Endogenous Fertility and Retirement Policy*

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Abstract

In a pay-as-you-go (PAYG) pension system, the welfare effects of fertility depend on the fiscal instrument through which the pension balance is restored. In standard analyses, where the pension budget is balanced by adjusting contribution rates or pension benefits, fertility generates a positive fiscal externality because additional children expand the future contributor base, implying that decentralized fertility is inefficiently low. However, pension systems are often adjusted through the retirement age. When retirement is the equilibrating margin, higher fertility not only improves pension financing but also allows earlier retirement, creating an additional retirement-leisure channel. In a simple overlapping-generation model with PAYG pension system, decentralized fertility can therefore be either too high or too low relative to the social optimum. The sign of the distortion depends on whether the retirement age required for PAYG balance is above or below the retirement age households would prefer, given the contribution rate and pension benefits.

JEL classification: H55, J11, J13, J26

Keywords: Fertility, Retirement, Pay-as-you-go pensions, Pension reform, Demographic change.

1 Introduction

Fertility rates across almost all OECD countries have remained below the replacement level of 2.1 for decades and continue to decline (Kearney and Levine, 2025). In several advanced economies, including South Korea, Italy, and Spain, total fertility has fallen below 1.3. This trend has many macroeconomic implications, but it is especially relevant for

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the sustainability of public pension systems, most of which are organized on a pay-as-you-go (PAYG) basis across OECD countries (Giupponi and Seibold, 2024). In such systems, current workers finance the pensions of current retirees, so lower fertility today implies a smaller contributor base tomorrow and therefore puts pressure on PAYG budgets. For this reason, the standard view is that decentralized fertility is inefficiently low: households do not internalize the positive fiscal externality generated by children, who enlarge the future tax base financing old-age transfers.

To preserve the long-run financial sustainability of PAYG systems, reforms can operate through three main margins: contribution rates, pension benefits, and the retirement age (OECD, 2025). Among these, increases in the statutory retirement age have become one of the central instruments of pension reform, with most OECD countries having legislated higher retirement ages for future cohorts (OECD, 2025). Yet most theoretical analyses examine environments in which pension balances are restored through contribution rates or pension benefits, with the retirement age fixed.

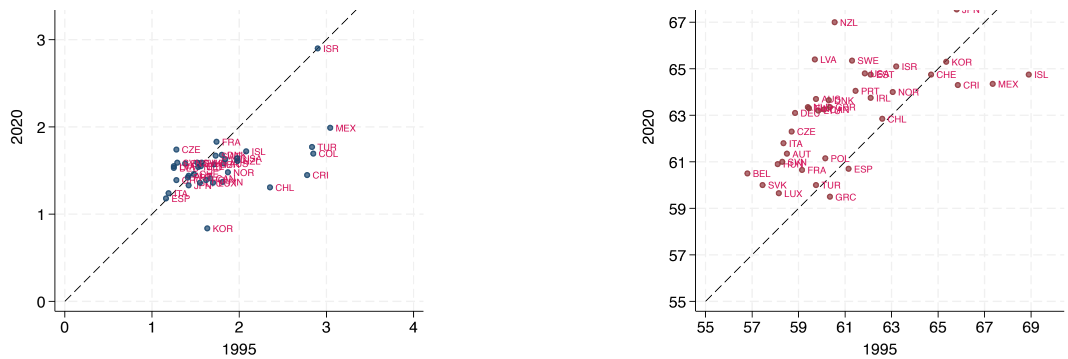
The relevance of this fertility-retirement link is also suggested by the data. Figure 1 illustrates this pattern by showing that, between 1995 and 2020, most OECD countries experienced both declining total fertility rates and rising effective retirement ages. Consistent with this pattern, using a panel of OECD countries over 1970-2023, we find that lower lagged fertility is associated with higher effective retirement ages.[1] These findings suggest that fertility matters for retirement policy not only through long-run demographic structure, but also through the fiscal pressures shaping pension reforms. This channel is likely to become increasingly relevant, as recent evidence points to a deceleration in longevity growth across high-income countries (Andrade et al., 2025), while fertility rates continue to decline worldwide (Bhattacharjee et al., 2024).

We study the fertility externality when the mandatory retirement age adjusts endogenously to maintain the PAYG balance. Higher fertility not only improves pension financing by increasing the future number of contributors, but also permits earlier retirement. Fertility therefore affects welfare through two channels: a standard financing externality and an additional retirement-leisure channel. As a result, decentralized fertility may be either inefficiently low or inefficiently high relative to the social optimum. This contrasts with standard analyses in which pension balance is restored through contribution rates or pension benefits and decentralized fertility is generally inefficiently low.

[1] In particular, we regress the effective retirement age on lagged total fertility rates (25-, 30-, 35-, 40-, 45-, and 50-year lags), controlling for life expectancy as well as country and year fixed effects. We find that a one-unit increase in the fertility rate 30-40 years earlier is associated with a reduction of approximately 1.6-2.2 years in the current effective retirement age, statistically significant at the 5% level and robust across alternative specifications. See appendix A.

Figure 1: Total Fertility Rate and Effective Retirement Age over time

Panel A: Total Fertility Rate　　　　Panel B: Effective Retirement Age



Notes: Each panel plots the 2020 value against the 1995 value for OECD countries. The dashed line is the 45-degree line. Points above the line indicate an increase over the period. Panel A shows the total fertility rate from the World Bank World Development Indicators. Panel B shows the effective labour market exit age from OECD Pensions at a Glance.

We formalize the interaction between fertility and retirement in a simple two-period overlapping-generations model with endogenous fertility and a PAYG pension system. We consider a small open economy with standard neoclassical technology and competitive factor markets, so that factor prices are constant. Contribution rates and pension benefits are exogenous, while the pension budget is balanced through adjustments in the mandatory retirement age.[2] We compare three allocations: a decentralized equilibrium in which households choose fertility taking pension policy as given; an unconstrained allocation in which households also choose retirement in the absence of the PAYG budget constraint; and a social planner allocation that internalizes the fiscal effects of fertility.

