Low Fertility and the Fiscal Limit: Inflation Possibilities in East Asia*

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ABSTRACT

This paper examines how very low fertility rates in East Asia might affect inflation in the face of fiscal limits. In a calibrated overlapping-generations model, low fertility rates cause the debt-to-GDP ratio to rise, which can push the tax rate to a political ceiling and force either monetary accommodation or reduced transfers to retirees. The fiscal limit creates inflationary pressure relative to a scenario with no fiscal limit, adding to our understanding of possible inflation outcomes in aging economies. Korea faces the strongest demographic headwind and is projected to experience the earliest fiscal limit and highest inflation rates, with inflation projected to peak roughly 10 years later and 2.5pp higher with a fiscal limit than without one. Taiwan's more favorable initial fiscal conditions help reduce inflationary pressure, and China benefits from a delayed demographic transition that leads to lower inflation, despite worse initial fiscal conditions than Taiwan. In all countries, a higher tax rate ceiling or older retirement age effectively reduce peak inflation.

Keywords: low fertility; demographic transition; population aging; East Asia; overlapping generations model; fiscal sustainability; inflation projections
JEL Classifications: J11, H63, E52, E63, J13

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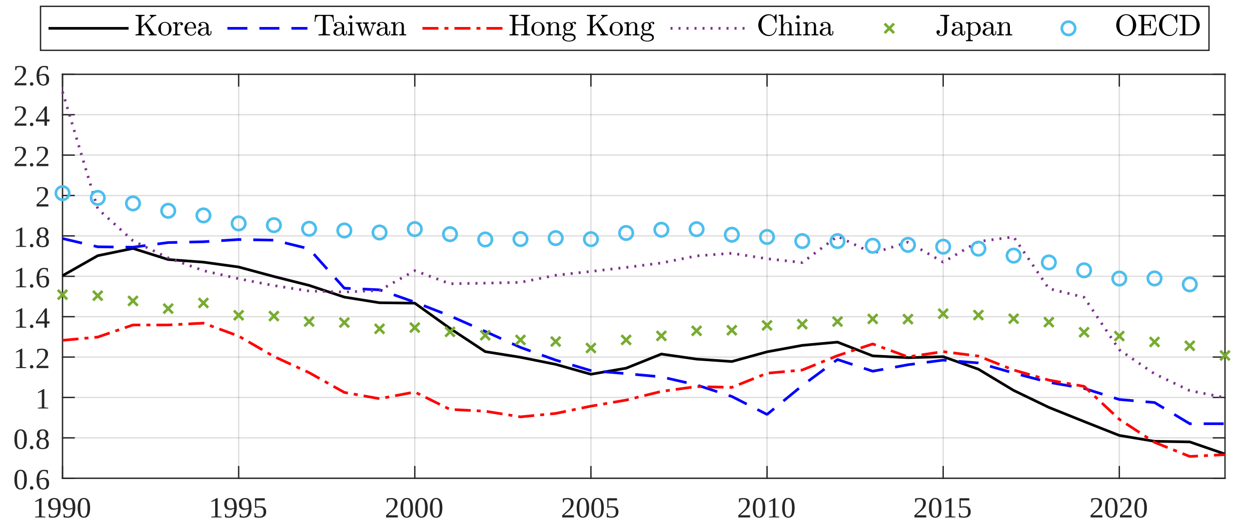
1 INTRODUCTION

Fertility rates across the globe are declining modestly, but they are plummeting in East Asia. Figure 1 shows the total fertility rate has recently fallen below one in Korea, Taiwan, and Hong Kong. China maintained a fertility rate between 1.6 and 1.8 until 2017, but it has decreased drastically to 1.0 in 2023. Very low fertility rates will eventually lead to shrinking populations and higher old-age dependency ratios. According to the UN World Population Prospect, the population in Korea, Taiwan, and China is projected to decrease by 18, 25, and 20 percent from 2025 to 2060, and the old-age dependency ratio will exceed 90 percent in Korea and Taiwan and 70 percent in China.[1]

Figure 1: Total Fertility Rates



Note: The Total Fertility Rate is the average number of children born to a female over their lifetime.
Source: UN World Population Prospects, OECD

Rapidly shrinking populations will create several economic challenges for these countries. In particular, very low fertility rates will intensify the fiscal burden for their governments. These countries have operated social welfare schemes for retirees, mainly through pension systems and medical expenditures, and the demographic transition will increase spending by governments that are ultimately responsible for those entitlements.[2] Without a substantial increase in tax revenue, government debt will need to rise to finance growing spending. That may ultimately constrain fiscal policy and has implications for the ability of the central bank to stabilize inflation.

