decisions and minimize the opportunity costs of childcare, i.e.,  $\psi = 0$ . However, if  $\psi$  is high, they will express opinions that are more in line with how they brought up their own children  $j$  periods ago.

### 3.3 Population Dynamics

The demographic structure of this economy, denoted  $\{\pi_{j,t}\}_{j=1}^J$ , evolves endogenously according to a law of motion driven by the fertility rate  $n_t$ .

Let  $\boldsymbol{\pi}_t = (\pi_{1,t}, \dots, \pi_{J,t})^T$  represent the population distribution across age groups at time  $t$ , where  $\pi_{j,t}$  is the share of individuals aged  $j$ . The population dynamics are governed by:

$$\boldsymbol{\pi}_{t+1} = \frac{\boldsymbol{\Pi}_t \cdot \boldsymbol{\pi}_t}{\|\boldsymbol{\Pi}_t \cdot \boldsymbol{\pi}_t\|_{L^2}}, \quad (14)$$

where  $\Pi_t$  is a  $J \times J$  demographic transition matrix.

The matrix  $\Pi_t$  has two key features: (1) elements in the  $j$ -th row and  $(j+1)$ -th column equal 1, reflecting aging from age  $j$  to  $j+1$ , and (2) the element in the first row and  $J_f$ -th column equals  $n_t/2.1$ , representing births from couples at age  $J_f$ , normalized by the replacement fertility rate (approximately 2.1 children per couple). The  $L^2$ -norm ensures the population shares sum to 1, maintaining a normalized distribution over time.

### 3.4 Model Solution

We now outline the solution algorithms for the model's steady state and transition path.

**Steady-State Solution** The steady state is computed using an iterative method that converges to a social norm consistent with household decisions:

1. Guess an initial social norm  $\eta$ .
2. Given  $\eta$ , solve the childcare arrangement problem (6) subject to the childcare constraint (5), yielding optimal childcare functions  $l^\varnothing(n)$  and  $l^\sigma(n)$ .
3. Using  $l^\varnothing(n)$  and  $l^\sigma(n)$ , calculate each gender's outside option utility,  $\bar{u}^g(n)$ , for  $g \in \{\varnothing, \sigma\}$ .
4. With the outside options, solve the Nash bargaining problem for consumption  $c^g(n)$  and utility  $u^g(n)$ , conditional on  $n$ .
5. Maximize each gender's utility,  $n^g = \arg \max_n u^g(n)$ , to determine desired fertility. The realized fertility is  $n = \min\{n^\varnothing, n^\sigma\}$ , with associated childcare arrangements  $l^\varnothing(n)$  and  $l^\sigma(n)$ .
6. Compute the implied social norm,  $\tilde{\eta} = l^\varnothing(n)/l^\sigma(n)$ . Update  $\eta$  and iterate until  $|\eta - \tilde{\eta}| < \epsilon$ , for a small tolerance  $\epsilon > 0$ .

**Transition Path** To compute the economy's dynamics, starting from any initial state (not necessarily the steady state), we use forward iteration:

1. Given the current social norm  $\eta_t$ , solve the static household optimization problem to obtain  $n_t$ ,  $l^\varnothing(n_t)$ , and  $l^\sigma(n_t)$ .
2. Using the current demographic structure  $\pi_t$  and fertility rate  $n_t$ , update the population distribution to  $\pi_{t+1}$  via Equation (14).
3. With  $\pi_{t+1}$  and the history of childcare arrangements  $\{l_{t-j}^\varnothing, l_{t-j}^\sigma\}_{j=0}^{J-J_f}$ , calculate tomorrow's social norm  $\eta_{t+1}$  using Equation (11) after solving the every older cohorts' minimization problem (13). Repeat from step 1 for the next period.

This iterative process captures the co-evolution of fertility, childcare norms, and population structure over time.

### 3.5 Mechanisms

The central prediction of this model is that fertility emerges from a dynamic tension between technological progress and evolving social norms. Technological change, by increasing women's relative wages, shifts the optimal childcare division toward greater gender equality for young couples making fertility decisions—absent social norm pressures. However, when social norms enforce traditional roles, requiring women to bear a disproportionate childcare burden, women prefer fewer children *ex ante*. This preference arises because raising children under such norms diminishes their utility in the outside option *ex post*, weakening their bargaining power over consumption within the household.

Conversely, social norms in this economy are endogenous, shaped by changes within- and between-cohort. Entering cohorts, influenced by improved labor market opportunities for women, may favor more equitable childcare arrangements. Older cohorts, aware of the changes in the gender wage gap, may also shift their positions and choose what opinions to express.

The evolution of the social norm thus stems from two sources. First, when new cohorts enter at age  $J_f$  and choose childcare contributions  $l^\varnothing$  and  $l^\sigma$  that diverge from established practices, they shift future norms toward their preferences. For instance, a



cohort opting for more egalitarian childcare ratios will incrementally reduce  $\eta_t$  in subsequent periods. This channel reflects between-cohort changes, also known as the cohort replacement effects.

Second, older cohorts choose the opinions they would like to express. This decision hinge on their past experiences, but also reflects their re-evaluation of the situation given the current conditions. This channel reflects within-cohort changes, also known as the social structural effects.