Our main result is that the sign of the fertility externality depends on whether the retirement age implied by PAYG balance is higher or lower than the age at which households would choose to retire, given the contribution rate and pension benefits. In particular, if PAYG balance requires agents to retire later than they would privately choose, decentralized fertility is inefficiently low relative to the social optimum; if it requires them to retire earlier, decentralized fertility is inefficiently high. Although the social planner allocation cannot be solved in closed form, it can be characterized by comparison with the decentralized and unconstrained allocations, both of which admit closed-form solutions. We show that the social planner retirement age always lies between the decentralized and unconstrained ones.

[2] In the model, retirement is compulsory at the statutory age. This simplification helps isolate the mechanism of interest. Pension systems are typically organized around statutory retirement ages that workers tend to follow. Consistent with this idea, Seibold (2021) documents substantial bunching at statutory retirement ages in Germany. More generally, minimum retirement-age limits are in place in most OECD countries, upper-age limits apply to broad categories of public employees, and disincentives to postpone the retirement age are largely spread (Simons et al., 2018; OECD, 2025).

The literature has already discussed several mechanism that lead fertility to differ from the social optimum in economies with PAYG pension systems. Furthermore, Van Groezen et al. (2003) shows that fertility in a PAYG economy generates a positive dependency-ratio externality, because additional children enlarge the future contributor base, but may also generate offsetting forces through capital accumulation. However there is a bright side of PAYG systems, (Sinn, 2004) argues that by pooling across households the old-age support that, allows individuals without children (voluntarily or involuntarily) to have support when old. Abìo et al. (2004) show that one way to achieve the optimum is by linking the retirement benefits to the number of the children. Much of the subsequent literature has emphasized the dependency-ratio externality, showing that PAYG pensions tend to depress fertility below the social optimum by socializing part of the fiscal return to childbearing (Cremer et al., 2006). Meier and Wrede (2010) includes the a quality- quantity trade off.. More recent work highlights additional mechanisms that may amplify or offset this result, including child quality, human capital investment, and capital dilution (Meier and Wrede, 2010; Cremer and Pestieau, 2011; Fan, 2022; Cipriani and Fioroni, 2024). Our paper contributes to this literature by showing that the sign of the fertility externality also depends on the fiscal instrument used to restore pension balance.

A related literature studies retirement age and pension reform in aging societies. Zhang and Zhang (2009) and Cipriani and Fioroni (2021) analyze the role of mandatory retirement, but focus primarily on the consequences of increased longevity. Dedry and Pestieau (2017) compare alternative retirement regimes and distinguish between aging driven by lower fertility and aging driven by higher longevity, but treat fertility as exogenous and study pension balance through adjustments in taxes or pension benefits rather than through the retirement margin. Our contribution is to make fertility endogenous and to show that, when retirement age is the equilibrating fiscal margin, the welfare effects of fertility are fundamentally altered.

The remainder of the paper is organized as follows. Section 2 presents the model environment and characterizes the decentralized, social planner, and unconstrained allocations. Section 3 compares these allocations and derives the main result on the sign of the fertility externality. Section 4 provides a numerical illustration of the mechanism and shows how the ranking of the different allocations varies with key parameters. Section 5 concludes and discusses policy implications. Details on the empirical evidence and the mathematical proofs are collected in appendices A and B, respectively.

2 Model

We consider a standard two-period overlapping-generations economy in discrete time, $t = 0, 1, 2, \ldots$. Agents live for two periods: they are young in the first and old in the second. Let N_t^y and N_t^o denote the size of the young and old generations, respectively, at time t. If

n_t is the per-capita fertility rate of the young at time t, demographic dynamics are given by:

$$N_{t+1}^y = N_t^y n_t, \qquad N_{t+1}^o = N_t^y. \tag{1}$$

Thus, each young cohort becomes old in the following period, while the size of the next young generation is proportional to current fertility.[3]

When young, agents supply one unit of labor inelastically, consume C_t^y, save S_t, and choose fertility n_t. When old, they supply $\phi_{t+1} \in [0, 1]$ units of labor, spend the remaining $1 - \phi_{t+1}$ units of time in retirement, and consume C_{t+1}^o. We interpret ϕ_{t+1} as a measure of retirement age. Preferences are given by:

$$\log C_t^y + \gamma \log n_t + \rho \left[\log C_{t+1}^o + \mu \log(1 - \phi_{t+1})\right], \tag{2}$$

where $\gamma > 0$ measures the preference for having children, $\rho > 0$ is the discount factor, and $\mu > 0$ captures the value of retirement leisure.[4]

Agents earn wage w per unit of labor, pay a payroll tax τ to finance a PAYG pension scheme, incur a per-child cost $\theta > 0$ when young, receive pension benefit b while retired, and earn the world interest rate R on savings when old.[5] Throughout, we assume $w(1 - \tau) > b$, so disposable labor income exceeds pension income. Individual budget constraints are:

$$C_t^y = w(1 - \tau) - \theta n_t - S_t, \tag{3}$$

$$C_{t+1}^o = S_t R + w(1 - \tau)\phi_{t+1} + b(1 - \phi_{t+1}). \tag{4}$$

The government balances the PAYG budget period by period by adjusting retirement age:

$$\tau w(N_t^y + \phi_t N_t^o) = b(1 - \phi_t)N_t^o. \tag{5}$$

Using equations (1) and (5), we define the retirement rule as a function of fertility rate, i.e., $\phi_{t+1} = \Phi(n_t)$, where:

$$\Phi(n_t) \equiv \frac{b}{b + \tau w} - \frac{\tau w}{b + \tau w} n_t. \tag{6}$$

Higher fertility increases the number of contributors relative to retirees and therefore relaxes

[3] In our framework, lifetime is constant and deterministic. For examples of studies investigating the role of time-varying or stochastic life expectancy, see Cipriani and Fioroni (2021) and Hwang and Kim (2023).

[4] It is worth mentioning that, in our framework, there is no interconnection between the welfare of different generations, even within the same household. Unlike Caballé and Fuster (2003), Zhang and Zhang (2009), and Córdoba and Ripoll (2016), parents derive utility from the number of children but not from their children's welfare. Unlike Prinz (1990) and Boldrin and Jones (2015), our adults do not rely on their children for support during retirement. Introducing and parameterizing intergenerational channels would not qualitatively affect our findings.