This paper investigates how low fertility rates might affect macroeconomic outcomes, particularly inflation, when fiscal and monetary policy become constrained. We calibrate an overlapping-

[1]The old-age dependency ratio is defined as the population older than 65 divided by the population between ages 20 and 64.

[2]We provide a summary of institutional background in Appendix A, including a review of old-age transfer policies in those countries.

generation (OLG) model with workers and retirees to match South Korea, China, or Taiwan, and project outcomes through 2060.[3] Time-varying labor force entrance, retirement, and survival rates govern worker and retiree population dynamics, which determine the old-age dependency ratio. The government collects labor and capital income tax to finance government consumption, transfers to retirees, and service the existing debt.

As in Davig et al. (2010), we assume there will be a ceiling, or fiscal limit, on the tax rate. In normal times, the tax rate passively adjusts to the debt-to-GDP ratio to stabilize debt. However, if rising debt causes the tax rate to reach the ceiling, political resistance prevents the tax rate from rising further and forces a stochastic regime change to either a monetary policy that passively allows inflation to stabilize real debt or to a fiscal policy that reduces transfers to retirees. For each country, we feed in the population projections and then simulate macroeconomic outcomes in the face of policy uncertainty to form baseline projections. The fiscal limit creates inflationary pressure that delays and increases peak inflation relative to a scenario with no fiscal limit, adding to our understanding of possible inflation trends in aging economies. We then consider alternative scenarios, which include certain policy reforms, such as delaying the retirement age, as well as changes to fertility or productivity growth rates.

Demographic changes in Korea, Taiwan, and China will shape macroeconomic outcomes as each approaches its fiscal limit. Korea faces the strongest demographic headwind: a lower labor force entrance rate, a higher retiree survival rate, and the steepest rise in its old-age dependency ratio. In our baseline projection, that will lead to an earlier binding fiscal limit and result in the highest peak inflation, with inflation projected to peak roughly 10 years later and 2.5pp higher with a fiscal limit than without one. Taiwan's slower decline in labor force entry and favorable initial conditions, such as lower initial debt, government spending, and real interest rates, provide it with modestly more fiscal space than Korea, which will delay hitting the fiscal limit and contain the rise in inflation. China benefits from a delayed demographic transition with initially the highest labor force entrance rate and lowest mid-century retirement rates. However, China's higher starting debt and government spending serve to constrain its fiscal space. The net effect is that China's fiscal limit is projected to bind 5 or more years after Korea and Taiwan, and its projected inflation is closer to Taiwan's, despite the delayed demographic transition.

We then conduct alternative scenarios, including fiscal policy reforms, to see how the projections change. For Korea, a modest increase in the income tax rate ceiling delays when the fiscal limit is hit, slows debt accumulation, and reduces peak inflation, while reducing promised transfers to retirees is less effective. Faster productivity growth or a delayed retirement age significantly expand fiscal space and mitigate inflationary pressure. In contrast, an increase in the fertility rate

[3] We exclude Japan from our analysis as its fertility rate is relatively stable above one, as seen in Figure 1. See Goodhart and Pradhan (2020) and Cochrane (2024) for discussions of Japanese demographic transition and inflation.

has no near-term effect due to the lag until labor force entry. These qualitative patterns also apply to Taiwan and China, showing that it is possible to counteract the effects of demographic changes, but the magnitude and timing of effects vary across countries. While they share ongoing and impending demographic challenges, each country's possible macroeconomic outcomes are shaped by unique structural conditions.

Related literature Much of the recent literature on the macroeconomic effects of population aging uses real models to study how demographic changes influence the natural rate of interest (e.g., Bielecki et al., 2020; Blanchard, 2023; Carvalho et al., 2016; Ferrero et al., 2019; Gagnon et al., 2021; Lisack et al., 2021; Papetti, 2021). These studies emphasize that a longer retirement horizon has increased desired savings, thereby contributing to a decline in real interest rates. Some papers use nominal models and find that population aging will lead to deflation (Braun and Ikeda, 2022; Kara and von Thadden, 2016) or deflationary bias in monetary policy (Bielecki et al., 2023). In contrast, Goodhart and Pradhan (2020) argue that the downward inflation trend will reverse. Because retirees consume more than they produce, a sharp decline in the global labor force combined with an increase in retirees will create inflationary pressure. Katagiri et al. (2020) also argue that inflation is a possibility when aging is driven by a declining fertility rate. Building on the existing literature, our model features demographic changes and nominal rigidities but also includes a fiscal limit. Thus, we are able to examine inflation possibilities in the presence of two opposing forces: the deflationary pressure from an aging population and the inflationary pressure from rising debt that eventually triggers the fiscal limit.