The influence of these two effects depends on the population weight of the corresponding cohort,  $\phi_{j,t}$ , which is itself an endogenous outcome of fertility decisions made by their parents' generation. Higher past fertility increases a cohort's size, amplifying its impact on  $\eta_t$ . This interplay between fertility, demographic structure, childcare choices, and opinions drives the norm's gradual adaptation over time.

Note that even though the social norm adjusts through both within- and between-cohort effects, the adaptation speed might still be slower than the rapid changes in technology. Therefore, the model predicts a non-monotonic fertility response to technological change that boosts women's wages. Initially, fertility declines sharply as the social norm lags, reflecting entrenched gender roles. Over time, as the social norm adjusts toward equality, fertility recovers. This transition highlights the interplay between short-term path-dependence and long-term adaptation.

The advantage of explicitly modeling the social norm is that we can quantify the above-mentioned channels and make numerical predictions. In the next section, we calibrate the model and conduct counterfactual analyses in the subsequent sections.

## 4. Calibration

This section outlines the calibration strategy and data sources, and presents the calibrated parameter values.

## 4.1 Identification Strategy

We calibrate the model to replicate key data moments from South Korea over the period 1999–2014. The parameters to be calibrated are:

$$\underbrace{J, J_f}_{\text{demographics}}, \quad \underbrace{\gamma, \rho, \psi, \lambda}_{\text{preferences}}, \quad \underbrace{\phi, \sigma, \alpha}_{\text{technologies}}.$$

Several parameters are directly sourced from the literature. The economies of scale from spousal cooperation,  $\alpha$ , is set to 1.2, following [Doepke and Kindermann \(2019\)](#). The time cost per child,  $\phi$ , is fixed at 0.15, based on [de La Croix and Doepke \(2003\)](#). We define each period as 5 years, setting  $J = 16$  (total lifespan of 80 years) and  $J_f = 6$  (child-bearing between 25 to 30) to align with South Korea’s life expectancy of approximately 80 years and a mean childbirth age of 25–30 during the study period.

The remaining parameters are calibrated to match the transition path of the South Korean economy from 1999 to 2014. In particular, we choose the exogenous time series for gender-specific wages,  $w_t^{\text{♀}}$  and  $w_t^{\text{♂}}$  to match the GDP per capita and gender wage gap statistics collected from the OECD database. Then, we simulate the path of the economy and ask the model to fit the observed trajectories of fertility, gender gaps in childcare responsibilities, and the share of within-cohort effects in social norm changes.

We collect fertility data from the United Nations. Gender-specific childcare time is computed using the micro-level data from the Korea Time Use Survey (KTUS) following the strategy of [Park \(2021\)](#). Lastly, we use the micro-level data from the Korean General Social Survey (KGSS) to compute the share of within-cohort effects in driving social norm changes. To be more specific, for any variable  $Y$ , we first compute the change in average over time, i.e., the gap between  $\bar{Y}_{\text{start time}}$  and  $\bar{Y}_{\text{end time}}$ . To compute within-cohort changes, we identify the cohorts that have more than  $N$  observations both at the start time and the end time. Then, we restrict the samples to the individuals from these cohorts, and compute how much  $Y$  changes over time in this sample, i.e., the gap between  $\bar{Y}_{\text{start time}}^{\text{subsample}}$  and  $\bar{Y}_{\text{end time}}^{\text{subsample}}$ . The ratio between these two gaps measures the importance of within-cohort effects, and is used as a targeted moment. In the KGSS data,

we evaluate this ratio for three variables as  $Y$ :

1. SEXROLE1: Opinions on gender roles: It is more important for a wife to help her husband's career than to pursue her own career,
2. SEXROLE2: Opinions on gender roles: A husband's job is to earn money; a wife's job is to look after the home and family, and
3. HBBYWK08: Agree or disagree: Husband's job is to earn money; wife's job is to look after the home and family.

For all three cases, we find that the ratio is close to 0.8, implying an important role for within-cohort effects in driving the broader social norm change in South Korea in the study period.

Although all parameters jointly influence the model's moments, certain moments provide stronger identification for specific parameters. Below, we outline the identification logic:

- The fertility weight,  $\gamma$ , is inferred from the initial fertility level in 1999, reflecting baseline preferences for children.
- The fertility curvature,  $\rho$ , governs the trade-off between consumption and fertility, identified by the fertility response to rising opportunity costs as wages increase for both genders.
- The childcare substitutability,  $\sigma$ , is determined by the initial gender gap in childcare time. Higher substitutability amplifies the initial gender gap by allowing greater specialization.
- The weight of individual's own experience in the formation of opinions, i.e., "stubbornness",  $\psi$ , is calibrated to match the share of between-cohort component in driving social norm changes. Smaller  $\psi$  leads to larger within-cohort effects.
- The social pressure parameter,  $\lambda$ , is calibrated to the persistence of gender gaps in childcare over time. A higher  $\lambda$  implies stronger resistance to change, as young couples face greater pressure from older cohorts' norms.

This strategy ensures the model captures both the levels and dynamics of fertility and childcare in South Korea over the calibration period.

## 4.2 Calibration Results

Table 2 presents the calibrated parameters alongside the corresponding data moments. The model closely replicates the observed trajectories of fertility and gender gaps in childcare responsibilities in South Korea from 1999 to 2014.