[5] We consider a small open economy such that the interest rate is constant and exogenously given, and assume that firms operate a standard neoclassical constant-returns production technology and competitive factor markets implying a constant wage w.

the pension budget, allowing earlier retirement, i.e., $\Phi'(n_t) < 0$.

2.1 Model solutions

We consider three environments. In the decentralized allocation (D), households choose consumption, savings, and fertility, taking the PAYG system as given and not internalizing the effect of fertility on the pension budget. In the unconstrained allocation (U), households are also allowed to choose retirement age directly, abstracting from the government budget constraint. This allocation need not satisfy PAYG balance and therefore is not a generally feasible equilibrium, its role being to identify the privately preferred retirement choice in the absence of the fiscal constraint. Finally, in the social planner allocation (S), the planner chooses fertility, taking into account that fertility affects the pension system through the retirement rule (6).

We begin with a compact formulation of the problem then derive the decentralized and unconstrained allocations, in closed form. Finally the social planner solution is implicitly characterized. Let define the problem in regimes $J \in \{D, U, S\}$ as:

$$\begin{aligned}\max_{\{C_t^y, n_t, \mathbf{1}_{J=U}\phi_{t+1}\}} \mathcal{L} \equiv\ & \log C_t^y + \gamma \log n_t \\ & + \rho \Big\{ \mathbf{1}_{J\in\{D,U\}} \Big[\log C_{t+1}^o\big(C_t^y, n_t, \phi_{t+1}\big) + \mu \log(1-\phi_{t+1}) \Big] \\ & + \mathbf{1}_{J=S} \Big[\log C_{t+1}^o\big(C_t^y, n_t, \Phi(n_t)\big) + \mu \log\big(1-\Phi(n_t)\big) \Big] \Big\},\end{aligned} \tag{7}$$

where ϕ_{t+1} is a choice variable only in regime U, and $C_{t+1}^o(\cdot)$ is derived by combining the consumption constraints (3) and (4). The corresponding first-order conditions are:

$$\frac{1}{C_t^y} = \frac{\rho R}{C_{t+1}^o}, \tag{8}$$

$$\frac{\gamma}{n_t} = -\frac{\rho}{C_{t+1}^o}\frac{\partial C_{t+1}^o}{\partial n_t} + \mathbf{1}_{J=S}\left(\frac{\rho\mu}{1-\Phi(n_t)} - \frac{\rho}{C_{t+1}^o}\frac{\partial C_{t+1}^o}{\partial \phi_{t+1}}\right)\frac{\partial \Phi(n_t)}{\partial n_t}, \tag{9}$$

$$0 = \mathbf{1}_{J=U}\left(\frac{1}{C_{t+1}^o}\frac{\partial C_{t+1}^o}{\partial \phi_{t+1}} - \frac{\mu}{1-\phi_{t+1}}\right). \tag{10}$$

Equation (8) is the standard Euler equation equating the marginal utility cost of reducing current consumption to the discounted marginal utility gain from higher future consumption. Equation (9) characterizes the fertility choice. In the decentralized and unconstrained environments, households equate the marginal utility gain from having more children to the marginal utility cost generated by the impact of financing parenthood on consumption. In the social planner problem, this condition includes an additional term capturing the effect of fertility on the PAYG budget through the retirement rule $\Phi(n_t)$. Since $\Phi'(n_t) < 0$, higher fertility relaxes the pension budget and lowers the equilibrium retirement age, thereby affecting both consumption and retirement leisure. Finally, equation (10) applies only in the unconstrained environment and determines the retirement age that households would choose by trading off the consumption gain from working longer against the utility cost of lower retirement leisure.

(D) Decentralized equilibrium. Given (τ, b, w, R), households take ϕ_{t+1} as given. Combining the optimality conditions and the private budget constraint yields the private locus relating retirement age and fertility, $\phi_{t+1} = \Psi(n_t)$, where:

$$\Psi(n_t) \equiv -\frac{Rw(1-\tau)+b}{w(1-\tau)-b} + \frac{R\theta\left(1+\frac{1+\rho}{\gamma}\right)}{w(1-\tau)-b}\, n_t. \tag{11}$$

Since optimal fertility and consumption move in the same direction, higher fertility requires more labor income, i.e., $\Psi'(n_t) > 0$. The decentralized equilibrium is pinned down by the intersection of the private locus $\phi_{t+1} = \Psi(n_t)$ and the PAYG rule $\phi_{t+1} = \Phi(n_t)$. Solving yields to:

$$n_t^D = \frac{\gamma w\big[(\tau w+b)(1-\tau)R+b\big]}{R\theta(1+\rho+\gamma)(\tau w+b)+\gamma\tau w\big[w(1-\tau)-b\big]}, \tag{12}$$

$$\phi_{t+1}^D = \frac{b\,R\theta(1+\rho+\gamma) \;-\; \gamma\tau w\big[w(1-\tau)R+b\big]}{R\theta(1+\rho+\gamma)(\tau w+b) \;+\; \gamma\tau w\big[w(1-\tau)-b\big]}, \tag{13}$$

where $\phi_{t+1}^D \equiv \Phi(n_t^D) = \Psi(n_t^D)$.

(U) Unconstrained solution. We next consider the allocation in which households choose retirement age directly, taking (τ, b, w, R) as given but abstracting from the government budget constraint. The resulting private solution (n_t^U, ϕ_{t+1}^U) is:

$$n_t^U = \frac{\gamma w(1+R)(1-\tau)}{R\theta\big(\gamma+\mu\rho+\rho+1\big)}, \tag{14}$$

$$\phi_{t+1}^U = 1 - \frac{\rho\mu(1+R)w(1-\tau)}{\big(w(1-\tau)-b\big)\big(1+\gamma+\rho+\mu\rho\big)}, \tag{15}$$

with $\phi_{t+1}^U \equiv \Psi(n_t^U)$. Equations (14) and (15) imply $\frac{n_t}{1-\phi_{t+1}} = \frac{\gamma[w(1-\tau)-b]}{\theta R\rho\mu}$ which describes the choice for fertility with respect to leisure as an increasing function of the relative preference for fertility $\gamma/\rho\mu$ and a decreasing function of its relative cost $\theta R/[w(1-\tau)-b]$.