The fiscal limit occurs when governments are eventually unable or unwilling to finance growing debt with higher tax rates, as modeled by Davig et al. (2010), Davig et al. (2011), and Richter (2015). In those models, an exogenous non-stationary transfers process leads to growing debt that is stabilized by a switch to an inflationary passive monetary and active fiscal policy regime, which allows the government's intertemporal budget constraint to determine the price level (Leeper, 1991). Rather than model a non-stationary transfers process, our contribution is to allow structural demographic changes to drive the economy toward the fiscal limit and trigger an inflationary policy regime. Also, we quantify how demographic reforms, such as delayed retirement, interact with fiscal limits and affect inflation possibilities.

Our paper is most closely related to Katagiri et al. (2020) as we also allow for the fiscal theory of the price level in an OLG model to study the relationship between aging and inflation.[4] Katagiri et al. (2020) focus on Japan and use their model to prove that aging is deflationary when driven by increased longevity but inflationary when caused by a declining birth rate. While Katagiri et al.

[4]Woodford (1995) generalized the theory of Leeper (1991) for a variety of monetary policies, demonstrating that money need not be the anchor for price level determinacy and that the intertemporal government budget constraint alone suffices, which he called the "the fiscal theory of the price level."

(2020) conduct comparative statics and simulate the effects of a one-time demographic shock in their model calibrated to Japan, this paper feeds demographic projections for Korea, Taiwan, and China into the model to simulate possible paths for inflation through 2060.

While much of the existing literature on the macroeconomic implications of demographic change focuses on the United States, Europe, or Japan, our paper focuses on East Asian economies with recent and rapid declines in fertility rates. Prior studies such as Gagnon et al. (2021), Lisack et al. (2021), and Blanchard (2023) emphasize U.S. demographics and fiscal conditions, often treating the U.S. as representative of advanced economies, and others study the Euro Area (Bielecki et al., 2020, 2023; Kara and von Thadden, 2016; Papetti, 2021) and Japan (Braun and Ikeda, 2022; Katagiri et al., 2020). While some papers include Korea or China in broader cross-country samples or comparative discussions, they do not focus on the unique fiscal conditions and demographic dynamics within these countries. Unlike the U.S. and Europe, where population aging has been gradual, or Japan, where the transition began earlier, the countries in this study are confronting a swift demographic shift. Our paper fills a gap by examining how a recent and unusually rapid decline in fertility rates combine with an interesting policy environment.

The remainder of the paper is organized as follows. Section 2 describes the OLG model used to make the projections. Section 3 discusses the calibration process for the model parameters. Section 4 summarizes the projection results, and Section 5 concludes.

2 MODEL

We develop a dynamic stochastic general equilibrium model with overlapping generations and a fiscal limit. Following Gertler (1999) and Kara and von Thadden (2016), the model distinguishes between workers and retirees whose population shares evolve over time (Carvalho et al., 2023). As in Davig et al. (2010), the fiscal limit is modeled as a ceiling on the tax rate; once reached, further debt stabilization must come from either passive monetary policy or fiscal policy in the form of reduced transfers to retirees. Thus, in our model the fiscal limit is triggered by deterministic demographic changes that lead to a growing debt-to-GDP ratio, unlike prior fiscal limit models that assume exogenous non-stationary transfers.

2.1 POPULATION Our annual model has two overlapping generations, and each year there are N_t workers and N_t^R retirees. We define g_t as the labor force entrance rate, i.e., the ratio of new workers that year over the number of workers in the previous year. All workers retire with probability φ_t, the retirement rate, and all retirees have the same survival rate, ξ_t (which makes $1-\xi_t$ the mortality rate). Thus, the laws of motion for the number of workers and retirees are $N_{t+1} = (1+g_{t+1}-\varphi_t)N_t$ and $N_{t+1}^R = \xi_t N_t^R + \varphi_t N_t$, and the total population is denoted $\tilde{N}_t = N_t + N_t^R$. In our calibration and results, we will use population projections for each country to set $\{g_t, \varphi_t, \xi_t\}_{t=2025}^{2060}$. The state of the time-varying population parameters, $\Omega_t = \{\varphi_{t-1}, \varphi_t, \xi_{t-1}, \xi_t, g_t, g_{t+1}, N_{t-1}, N^R_{t-1}\}$, are known in the following optimization problems for the retirees and workers.