Table 2: Calibrated Parameters

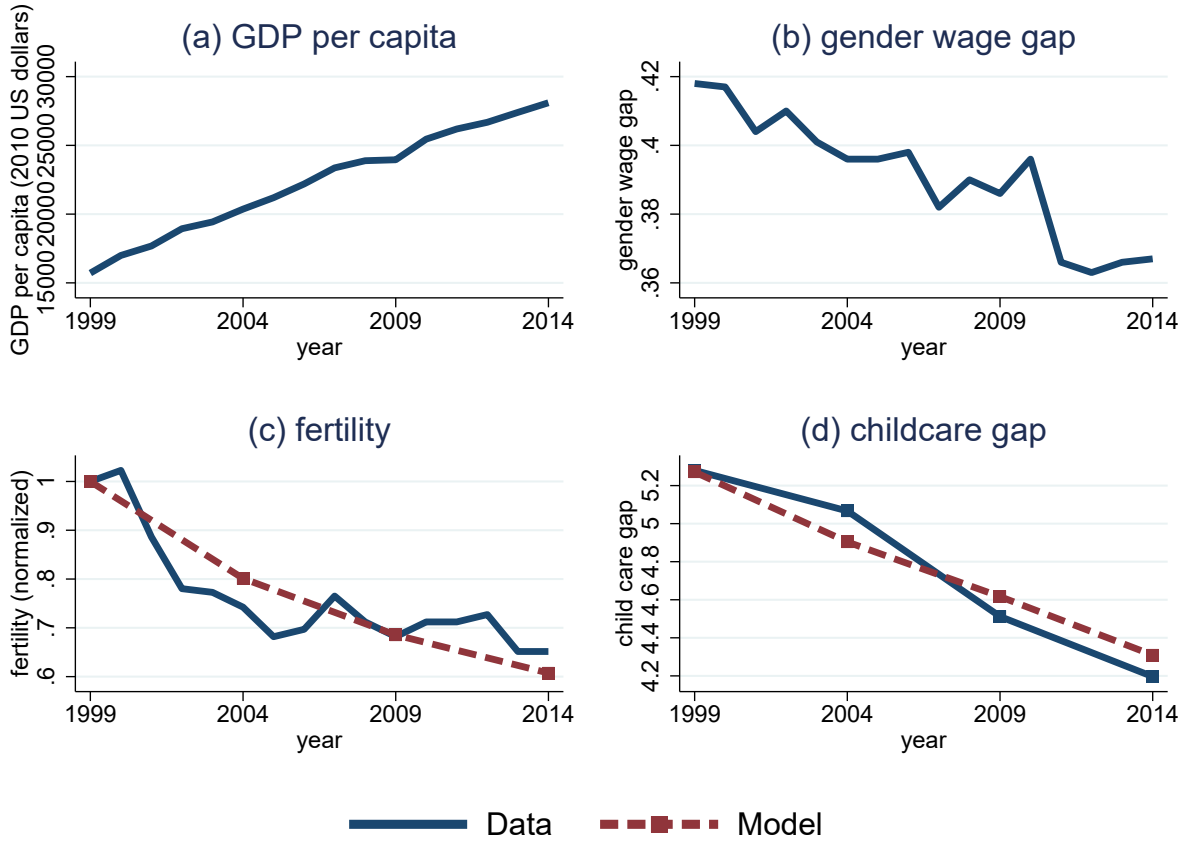
	Parameter	Value	Data moment	Source	Model fit
$\gamma$	Fertility weight	0.24	$n_{1999} = 1.42$	United Nations	1.42
$\sigma$	Childcare substitutability	3.05	$\eta_{1999} = 5.25$	Park (2021)	5.25
$\rho$	Fertility curvature	2.4	$n_{1999} \sim n_{2014}$	United Nations	See Figure 2
$\psi$	Stubbornness	3.0	Within-cohort effects	KGSS	80%
$\lambda$	Social pressure	0.0006	$\eta_{1999} \sim \eta_{2014}$	Park (2021)	See Figure 2
$\alpha$	Economies of scale	1.2	Doepke and Kindermann (2019)		
$\phi$	Time costs per child	0.15	de La Croix and Doepke (2003)		
$J$	Total number of periods	16	80 years	World Health Organization	
$J_f$	The fertile period	6	25 to 30 yo	Statista	

The calibrated childcare substitutability,  $\sigma = 3.05$ , aligns closely with the value of 3.03 reported by Knowles (2013). Similarly, the social pressure parameter,  $\lambda = 0.0006$ , yields psychic costs comparable to those in Myong et al. (2021) and Kim et al. (2024). To illustrate these parameters' implications and the model's mechanisms, Table 3 compares childcare gaps and fertility across three scenarios.

The first scenario “old tech. & old norm” depicts a steady-state economy with a large gender wage gap ( $w^{\varphi}/w^{\sigma} = 0.58$ ). Here, women shoulder 5.25 times more childcare than men, consistent with the prevailing social norm ( $\eta = 5.25$ ). Young couples' choices align with this norm, resulting in a fertility rate of  $n = 1.43$ .