(S) Social planner equilibrium. The social planner internalizes that fertility affects the pension budget through the retirement rule (6). The planner's fertility choice n_t^S is therefore characterized by:

$$\frac{\gamma}{n_t^S} + \frac{\rho\mu}{1+n_t^S} = \frac{(1+\rho)\left[R\theta(\tau w+b)+\tau w(w(1-\tau)-b)\right]}{(\tau w+b)\big[Rw(1-\tau)-R\theta n_t^S+b\big]+\big(w(1-\tau)-b\big)\big(b-\tau w n_t^S\big)}. \tag{16}$$

Since the left-hand side of equation (16) is decreasing in n, while the right-hand side is increasing in n, the equation admits a unique solution. Given n_t^S, retirement age is determined by the PAYG rule:

$$\phi_{t+1}^S \equiv \Phi(n_t^S). \tag{17}$$

3 Model analysis

Throughout this section, we suppress time indices for notational simplicity. We compare the three allocations:

$$D = (n^D, \phi^D), \qquad U = (n^U, \phi^U), \qquad S = (n^S, \phi^S). \tag{18}$$

The decentralized allocation D is given by the intersection of the private locus, $\phi = \Psi(n)$, and the PAYG feasibility rule, $\phi = \Phi(n)$. The unconstrained allocation U also lies on the private locus $\Psi(n)$, since it is consistent with the optimal choice of fertility and consumption under the private budget constraint, but it does not generally satisfy the government budget constraint. By contrast, the social planner allocation S must satisfy the PAYG rule $\phi = \Phi(n)$, because the planner respects fiscal feasibility, but it need not lie on the private locus $\phi = \Psi(n)$. The underlying idea is that the social planner can introduce fiscal incentives to shift the private budget and, consequently, the locus $\phi = \Psi(n)$, to intersect the PAYG rule at the desired point.

By comparing the allocations pairwise, we characterize S as a function of the position of U relative to D.

Lemma 1 (Decentralized vs. Unconstrained)**.**

$$\phi^U \gtreqless \phi^D \iff n^U \gtreqless n^D. \tag{19}$$

Proof in the appendix B. □

Lemma 1 shows that, because both D and U satisfy the private optimality condition and therefore lie on the same upward-sloping locus $\phi = \Psi(n)$, a higher privately desired retirement age is associated with a higher privately desired fertility choice, and vice versa. The unconstrained allocation thus provides a benchmark for the retirement choice households would make absent the fiscal restriction imposed by a balanced PAYG system.

The next step is to compare the social planner and decentralized allocations.

Lemma 2 (Decentralized vs. Social Planner)**.**

$$\phi^U \gtreqless \phi^D \iff \phi^S \gtreqless \phi^D. \tag{20}$$

Proof in the appendix B. □

Lemma 2 implies that the planner's retirement age moves away from the decentralized allocation in the same direction indicated by the private benchmark U. If the retirement age required by the balanced PAYG system in the decentralized equilibrium is below the level households would privately choose, i.e., $\phi^U > \phi^D$ (see Figure 2), then the planner raises the retirement age relative to the decentralized allocation, so $\phi^S > \phi^D$. Since the planner allocation must lie on the downward-sloping PAYG rule, this requires lower fertility, that is, $n^S < n^D$. Conversely (see Figure 3), if the decentralized equilibrium implies excessively high retirement age from the household perspective, i.e., $\phi^U < \phi^D$, then the planner lowers ϕ relative to D, which along the PAYG rule requires higher fertility, that is, $n^S > n^D$.

The adjustment takes place along the branch of the PAYG constraint that brings retirement closer to its private benchmark, even at the cost of moving fertility farther away from its private benchmark. The intuition is that, at point D, households choose fertility by optimally trading it off against consumption, but they do not internalize the effect of fertility on the PAYG budget through retirement. In the case illustrated in Figure 2, this externality is negative, since households would prefer a later retirement age. Correcting this distortion, therefore, requires shifting the consumption-fertility margin in favor of consumption, which is only possible by moving along the left/up branch of the PAYG constraint.

The final step is to locate the social planner solution relative to the unconstrained allocation.

Lemma 3 (Unconstrained vs. Social Planner)**.**

$$\phi^U \gtreqless \phi^D \quad \Longleftrightarrow \quad \phi^U \gtreqless \phi^S. \tag{21}$$

Proof in the appendix B. □

Lemma 3 shows that the planner corrects the retirement-age distortion present in the decentralized equilibrium, but does not go beyond the unconstrained allocation. Intuitively, in the unconstrained allocation, the optimal choice requires fertility and the retirement age to move in the same direction. Under the social planner, however, this joint adjustment is not feasible. As a result, the planner cannot fully exploit the gains from adjusting ϕ, implying a smaller change in ϕ than in the unconstrained allocation.

Combining Lemmas 1, 2, and 3 yields the main result.

Proposition 1 (Characterization of the social planner)**.**

$$n^U \gtreqless n^D \gtreqless n^S, \qquad \phi^U \gtreqless \phi^S \gtreqless \phi^D. \tag{22}$$

Proof in the appendix B. □

Proposition 1 shows that the social planner's retirement age lies between the decentralized and unconstrained allocations, and that the sign of the fertility externality depends on the relative position of D and U. This implies that the sign of the fertility distortion is not determined solely by the standard PAYG externality, through which higher fertility enlarges the future contributor base, but also by the margin through which pension balance is restored. In our framework, adjustment occurs through the retirement age. As a result, fertility affects not only the size of the future tax base but also retirement leisure, and overall disposable income.