2.2 Retirees

When workers retire they transfer their assets to a retirement fund, which collectively manages assets and distributes an equal amount to each retiree at the beginning of each year.[5] The fund allocates assets in a portfolio of government bonds and physical capital but is indifferent between bonds and capital, as the no-arbitrage condition equalizes their returns. We suppose that the allocation matches the worker portfolio, so that they have identical bond-to-capital ratios, which also equals the bond-to-capital ratio supplied in equilibrium. Furthermore, we assume quadratic adjustment costs on the change in retiree assets, which is paid to workers at the retirement fund. This reflects the observation that retirees adjust assets to smooth consumption less frequently than workers, and they have a higher marginal propensity to consume.[6]

Due to the risk sharing provided by the retirement fund, a single agent can represent the retirees. The representative retiree receives transfer income, $\lambda_t z_t$, from the government, where z_t denotes promised transfers and λ_t is the fraction honored by the government. Although $\lambda_t = 1$ usually, it falls below one if the fiscal limit is hit and policy switches to the passive fiscal regime where the government reneges on promised transfers (and more details about λ_t are provided in Section 2.5). We assume there is no bequest to workers, and deceased retirees' assets are retained by the retirement fund.

Given last year's savings, A^R_t, and population parameters, Ω_t, the representative retiree chooses consumption, c^R_t, and savings, A^R_{t+1} to maximize their value function,

$$V^R_t = \max_{c^R_t, A^R_{t+1}} \left[\ln c^R_t + \beta^R \xi_t E_t V^R_{t+1}\right], \tag{1}$$

subject to the budget constraint,

$$c^R_t + \frac{A^R_{t+1}}{N^R_t} + \frac{\mu}{2}\left(\frac{A^R_{t+1} - A^R_t}{N^R_t}\right)^2 = \frac{R^A_t A^R_t + X_t}{N^R_t} + \lambda_t z_t, \tag{2}$$

where μ is the adjustment cost parameter, R^A_t denotes the gross return on last year's savings, X_t are assets contributed by new retirees, and $\lambda_t z_t$ is government transfer income.

Substituting the budget constraint into the value function, we have

[5] This assumption is justified by the design of most pensions in East Asian countries, where worker contributions function as their accumulated savings at retirement.

[6] For example, Kaplan et al. (2014) simulate an incomplete markets model with liquid and illiquid assets and find that households over 60 exhibit a higher marginal propensity to consume than younger households.

$$V_t^R = \max_{A_{t+1}^R} \left[\ln \left(\frac{R_t^A A_t^R + X_t}{N_t^R} + \lambda_t z_t - \frac{A_{t+1}^R}{N_t^R} - \frac{\mu}{2} \left(\frac{A_{t+1}^R - A_t^R}{N_t^R} \right)^2 \right) + \beta^R \xi_t E_t V_{t+1}^R \right]. \tag{3}$$

The first order condition with respect to A_{t+1}^R is

$$\left(\frac{1 + \mu(A_{t+1}^R - A_t^R)/N_t^R}{N_t^R} \right) \frac{1}{c_t^R} = \beta^R \xi_t E_t \frac{\partial V_{t+1}^R}{\partial A_{t+1}^R}. \tag{4}$$

Using the envelope theorem, we can find the derivatives of the value function and derive a consumption Euler equation for retirees,

$$\frac{1 + \mu(A_{t+1}^R - A_t^R)/N_t^R}{c_t^R N_t^R} = \beta^R \xi_t E_t \frac{R_{t+1}^A + \mu(A_{t+2}^R - A_{t+1}^R)/N_{t+1}^R}{c_{t+1}^R N_{t+1}^R}. \tag{5}$$

2.3 WORKERS

Given last year's capital, k_t, nominal bonds, B_t, and population parameters, Ω_t, a representative worker chooses consumption, c_t, labor supply, l_t, k_{t+1}, and B_{t+1} to maximize their value function, which accounts for the possibility of retiring,

$$V_t = \max_{c_t, l_t, k_{t+1}, B_{t+1}} \ln c_t - \chi \frac{l_t^{1+\eta}}{1+\eta} + \beta E_t \left[(1-\varphi_t) V_{t+1} + \varphi_t V_{t+1}^R \right] \tag{6}$$

subject to the budget constraint,

$$c_t + k_{t+1} + \frac{P_t^B B_{t+1}}{P_t} = (1-\tau_t)[w_t l_t + r_t^k k_t] + (1-\delta) k_t + \frac{B_t}{P_t} + d_t, \tag{7}$$

where P_t^B is the one-period discount bond price, τ_t is the income tax rate, w_t is the real wage, r_t^k is the return on capital, δ is the depreciation rate, P_t is the price of final goods, and d_t includes a dividend from firms and the retirement fund's adjustment fees.