The second scenario “new tech. & new norm” represents a new steady state with a narrower wage gap ( $w^{\varphi}/w^{\sigma} = 0.74$ ). Reduced wage disparity lowers the opportunity

Figure 2: Calibration and Model Fit



cost of men's childcare time, shifting the optimal allocation to a more equitable  $l^{\varphi}/l^{\sigma} = 2.53$ , which matches the updated norm ( $\eta = 2.53$ ). Fertility dips slightly to  $n = 1.37$ , driven by the substitution effect between consumption and children, as parameterized by  $\rho$ .

The third scenario "new tech. & old norm" explores a transitional case where technology narrows the wage gap to  $w^{\varphi}/w^{\sigma} = 0.74$ , but the social norm remains fixed at  $\eta = 5.25$ . Young couples, constrained by this norm, settle on a childcare division of  $l^{\varphi}/l^{\sigma} = 4.66$ , balancing monetary and psychic costs. The unequal allocation worsens women's outside option, leading them to favor fewer children. With fertility determined by mutual agreement, the result is  $n = 1.32$ —notably lower than the long-run equilibrium in the second scenario. The psychic cost of adopting the egalitarian allocation ( $l^{\varphi}/l^{\sigma} = 2.53$ ) under the old norm amounts to 3.48% of child-rearing costs, similar to

the 4.3% estimated by [Myong et al. \(2021\)](#) and [Kim et al. \(2024\)](#).

**Table 3:** Three Different Cases

	Old tech. & old norm	New tech. & new norm	New tech. & old norm
$w^{\varnothing}/w^{\sigma}$	0.58	0.74	0.74
$\eta$	5.25	2.53	5.25
$l^{\varnothing}/l^{\sigma}$	5.25	2.53	4.66
$n$	1.43	1.37	1.32

These results highlight the model’s ability to capture both steady-state outcomes and transitional dynamics driven by technology and social norms.

## 5. Counterfactual Analysis

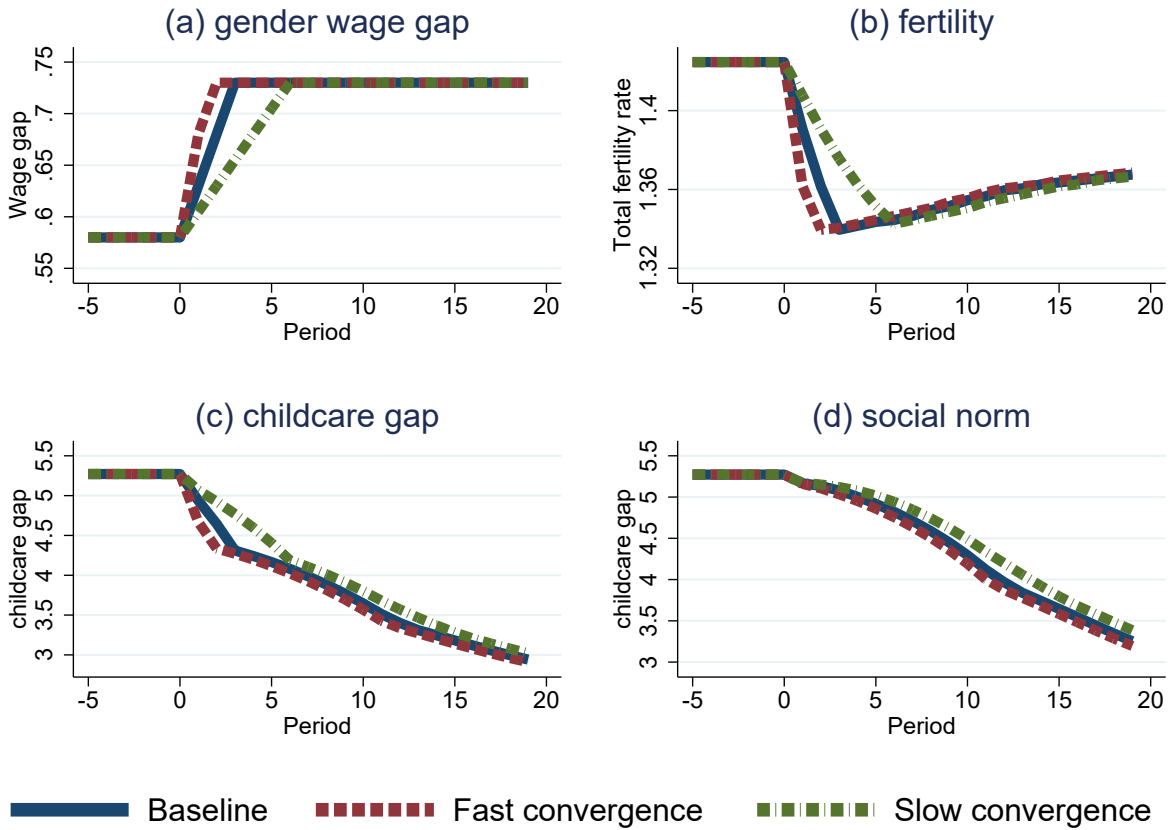
This section conducts counterfactual experiments to explore how technological change, social norms, and policy interventions affect fertility, childcare allocation, and social norms. To focus on technological impacts via the gender wage gap, we hold men’s wages,  $w_t^{\sigma}$ , constant, letting variations in  $w_t^{\varnothing}$  drive the results. We analyze four scenarios, with outcomes depicted in [Figures 3, 4, 5, and 6](#), each plotting the trajectories of (a) gender wage gap, (b) fertility, (c) childcare gap, and (d) social norm.