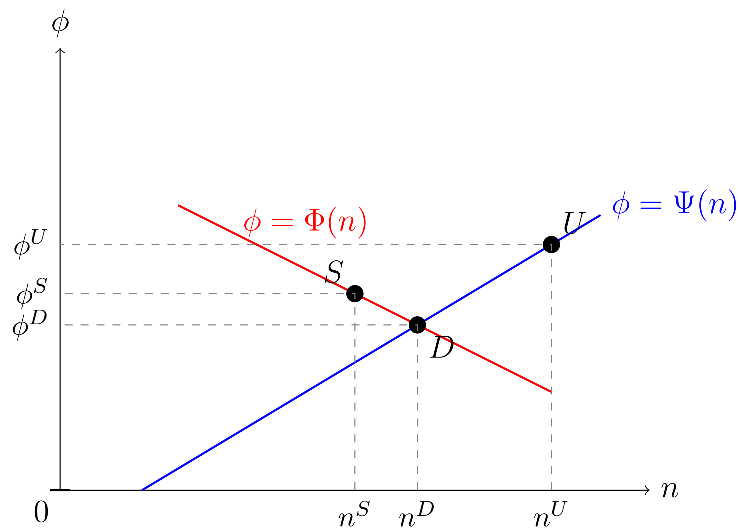


Figure 2: Allocation ordering when the unconstrained allocation lies above the decentralized one. The private benchmark U satisfies $n^U > n^D$ and $\phi^U > \phi^D$. The planner then chooses lower fertility and higher retirement age than in the decentralized equilibrium, so $n^S < n^D < n^U$ and $\phi^D < \phi^S < \phi^U$.

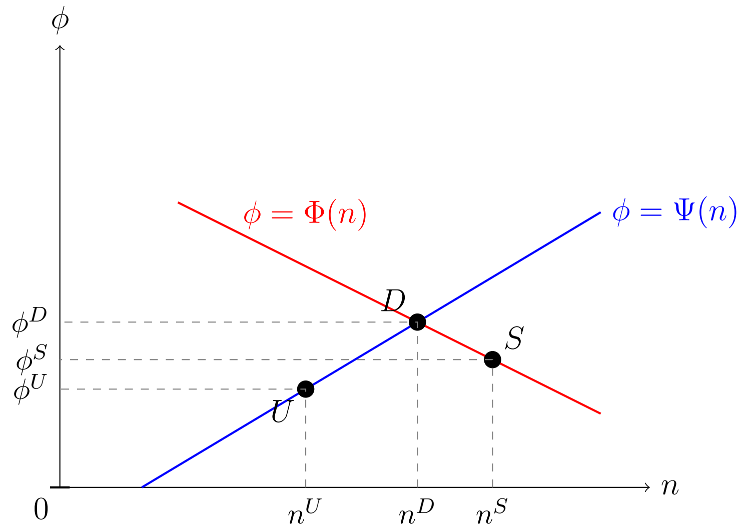


Figure 3: Allocation ordering when the unconstrained allocation lies below the decentralized one. The private benchmark U satisfies $n^U < n^D$ and $\phi^U < \phi^D$. The planner then chooses higher fertility and lower retirement age than in the decentralized equilibrium, so $n^U < n^D < n^S$ and $\phi^U < \phi^S < \phi^D$.

4 Numerical analysis

In this section, we present a numerical exercise to illustrate how parameter changes affect the model solutions and their ordering across the different scenarios. We focus on three parameters: the preference for retirement leisure, μ, the preference for having children, γ, and the contribution rate, τ.

Our baseline calibration follows primarily Cipriani and Fioroni (2024): $\mu = 0.2$, $\gamma = 0.27$, $\rho = 0.74$, $\theta = 0.095w$, $b = 0.615w$, $\tau = 0.15$, and $R = 1/\rho$. The wage, $w = 6$, is set to have $n \simeq 2$. Starting from this benchmark, we vary one parameter at a time while keeping all others fixed. In particular, we consider $\mu \in [0.17, 0.23]$, $\gamma \in [0.15, 0.40]$, and $\tau \in [0.10, 0.20]$. Figure 4 reports fertility n in the first row, retirement age ϕ in the second row, and first-period consumption C^y in the third row.[6] The first column varies μ, the second varies γ, and the third varies τ. The blue solid lines denote the decentralized allocation, the red dashed lines the unconstrained allocation, and the yellow dotted lines the social planner allocation.

Preference for retirement leisure. An increase in μ does not affect the decentralized allocation (see Equations (12) and (13)). In this scenario, there is no channel taking into account the relevance of retirement leisure. The PAYG rule is just an accounting constraint, and households can choose only consumption and the number of children for a given retirement age. By contrast, in the unconstrained allocation, a stronger preference for retirement leisure induces households to work less in old age, so that ϕ^U declines with μ. The resulting

[6] As Equation (8) closely relates C^y to C^o, our comments will refer to consumption in general.