The contribution workers make to the retirement fund equals the number of new retirees times the assets held by workers, $X_t \equiv \varphi_{t-1} N_{t-1}[(1-\tau_t) r_t^k k_t + (1-\delta) k_t + B_t/P_t]$. Applying this definition to V_{t+1}^R and using the envelope theorem gives us the worker Euler equations,

$$\frac{1}{c_t} = \beta E_t \left\{ \left[(1-\tau_{t+1}) r_{t+1}^k + (1-\delta) \right] \left[(1-\varphi_t) \frac{1}{c_{t+1}} + \varphi_t \frac{\varphi_t N_t}{c_{t+1}^R N_{t+1}^R} \right] \right\}, \tag{8}$$

$$\frac{P_t^B}{P_t} \frac{1}{c_t} = \beta E_t \left\{ \left[(1-\varphi_t) \frac{1}{c_{t+1}} + \varphi_t \frac{\varphi_t N_t}{c_{t+1}^R N_{t+1}^R} \right] \frac{1}{P_{t+1}} \right\}. \tag{9}$$

For example, (8) states that in equilibrium the worker's marginal utility of consumption, $1/c_t$, or the loss of current utility by an additional unit of saving should equal the expected discounted present utility of additional consumption considering a worker retires with probability φ_t.

Moreover, the first-order condition for labor yields the labor supply decision,

$$\chi l_t^{\eta} = \frac{(1-\tau_t)w_t}{c_t}. \tag{10}$$

2.4 FIRMS The production sector is comprised of intermediate goods producers in a monopolistically competitive environment and a representative final goods producer. Intermediate goods firms, $j \in [0,1]$, have production function $Y_t(j) = K_t(j)^{\alpha}(\varkappa_t L_t(j))^{1-\alpha}$, where $K_t(j)$ and $L_t(j)$ denote firm j's capital and labor input and $\varkappa_t$ is labor-augmenting technology. The final goods firm purchases all intermediate goods and bundles them into $Y_t = [\int_0^1 Y_t(j)^{(\theta-1)/\theta} dj]^{\theta/(\theta-1)}$, where θ determines the elasticity of substitution between intermediate goods. As is standard for the Dixit and Stiglitz (1977) problem, the demand function for each intermediate good is $Y_t(j) = (P_t(j)/P_t)^{-\theta} Y_t$, and the price of the final good is $P_t = [\int_0^1 P_t(j)^{1-\theta} dj]^{1/(1-\theta)}$.

Following Rotemberg (1982), there is a quadratic adjustment cost, $Adj_t(j)$, on intermediate goods prices. Each firm chooses $P_t(j)$ to maximize the expected discounted present value of real profits, $E_t \sum_{k=t}^{\infty} Q_{t,k} D_k(j)$, where $Q_{t,k}$ is the time t price of a real bond that yields one consumption good in time k. In a symmetric equilibrium, every firm makes an identical decision, and the first order condition gives rise to a modified Phillips curve,

$$\kappa\left(\frac{\pi_t}{\bar{\pi}} - 1\right)\frac{\pi_t}{\bar{\pi}} = (1-\theta) + \theta\Psi_t + \kappa E_t\left[Q_{t,t+1}\left(\frac{\pi_{t+1}}{\bar{\pi}} - 1\right)\frac{\pi_{t+1}}{\bar{\pi}}\frac{Y_{t+1}}{Y_t}\right]. \tag{11}$$

Also, firms choose optimal inputs given the price level, yielding input demand for labor and capital. In a symmetric equilibrium, these input demands are aggregated as $w_t = mc_t(1-\alpha)Y_t/L_t$, $r_t^k = mc_t \alpha Y_t/\tilde{K}_t$, where mc_t is real marginal cost, L_t is aggregate labor, and $\tilde{K}_t$ is aggregate capital. The aggregation of those inputs is discussed in detail in Section 2.6.

2.5 GOVERNMENT POLICIES Defining aggregate nominal and real debt issuance as $\tilde{B}_{t+1}$ and $\tilde{b}_{t+1} \equiv \tilde{B}_{t+1}/P_t$, the government uses new debt and income tax revenue to finance expenditures, G_t, aggregate transfers, $N_t^R \lambda_t z_t$, and outstanding real debt obligations,

$$P_t^B \tilde{b}_{t+1} + \tau_t\left(w_t L_t + r_t^k \tilde{K}_t\right) = G_t + N_t^R \lambda_t z_t + \tilde{b}_t/\pi_t. \tag{12}$$