### 5.1 Speed of Structural Change

We first examine how the pace of structural change influences the economy’s dynamics, comparing a baseline path to fast and slow convergence scenarios. Starting from the 1999 steady state (gender wage gap of 42% ( $w_t^{\varnothing}/w_t^{\sigma} = 0.58$ )), we simulate a reduction to 27% ( $w_t^{\varnothing}/w_t^{\sigma} = 0.73$ ), as observed in South Korea by 2014. In the baseline, this convergence occurs over 15 years (1999–2014). The fast convergence scenario compresses it to 10 years (1999–2009), while the slow convergence scenario extends it to 25 years (1999–2024). [Figure 3](#) presents these results.

In the fast convergence case, the gender wage gap (panel a) declines sharply, outpacing the adjustment of the social norm (panel d), which remains near its initial value of 5.25 for several years due to cohort replacement lags and limited re-evaluation by older cohorts. This mismatch drives a rapid fertility decline (panel b), dropping from 1.43 to approximately 1.33 within a decade, as women, facing higher opportunity costs, prefer fewer children under a norm favoring unequal childcare (panel c,  $l_t^{\varnothing}/l_t^{\sigma} \approx 5.0$ ). Over time, as entering cohorts adopt more equitable allocations, the childcare gap and norm converge toward 3, and fertility recovers to 1.37 by 2024. The slow convergence case shows a smoother transition: the gender wage gap declines gradually, allowing the social norm and childcare gap to adjust in tandem (e.g.,  $\eta_t$  and  $l_t^{\varnothing}/l_t^{\sigma}$  fall steadily to 5 and 4.3 by 2014 respectively), with fertility dipping only to 1.35 before stabilizing. The baseline lies between these, with fertility falling to 1.33 by 2014, consistent with calibration.

Figure 3: The Role of Structural Change



Notably, the paths of the childcare gap ( $l_t^{\text{♀}}/l_t^{\text{♂}}$ ) and social norm ( $\eta_t$ ) remain broadly similar across scenarios and to the calibrated baseline. This stability reflects the strong social pressure parameter ( $\lambda = 0.0006$ ), which penalizes deviations from traditional practices, and limited re-evaluation by older cohorts ( $\psi = 3$ ). Even as women’s wages rise, young couples adjust childcare allocations incrementally, constrained by the psychic costs of defying a norm shaped by older generations, who express opinions that are similar to their own past practices. The primary divergence thus lies in fertility, underscoring its sensitivity to the timing of structural change relative to norm evolution.

These results, depicted in Figure 3, highlight a non-monotonic fertility response consistent with the model’s mechanisms: rapid technological shifts exacerbate short-term fertility declines by amplifying the tension between economic opportunities and social constraints, while slower changes allow for smoother transitions in fertility.

## 5.2 The Role of Social Pressure

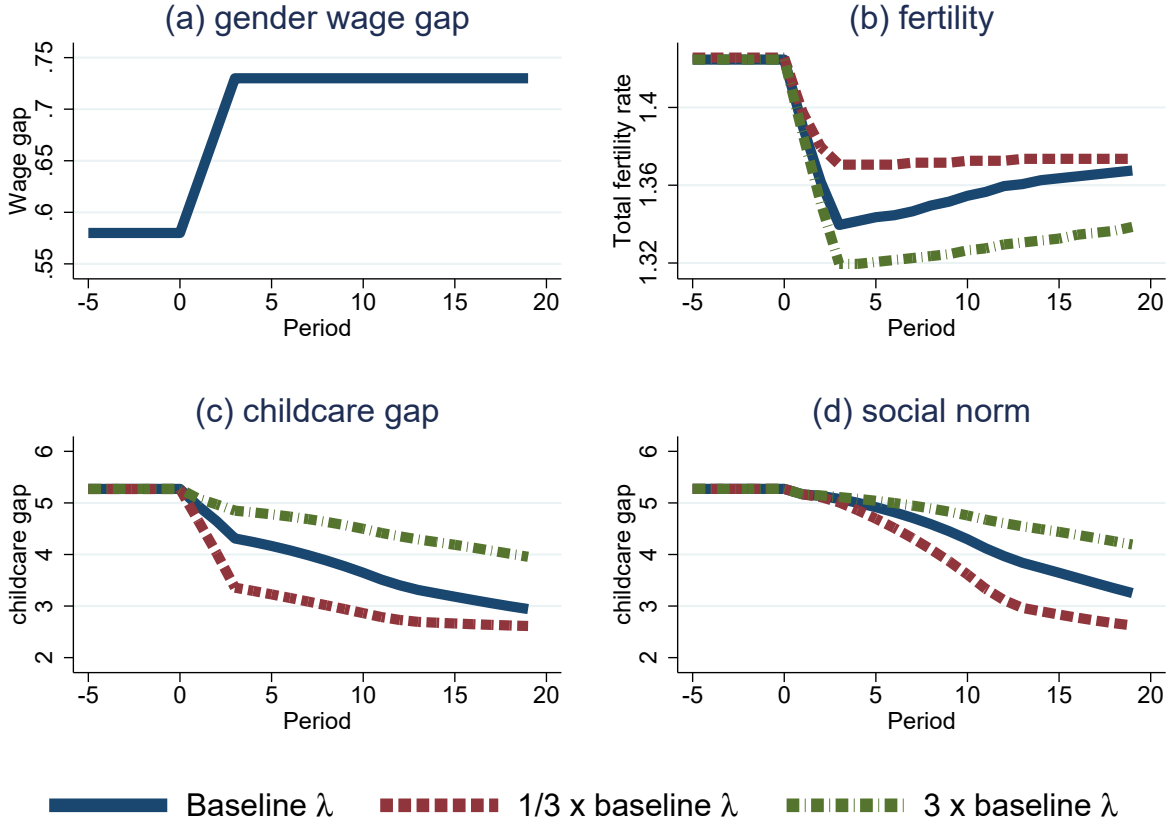
Next, we assess how social pressure modulates the response to structural change. We simulate the baseline 15-year wage gap convergence (42% to 27%) under three levels of social pressure: the calibrated  $\lambda = 0.0006$  (baseline), a lower  $\lambda = 0.0002$  (weak pressure), and a higher  $\lambda = 0.0018$  (strong pressure). Figure 4 displays the outcomes.