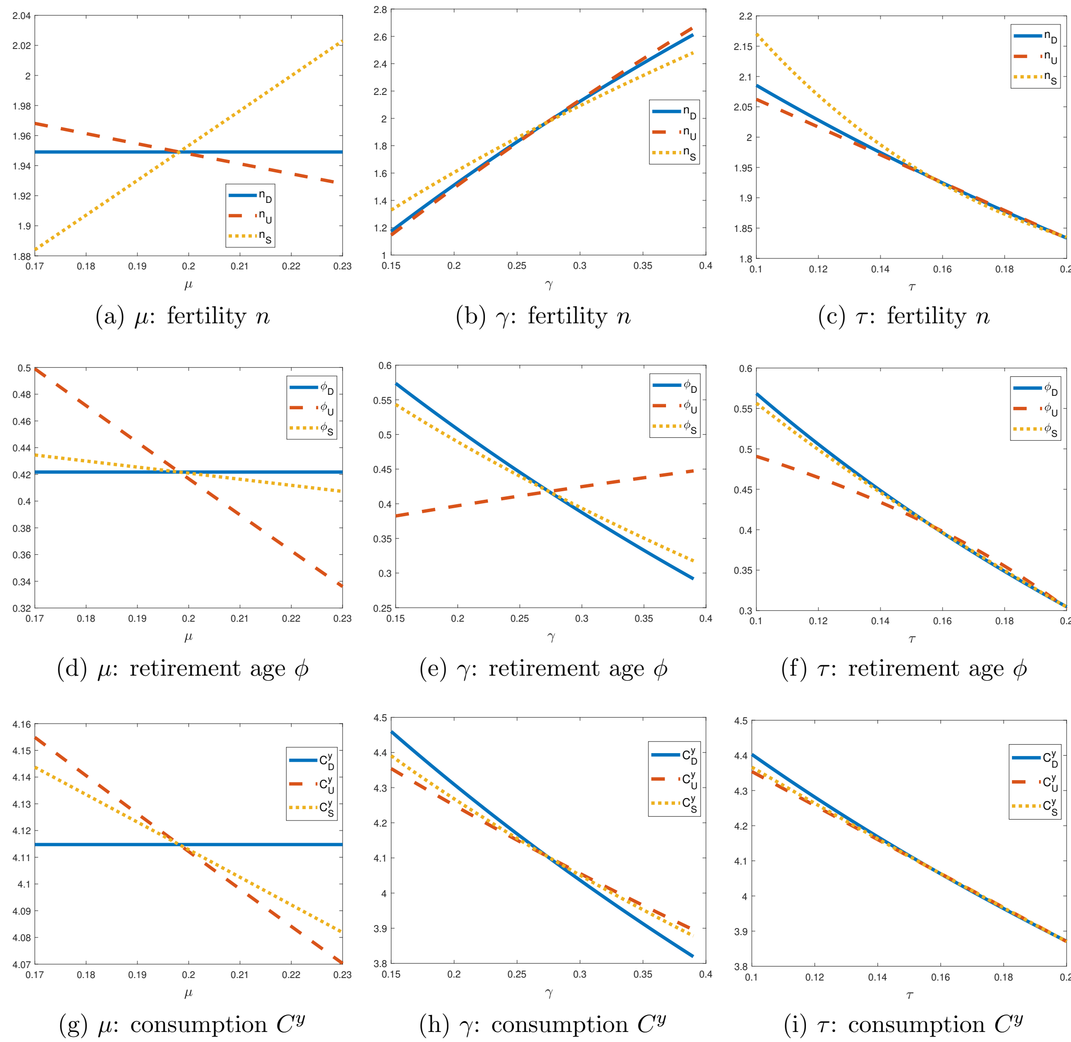
decline in second-period labor income makes childbearing less attractive, implying a lower n^U, and also reduces consumption C^y. This comparison also pins down the social planner allocation through Proposition 1. For low values of μ, the unconstrained allocation lies above the decentralized one, with $n^U > n^D$ and $\phi^U > \phi^D$. It follows that $n^U > n^D > n^S$ and $\phi^U > \phi^S > \phi^D$: the planner reduces fertility relative to the decentralized equilibrium because additional fertility relaxes the PAYG constraint and pushes retirement even earlier, which is inefficient when households would instead prefer to retire later. For high values of μ, the ordering reverses, and the planner raises fertility relative to the decentralized allocation because higher fertility moves the retirement distortion in a welfare-improving direction.

Preference for having children. An increase in γ raises fertility in all three allocations, but through different mechanisms. In the decentralized equilibrium, higher fertility translates into lower retirement age through the balanced PAYG rule, so n^D increases while ϕ^D falls. The combination of higher spending for children and earlier retirement reduces consumption. In the unconstrained allocation, instead, households can partly offset the cost of having more children by working longer in old age. Accordingly, both n^U and ϕ^U increase with γ. The higher preference for having children implies a sacrifice in terms of both retirement leisure and consumption. As γ rises, the unconstrained allocation moves from below to above the decentralized one. For low values of γ, $n^U < n^D$ and $\phi^U < \phi^D$, which implies $n^U < n^D < n^S$ and $\phi^U < \phi^S < \phi^D$: in this region the planner encourages fertility relative to the decentralized equilibrium. For high values of γ, the opposite occurs and the social planner discourages fertility. Quantitatively, the social planner response to an increase in γ is lower than the decentralized one, because the planner internalizes that higher fertility not only expands the contributor base but also relaxes the retirement constraint and induces a lower retirement age.

Contribution rate. An increase in τ reduces disposable labor income and therefore lowers fertility and consumption in all allocations.[7] In the decentralized and social planner equilibria, a higher contribution rate also relaxes the balanced PAYG condition directly, allowing households to supply less labor in old age. Hence both n and ϕ decline with τ along the PAYG schedule. In the unconstrained allocation, the same increase in τ reduces the net return from working, which also pushes ϕ^U downward and lowers fertility. Compared with the previous two exercises, changes in τ mainly shift the three allocations together rather than generating large differences between them. Over the parameter range considered, the decentralized, unconstrained, and social planner allocations get closer the higher the contribution rate, i.e., the lower the income premium from working.

[7] We focus on changes in the contribution rate, τ. The analysis of changes in the wage, w, or the pension benefit, b, follows the same logic.

Figure 4: Comparative statics of the decentralized, unconstrained, and social planner allocations. The first row reports fertility, the second row retirement age, and the third row first-period consumption. The first column varies μ, the second varies γ, and the third varies τ.



(a) μ: fertility n (b) γ: fertility n (c) τ: fertility n

(d) μ: retirement age ϕ (e) γ: retirement age ϕ (f) τ: retirement age ϕ

(g) μ: consumption C^y (h) γ: consumption C^y (i) τ: consumption C^y

5 Conclusion

This paper studies how the fiscal adjustment margin of a pay-as-you-go pension system shapes the welfare effects of fertility. In standard PAYG environments, higher fertility is socially valuable because it enlarges the future contributor base that finances old-age pensions. We show that this conclusion changes when pension balance is restored through the retirement margin. In that case, higher fertility not only improves pension financing but also affects retirement behavior, so its welfare consequences depend on whether the induced change in retirement moves the economy toward or away from households' privately preferred allocation.

To make this point, we develop a simple overlapping-generations model with endogenous fertility and compare a decentralized equilibrium, an unconstrained private allocation, and a social planner allocation. Our main result is that decentralized fertility may be either inefficiently low or inefficiently high. When the retirement rule implied by PAYG balance forces households to work longer than they would privately prefer, the planner raises fertility. When instead the balanced pension system implies retirement that is too early relative to private preferences, the planner reduces fertility. More generally, the planner allocation lies between the decentralized and unconstrained allocations.