We assume there are three monetary and fiscal policy regimes, $S_{P,t} \in \{1,2,3\}$, which determine the prevailing interest rate, income tax, and transfers policies,

$$R_t = \begin{cases} \bar{R}(\pi_t/\pi^*)^{\phi_A}, \phi_A > 1, \text{ for } S_{P,t} \in \{1,3\}, \\ \bar{R}(\pi_t/\pi^*)^{\phi_B}, \phi_B < 1, \text{ for } S_{P,t} = 2, \end{cases} \tag{13}$$

$$\tau_t = \begin{cases} \bar{\tau} + \gamma \left(\frac{\tilde{b}_t}{\pi_t Y_t} - \frac{\bar{b}}{\bar{\pi}\bar{Y}} \right), \ \gamma > 0, \ \text{for } S_{P,t} = 1, \\ \bar{\tau}^{FL}, \ \text{for } S_{P,t} \in \{2, 3\}, \end{cases} \tag{14}$$

$$\lambda_t \begin{cases} = 1, & \text{for } S_{P,t} \in \{1, 2\}, \\ \in [0, 1) & \text{for } S_{P,t} = 3. \end{cases} \tag{15}$$

Before the fiscal limit is hit, $S_{P,t}$ = 1, monetary policy actively adjusts the interest rate to stabilize inflation, while fiscal policy is passive in that the income tax rate adjusts to stabilize government debt-to-GDP. When the fiscal limit is hit, say in period T^{FL}, fiscal policy becomes active as the tax rate is independent from debt-to-GDP (i.e., $\tau_t = \bar{\tau}^{FL}$ for all $t \geq T^{FL}$), and the regime switches to $S_{P,t} = 2$ with probability p_q or $S_{P,t} = 3$ with probability $1 - p_q$. For $S_{P,t} = 2$, while the tax rate is fixed, monetary policy passively adjusts the interest rate so that inflation stabilizes real government debt. And for $S_{P,t} = 3$, while the tax rate is fixed and the monetary policy remains active, fiscal policy becomes passive in that the government reneges on transfers promised to retirees.

Once the economy reaches the fiscal limit, policies can switch between regime 2 and 3 but do not return to regime 1. If the current regime is 2, then it remains with probability p_{22} or switches to 3 with probability $1 - p_{22}$. Similarly, if the current regime is 3, then it remains with probability p_{33} or switches to 2 with probability $1 - p_{33}$.

2.6 AGGREGATION

Aggregate labor equals the sum over individual worker labor, $L_t \equiv l_t N_t$. To aggregate assets, define Δ_t^R as the ratio of retiree assets to total assets, $\tilde{K}_t$ as total capital, and $\tilde{B}_t$ as total nominal bond holdings. As workers and retirees have identical portfolio composition, the following relationships hold:

$$\tilde{K}_{t+1} = \frac{1}{1 - \Delta_{t+1}^R} k_{t+1} N_t, \quad \tilde{B}_{t+1} = \frac{1}{1 - \Delta_{t+1}^R} B_{t+1} N_t. \tag{16}$$

Also, retiree savings equal their asset holdings,

$$A_{t+1}^R = \Delta_{t+1}^R \left(\tilde{K}_{t+1} + P_t^B \tilde{b}_{t+1} \right). \tag{17}$$

Deriving the aggregate resource constraint begins with combining the worker budget constraints,

$$\begin{aligned} &C_t + k_{t+1} N_t + P_t^B \tilde{b}_{t+1} N_t \\ &= w_t (1 - \tau_t) L_t + (1 - \varphi_{t-1}) N_{t-1} \left[(1 - \tau_t) r_t^k k_t + (1 - \delta) k_t + \tilde{b}_t / \pi_t \right] + D_t, \end{aligned} \tag{18}$$

where C_t = $c_t N_t$, and D_t = $d_t N_t$. Then we add the retiree budget constraint to (18) and use the definitions of total capital and bonds,

$$C_t + C_t^R + \tilde{K}_{t+1} + P_t^B \tilde{b}_{t+1} \\ = w_t(1-\tau_t)L_t + \{(1-\delta) + (1-\tau_t)r_t^k\}\tilde{K}_t + \tilde{b}_t/\pi_t + N_t^R \lambda_t z_t + D_t, \tag{19}$$

where $C_t^R = c_t^R N_t^R$. Substituting the government budget constraint, (12), the law of motion for capital, $I_t = \tilde{K}_{t+1} - (1-\delta)\tilde{K}_t$, and the price adjustment cost $Adj_t = Y_t - w_t L_t - r_t^k \tilde{K}_t - D_t$ into (19) reduces to the aggregate resource constraint,

$$C_t + C_t^R + G_t + I_t + Adj_t = Y_t. \tag{20}$$

3 CALIBRATION

Table 1 shows the calibration of the model's parameters to each country. We take the population projection for China and Taiwan from the UN World Population Prospects and Korea's from Statistics Korea. Because the UN population projection only had 5-year age groups, we approximated 1-year age groups by linear interpolation. We rely on the population projection for the future path of workforce entrance rates, g_t, and retirement rates, φ_t, as there are no credible data or projections for those. We assume people enter the workforce at age 20 and retire by age 64, given that the OECD definition of the working age is 15-64 and ages 15-19 usually do not work in these countries. We calculate g_t and φ_t as the proportion of the respective population in the total working-age population, then derive the survival rate, ξ_t, using the retiree population projection.