With weak social pressure, the gender wage gap’s decline (panel a) prompts a swift reduction in the childcare gap (panel c), falling from 5.25 to 3.3 within 15 years, as couples face lower psychic costs for equitable allocations. The social norm (panel d) follows suit, dropping to 4.8 by 2014, accelerating fertility convergence (panel b) to the long-run level of 1.37. Strong pressure, conversely, locks the childcare gap near 5.0 and the norm near 5.25 for longer, deepening the fertility drop to 1.32 by 2014, with minimal recovery thereafter. The baseline case shows intermediate dynamics: the childcare gap declines to 4.4 and the norm to 4.9 by 2014, with fertility at 1.33.

These findings, shown in Figure 4, underscore social pressure as a critical amplifier of technological shocks. Lower  $\lambda$  facilitates a smoother transition by reducing the tension between rising female wages and lagging norms, while higher  $\lambda$  intensifies short-term



Figure 4: The Role of Social Pressure



fertility losses and prolongs inequitable childcare burdens.

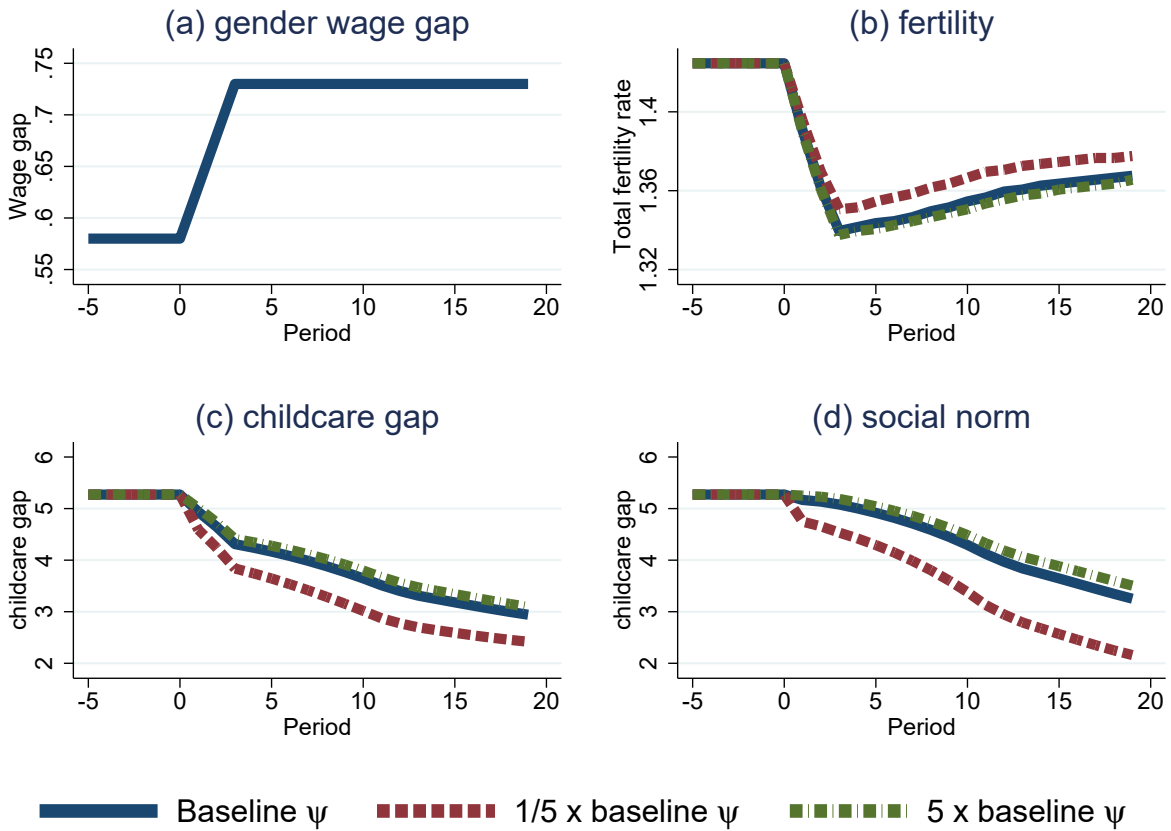
### 5.3 The Role of Older Cohorts' Re-evaluation

Next, we assess how the re-evaluation by older cohorts when they form social opinions affect the economy's response to structural change. We simulate the baseline 15-year wage gap convergence (42% to 27%) under three levels of "stubbornness": the calibrated  $\psi = 3.0$  (baseline), a lower  $\psi = 1.0$  (low "stubbornness"), and a higher  $\psi = 9.0$  (high "stubbornness"). Figure 5 displays the outcomes.