The broader implication is that fertility policies cannot be evaluated independently of pension design. Once retirement age becomes the adjustment margin through which fiscal balance is restored, fertility-enhancing interventions are no longer unambiguously welfare-improving. More generally, the paper shows that the sign of the fertility externality is shaped not only by the financing structure of the pension system, but also by the instrument through which adjustment takes place. Our numerical analysis illustrates how this mechanism depends on key parameters, with preference parameters playing a central role in determining the sign of the distortion and the tax rate mainly affecting the overall level of fertility.

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A Empirical evidence

We estimate the following benchmark specification:

$$\text{RetirementAge}_{it} = \alpha + \sum_{k} \beta_k \cdot \text{TFR}_{i,t-k} + \mu_i + \lambda_t + \varepsilon_{it} \tag{23}$$

where $k \in \{25, 30, 35, 40, 45, 50\}$, $\text{RetirementAge}_{it}$ is the effective labour market exit age from OECD Pensions at a Glance, $\text{TFR}_{i,t-k}$ is the total fertility rate lagged k years from the World Bank World Development Indicators, and μ_i and λ_t are country and year fixed effects. The range of lags from 25 to 50 years spans the time between birth and the various stages of a worker's career, capturing the effect of past cohort size on the current working-age and near-retirement population supporting the pension system. Standard errors are clustered at the country level. We then augment the benchmark by sequentially adding life expectancy at t, $t-5$, and $t-10$ as controls, to account for the well-documented positive relationship between longevity and retirement ages.

Turning to the results, reported in Table 1, the coefficients on $\text{TFR}_{i,t-30}$ and $\text{TFR}_{i,t-40}$ are negative and statistically significant at the 5% level across all specifications. A one-unit increase in the fertility rate 30-40 years ago is associated with a reduction of approximately 1.6-2.2 years in the current effective retirement age. This is consistent with the intuition that countries experiencing higher fertility in the past face less pressure on their pay-as-you-go pension systems today, larger cohorts entering the labour market ease the fiscal burden, reducing the urgency of raising the retirement age. The remaining lags are statistically insignificant, suggesting that the demographic pressure on retirement policy operates primarily through cohorts that are currently at the peak of their working lives. Life expectancy enters with the expected positive sign but is itself not significant in this specification, with the within-R^2 rising modestly from 0.188 in the benchmark to around 0.20-0.24 once longevity is controlled for.

Table 1: Effect of Past Fertility on Effective Retirement Age

	(1)	(2)	(3)	(4)
Fertility rate (t-25)	-0.251	-0.093	0.011	-0.393
	(1.804)	(1.638)	(1.834)	(1.812)
Fertility rate (t-30)	-1.951**	-1.805**	-2.146**	-1.897*
	(0.855)	(0.783)	(0.882)	(0.986)
Fertility rate (t-35)	0.239	-0.783	0.349	0.157
	(1.207)	(1.552)	(1.182)	(1.141)
Fertility rate (t-40)	-1.865**	-1.642*	-2.191**	-2.011**
	(0.816)	(0.966)	(0.916)	(0.809)
Fertility rate (t-45)	-0.794	-1.284	-0.714	-0.753
	(1.020)	(1.079)	(1.066)	(1.003)
Fertility rate (t-50)	-0.059	0.073	0.028	0.096
	(0.650)	(0.721)	(0.666)	(0.658)
Life expectancy (t)		0.010		
		(0.079)		
Life expectancy (t-5)			-0.452	
			(0.380)	
Life expectancy (t-10)				-0.331
				(0.299)
Observations	155	124	155	155
Within R^2	0.188	0.235	0.203	0.202

Notes: The dependent variable is the effective retirement age from OECD Pensions at a Glance. Column (1) includes all fertility lags from $t-25$ to $t-50$, with no life expectancy control. Columns (2)-(4) add contemporaneous life expectancy, life expectancy at $t-5$, and life expectancy at $t-10$, respectively, from the World Bank World Development Indicators. All specifications include country and year fixed effects. Standard errors clustered at the country level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

B Proof of Proposition 1

Proposition 1 follows from Lemmas 1, 2, and 3. Lemmas 1 and 2 rely on Lemma 4. Throughout, we suppress time indices and restrict attention to interior allocations.

Let $V(n, \phi)$ denote indirect lifetime utility after optimizing savings. Using the Euler equation and the budget constraints, this can be written, up to an additive constant, as

$$V(n, \phi) = (1 + \rho) \log K(n, \phi) + \gamma \log n + \rho\mu \log(1 - \phi), \tag{24}$$

where

$$K(n, \phi) \equiv R\big(w(1 - \tau) - \theta n\big) + b + \big(w(1 - \tau) - b\big)\phi. \tag{25}$$

Hence

$$V_\phi(n, \phi) = \frac{(1 + \rho)\big(w(1 - \tau) - b\big)}{K(n, \phi)} - \frac{\rho\mu}{1 - \phi}, \tag{26}$$

$$V_n(n, \phi) = \frac{\gamma}{n} - \frac{(1 + \rho)R\theta}{K(n, \phi)}, \tag{27}$$

and

$$V_{\phi n}(n, \phi) > 0, \qquad V_{nn}(n, \phi) < 0. \tag{28}$$

Define

$$n_\Phi(\phi) \equiv \Phi^{-1}(\phi), \tag{29}$$

$$G(n) \equiv V\big(n, \Phi(n)\big), \tag{30}$$

and

$$W(\phi) \equiv V\big(n_\Phi(\phi), \phi\big). \tag{31}$$

Lemma 4 (Strict concavity of G and W)**.** *The function G is strictly concave in n, and the function W is strictly concave in ϕ.*

Proof. Differentiating (24) twice yields

$$V_{nn}(n, \phi) = -\frac{\gamma}{n^2} - \frac{(1 + \rho)R^2\theta^2}{K(n, \phi)^2} < 0, \tag{32}$$

$$V_{\phi\phi}(n, \phi) = -\frac{(1 + \rho)\big(w(1 - \tau) - b\big)^2}{K(n, \phi)^2} - \frac{\rho\mu}{(1 - \phi)^2} < 0, \tag{33}$$

and

$$V_{n\phi}(n, \phi) = V_{\phi n}(n, \phi) = \frac{(1 + \rho)R\theta\big(w(1 - \tau) - b\big)}{K(n, \phi)^2} > 0. \tag{34}$$

Consider first $G(n) = V(n, \Phi(n))$. Since Φ is linear, $\Phi''(n) = 0$, so

$$G''(n) = V_{nn}\big(n, \Phi(n)\big) + 2V_{n\phi}\big(n, \Phi(n)\big)\Phi'(n) + V_{\phi\phi}\big(n, \Phi(n)\big)\big(\Phi'(n)\big)^2. \tag{35}$$

Since $\Phi'(n) < 0$, all three terms on the right-hand side are strictly negative by (32)-(34). Hence

$$G''(n) < 0, \tag{36}$$

so G is strictly concave.