The model in our analysis does not have a steady state because of population dynamics. However, we define a hypothetical steady state where worker and retiree populations are stable to calibrate the deep parameters. The steady-state worker population is normalized to one, and the retiree population is set to match each country's average retiree-to-worker population ratio in 2023. The worker discount rate, β, corresponds to each country's real interest rate, calculated by the average difference between the short-term interest rate and CPI inflation since 2010. For the short-term interest rate, we use the 3-month interbank rate for China, the overnight call rate for South Korea, and the central bank discount rate for Taiwan. We calibrate the retiree discount rate, β^R, such that steady-state consumption per retiree is 70 percent of consumption per worker.

For each country, the share of capital in the production function, α, targets their average investment-to-GDP ratio, and the depreciation rate δ reflects their average capital stock-to-GDP ratio, since 2010. Those ratios come from investment and output data in each country's national account statistics and the capital stock is from the Penn World Table. The steady-state income tax rate, τ, is set so that the model for each country matches its government debt-to-GDP ratio as reported in the IMF Global Debt Database. We calibrate transfers per person so that the to-

Table 1: Parameter calibration

Parameter	Description	China	South Korea	Taiwan
χ	Leisure preference	4.02	4.45	4.72
η	Inverse labor elasticity	0.50	0.50	0.50
β	Worker discount factor	1.013	1.026	1.022
β^R	Retiree discount factor	1.031	1.033	1.035
α	Capital share in production	0.51	0.45	0.36
δ	Depreciation rate	0.092	0.065	0.068
$\bar{\tau}$	Steady state tax rate	0.198	0.186	0.174
κ	Adjustment cost	10	10	10
θ	Price elasticity of demand	7.67	7.67	7.67
μ	Retiree asset adjustment cost	0.002	0.002	0.002
ϕ_A	Reaction to inflation, active MP	1.5	1.5	1.5
ϕ_B	Reaction to inflation, passive MP	0.95	0.95	0.95
γ	Tax reaction to debt, passive FP	0.1	0.1	0.1
λ	Transfer ratio, baseline passive TP	0.7	0.7	0.7
p_q	Probability of entering regime 2 in FL	0.5	0.5	0.5
p_{22}	Probability of staying in regime 2	0.7	0.7	0.7
p_{33}	Probability of staying in regime 3	0.9	0.9	0.9
p_s	Logistic function slope	6.44	6.44	6.44
p_i	Logistic function intercept	94.08	94.08	94.08

tal steady-state transfer to retirees is 1 percent of GDP for Korea and Taiwan, and 0.7 percent for China, ratios that approximately match each country's current government subsidies to their pension system and elderly medical care (see Appendix A).

For the following parameters, we assume identical values for all countries. The leisure preference parameter, χ, is set to normalize the steady-state labor per worker, $\bar{l}$, at 0.33. The inverse Frisch labor elasticity parameter η equals 0.5, following Chetty et al. (2013). The price adjustment cost parameter, κ, is set to 10. The price elasticity of demand, θ, is set to 7.67, implying the steady-state markup, $\frac{\theta}{\theta-1}$, of 15 percent. The retiree asset adjustment cost parameter, μ, is assigned to 0.002, commensurate with typical asset management fees. The monetary policy reaction to inflation is above one when active ($\phi_A = 1.5$) and below one when passive ($\phi_B = 0.95$). The tax rate reaction to debt-to-GDP, γ, is set to 0.1 in the passive fiscal policy regime. The fraction of transfer awarded during the passive transfer regime, λ, is set to 0.7 in the baseline scenario. In Section 4, we also consider a scenario with a lower value, $\lambda = 0.5$. As for the probability of fiscal limit regimes, the probability of regime 2 at the outset of the fiscal limit, p_q, is set to 0.5. p_{22} and p_{33} are set to 0.7 and 0.9, respectively, implying that the average duration once entering each regime is about 3 years for regime 2 and 10 years for regime 3. The parameters for the logistic function, which is used to calculate the fiscal limit probability, are calibrated so that there is 0.1%

probability of the fiscal limit at the steady state tax rate, but the probability increases to 15% when the tax rate increases by 5 percentage points.