With low "stubbornness", the gender wage gap's decline (panel a) prompts a faster reduction in the childcare gap (panel c), as older cohorts express more egalitarian opinions and exert lower psychic costs for young couples. The social norm (panel d) con-

verges faster to the new steady state, accelerating fertility convergence (panel b) to the long-run level of 1.37. High “stubbornness”, conversely, locks the childcare gap and the social norm at the original level for longer. The baseline case shows intermediate dynamics: the childcare gap declines to 4.4 and the norm to 4.9 by 2014, with fertility at 1.33.

Figure 5: The Role of Older Cohorts’ Reevaluation



These findings, shown in Figure 5, underscore the re-evaluation by older cohorts as another important amplifier of technological shocks. Lower  $\psi$  facilitates a smoother transition by reducing the tension between rising female wages and lagging norms, while higher  $\lambda$  intensifies short-term fertility losses and prolongs inequitable childcare burdens.

## 5.4 Policy Evaluation

Finally, we evaluate a policy reducing the initial social norm by 1 unit (from 5.25 to 4.25 in 2004), simulating a campaign for egalitarian childcare, applied alongside the baseline 15-year wage convergence. Figure 6 compares this to the no-policy baseline.

The policy lowers the social norm (panel d) immediately, easing the childcare gap's decline (panel c) to 4.2 by 2004 (vs. 5.0 without policy), as couples adjust allocations with reduced psychic costs. Fertility (panel b) is slightly higher in the short run (e.g., 1.40 vs. 1.39 by 2004). Over the medium term, the norm falls further (e.g., to 4.2 by 2014 vs. 5.1), boosting fertility to 1.36 (vs. 1.34 without the policy), reflecting larger cohorts' influence. These modest gains compound, amplifying long-term population differences.

Figure 6: Changing Initial Social Norm

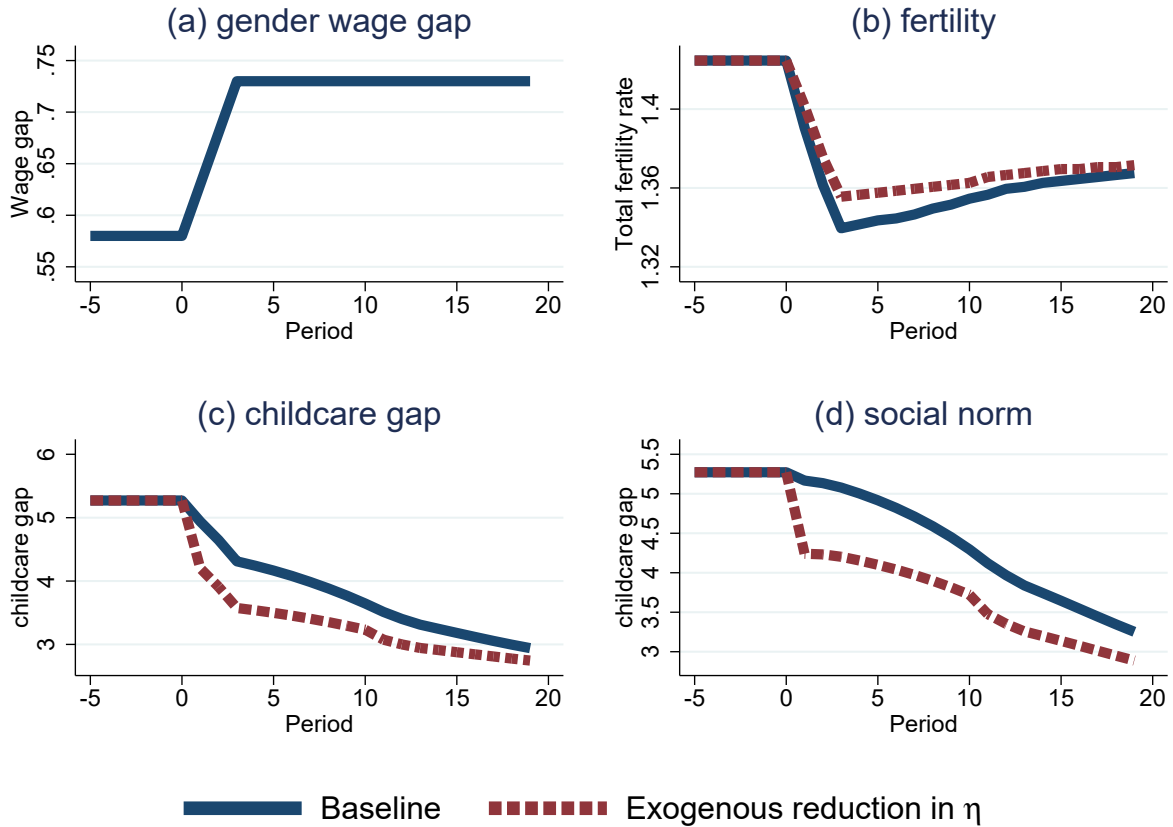


Figure 6 illustrates these dynamics, highlighting the policy's role in breaking norm