Next consider $W(\phi) = V(n_\Phi(\phi), \phi)$. Since $n_\Phi = \Phi^{-1}$ and Φ is linear, $n''_\Phi(\phi) = 0$, so

$$W''(\phi) = V_{\phi\phi}\big(n_\Phi(\phi), \phi\big) + 2V_{\phi n}\big(n_\Phi(\phi), \phi\big)n'_\Phi(\phi) + V_{nn}\big(n_\Phi(\phi), \phi\big)\big(n'_\Phi(\phi)\big)^2. \tag{37}$$

Since $n'_\Phi(\phi) < 0$, all three terms on the right-hand side are strictly negative. Hence

$$W''(\phi) < 0, \tag{38}$$

so W is strictly concave. □

Proof of Lemma 1. Both (n^D, ϕ^D) and (n^U, ϕ^U) satisfy the private fertility first-order condition and therefore lie on the locus $\phi = \Psi(n)$. Since Ψ is strictly increasing,

$$\phi^U \gtreqless \phi^D \quad \Longleftrightarrow \quad n^U \gtreqless n^D. \tag{39}$$

□

Proof of Lemma 2. The decentralized fertility condition $V_n(n, \phi) = 0$ defines the locus $\phi = \Psi(n)$. Since both (n^D, ϕ^D) and (n^U, ϕ^U) lie on this locus, define

$$H(\phi) \equiv V_\phi\big(n_\Psi(\phi), \phi\big), \tag{40}$$

where $n_\Psi(\phi)$ is the inverse of Ψ. Using the explicit expression for Ψ, we obtain

$$H(\phi) = \frac{(1 + \rho + \gamma)\big(w(1 - \tau) - b\big)}{Rw(1 - \tau) + b + \big(w(1 - \tau) - b\big)\phi} - \frac{\rho\mu}{1 - \phi}. \tag{41}$$

Since $H'(\phi) < 0$, the function H is strictly decreasing. Moreover, $H(\phi^U) = 0$ by the unconstrained retirement FOC, while $H(\phi^D) = V_\phi(n^D, \phi^D)$. Therefore,

$$\phi^U \gtreqless \phi^D \quad \Longrightarrow \quad V_\phi(n^D, \phi^D) \gtreqless 0. \tag{42}$$

By Lemma 4, G is strictly concave. At the decentralized allocation,

$$G'(n^D) = V_\phi(n^D, \phi^D)\Phi'(n^D), \tag{43}$$

because $V_n(n^D, \phi^D) = 0$. Since $\Phi'(n^D) < 0$, (42) implies

$$\phi^U \gtreqless \phi^D \quad \Longrightarrow \quad G'(n^D) \lesseqgtr 0. \tag{44}$$

By strict concavity of G, this yields

$$\phi^U \gtreqless \phi^D \quad \Longrightarrow \quad n^S \lesseqgtr n^D. \tag{45}$$

Since $\Phi'(n) < 0$, this is equivalent to

$$\phi^U \gtreqless \phi^D \quad \Longleftrightarrow \quad \phi^S \gtreqless \phi^D, \tag{46}$$

which proves (20). □

Proof of Lemma 3. By Lemma 4, W is strictly concave. Since $\Phi'(n) < 0$, we have $n'_\Phi(\phi) < 0$. Moreover,

$$W'(\phi^U) = V_\phi\big(n_\Phi(\phi^U), \phi^U\big) + n'_\Phi(\phi^U) V_n\big(n_\Phi(\phi^U), \phi^U\big), \tag{47}$$

while the unconstrained allocation satisfies

$$V_\phi(n^U, \phi^U) = 0, \qquad V_n(n^U, \phi^U) = 0. \tag{48}$$

If $\phi^U \gtreqless \phi^D$, then $n_\Phi(\phi^U) \lesseqgtr n^D$, and by Lemma 1, $n^D \gtreqless n^U$. Hence

$$n_\Phi(\phi^U) \lesseqgtr n^U. \tag{49}$$

Using $V_{\phi n} > 0$, $V_{nn} < 0$, and (48), it follows that

$$V_\phi\big(n_\Phi(\phi^U), \phi^U\big) \lesseqgtr 0, \qquad V_n\big(n_\Phi(\phi^U), \phi^U\big) \gtreqless 0. \tag{50}$$

Since $n'_\Phi(\phi^U) < 0$, both terms in (47) have sign $\lesseqgtr 0$, so

$$\phi^U \gtreqless \phi^D \quad \Longrightarrow \quad W'(\phi^U) \lesseqgtr 0. \tag{51}$$

By strict concavity of W, (51) implies

$$\phi^U \gtreqless \phi^S. \tag{52}$$

Combining this with Lemma 2, which gives $\phi^S \gtreqless \phi^D$, yields

$$\phi^U \gtreqless \phi^D \quad \Longleftrightarrow \quad \phi^U \gtreqless \phi^S, \tag{53}$$

which proves (21). □

Proof of Proposition 1. By Lemmas 2 and 3,

$$\phi^U \gtreqless \phi^S \gtreqless \phi^D. \tag{54}$$

By Lemma 1,

$$\phi^U \gtreqless \phi^D \quad \iff \quad n^U \gtreqless n^D. \tag{55}$$

Since $\Phi'(n) < 0$,

$$\phi^S \gtreqless \phi^D \quad \iff \quad n^S \lesseqgtr n^D. \tag{56}$$

Hence

$$n^U \gtreqless n^D \gtreqless n^S, \tag{57}$$

which together with (54) proves (22). $\square$