inertia. While short-run effects are modest due to persistent social norm, the medium- and long-run benefits, i.e., higher fertility and a larger population, suggest that norm-targeted interventions could effectively mitigate the adverse fertility consequences of rapid technological change. The difference between policy effects over time also highlights the importance of having a dynamic perspective in policy evaluation.

## 6. Robustness

This section discusses the robustness of our calibration and model specification.

### 6.1 Initial State

One limitation of our baseline calibration is the assumption that the initial gender gap in childcare responsibilities among young couples in 1999 (i.e.,  $l_{1999}^{\text{♀}}/l_{1999}^{\text{♂}} = 5.25$ ) reflects the prevailing social norm,  $\eta_{1999}$ . Ideally,  $\eta_t$  should aggregate the opinions of old cohorts, as specified in Equation (11), which depends on historical childcare practices before 1999, but such data are unavailable to the best of our knowledge. To test the sensitivity of our results to this assumption, we experimented with initial norms more unequal than the observed 1999 value—e.g., setting  $\eta_{1999} = 6.0$  or  $6.5$ , implying greater gender gaps among older generations. Alternatively, we have experimented a specification where we assume the economy was in the steady state in 1950 with a gender wage gap  $w^{\text{♀}}/w^{\text{♂}} = 0.3$ , whereas the episode we observe between 1999 to 2014 is part of the transition path. Recalibrating the model under these conditions, we find that the quantitative outcomes, including fertility paths ( $n_t$ ), childcare allocations ( $l_t^{\text{♀}}/l_t^{\text{♂}}$ ), and norm evolution ( $\eta_t$ ), remain consistent with the baseline. The counterfactual results also remain unaffected.

### 6.2 Rising Childcare Cost

A second concern is the potential rise in childcare costs over time, which could confound the effects of wage convergence on fertility. For instance, [Kim et al. \(2024\)](#) docu-

ment increasing parental investment due to status competition, a trend that may elevate the time cost per child,  $\phi$ . To explore this, we modify the model to allow  $\phi$  to vary over the calibration period (1999–2014), calibrating its increase to match the rising parental childcare time reported by [Park \(2021\)](#).

Specifically, we assume  $\phi_t$  grows linearly from 0.15 in 1999 to 0.20 by 2014, reflecting intensified child-rearing demands. Incorporating this time-varying  $\phi_t$  requires adjustments to two parameters. First, the fertility curvature,  $\rho$ , rises from 2.4 to 3.4, as the observed fertility decline (e.g., from 1.42 to below 1.3) stems not only from productivity gains and wage gap convergence but also from higher childcare costs reducing the substitutability between consumption and children. Second, the fertility weight,  $\gamma$ , increases from 0.24 to 0.34 to maintain the initial fertility level ( $n_{1999} = 1.42$ ) despite the elevated  $\phi_{1999}$ . The value of other parameters—such as  $\sigma$ ,  $\psi$ , and  $\lambda$ —remains unaffected. Critically, the model’s fit to the 1999–2014 fertility and childcare gap trajectories, as well as the counterfactual predictions (e.g., non-monotonic fertility responses), remains quantitatively similar to the baseline. The slightly higher  $\rho$  and  $\gamma$  amplify the fertility response to cost increases, but the core mechanisms—driven by wage gaps and norm dynamics—persist.

These robustness checks affirm that our key conclusions are not overly sensitive to the initial norm specification or the assumption of constant childcare costs. The model’s ability to accommodate these variations while preserving its predictive power underscores its reliability for analyzing the interplay of technology, norms, and fertility.

## 7. Conclusion

Fertility rates are declining globally, posing significant economic and demographic challenges. This paper documents an important pattern: fertility falls more precipitously in economies undergoing rapid structural change, with the decline amplified in societies where rigid social norms govern childcare responsibilities. To unpack this relationship, we develop a novel quantitative model of fertility bargaining, where equilibrium outcomes emerge from the interplay between technological progress—manifested as rising

female wages—and endogenous social norms shaped by past cohorts’ opinions, which hinges on the historical childcare practices. Our findings reveal that intense social pressure delays the transition to equitable childcare allocations, exacerbating short-term fertility declines and entrenching traditional gender roles. Yet, the model also predicts a gradual fertility recovery as norms evolve through cohort replacement, a process that policies promoting gender equality can accelerate.

Calibrated to South Korea’s experience from 1999 to 2014, our model closely matches the observed trajectories of fertility and childcare gaps, capturing the tension between wage convergence and norm inertia. Counterfactual analyses highlight the pivotal role of adjustment speed: rapid technological change outpaces norm evolution, driving sharper fertility drops, while weaker social pressure, more re-evaluation by older cohorts, or norm-shifting policies mitigate these declines and hasten recovery.

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