For the simulation analysis, the initial values for population, N_0, N_0^R, and for assets $\tilde{K}_1$, $\tilde{B}_1$, Δ_1^R are set as their steady state values. Also, we assume technology growth in the baseline model is the same as each country's average productivity growth since 2010, taken from the Penn World Table. Table 2 summarizes the target and model-simulated moments for each country. Overall, the model for each country yields moments that are close to their targets.

Table 2: Calibration targets and model-generated values

Country	China	South Korea	Taiwan
Moments	Target (Model)	Target (Model)	Target (Model)
SS Capital/output	3.50 (3.47)	4.50 (4.54)	3.50 (3.54)
SS Investment/output	0.40 (0.32)	0.30 (0.30)	0.24 (0.24)
SS Government spending/output	0.16 (0.16)	0.15 (0.15)	0.14 (0.14)
SS Government debt/output	0.50 (0.46)	0.40 (0.42)	0.30 (0.32)
SS Transfer to retirees/output	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
SS real interest rate	1.5% (1.1%)	0.1% (0.5%)	0.5% (0.5%)
SS inflation	2.0% (2.0%)	2.0% (2.0%)	2.0% (2.0%)
Initial population ratio, retirees/workers	0.23(0.23)	0.29 (0.29)	0.29 (0.29)
Productivity growth	0.5% (0.5%)	0.5% (0.5%)	0.5% (0.5%)

Note: This table lists the target values of calibration, obtained from data, and model-generated counterparts in parentheses. SS means the steady state.

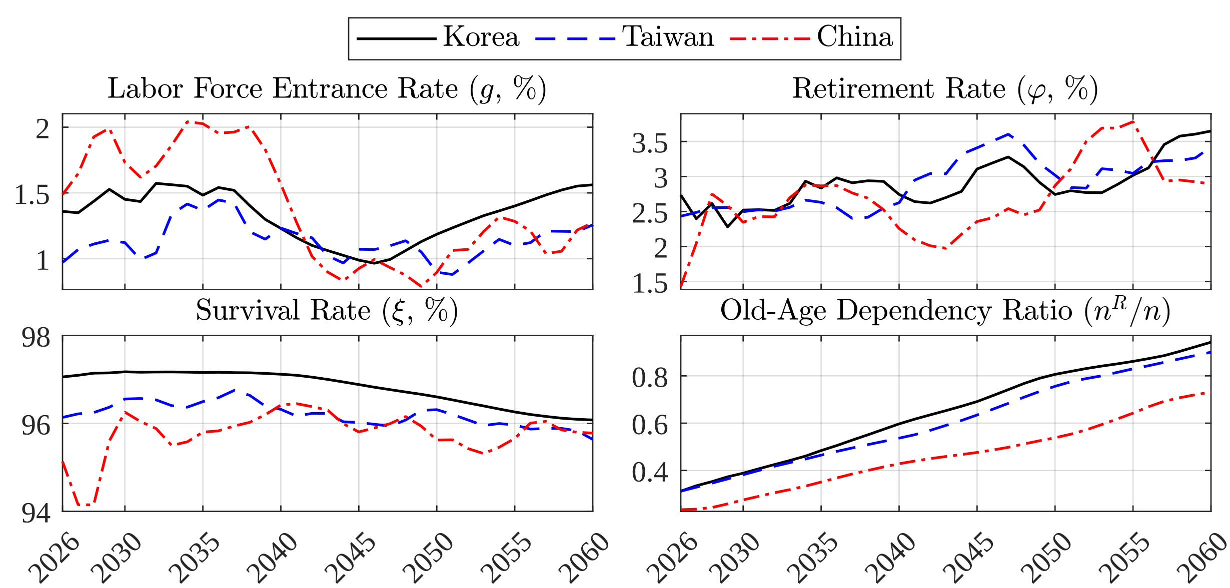
Solution Method For this model, a solution method should account for nonlinear features such as the non-stationary demographics and discrete changes to the policy mix. Given the calibration for each country, we solve the model globally using the policy function iteration (PFI) algorithm in Richter et al. (2014), which is based on the theoretical work in Coleman (1991). Essentially, the algorithm minimizes the Euler equation errors on each node in the state space and computes the maximum change in the policy functions. It then iterates until the maximum change is below a specified tolerance criterion. Fiscal limit models have been solved with PFI algorithms in Davig et al. (2010), Davig et al. (2011), and Richter (2015), but those papers do not feature demographic changes in an OLG model. We build on the specific algorithm used to solve a fiscal limit model in Richter (2015) in the following ways. First, we solve for a sequence of time-varying policy functions that are conditional on the country-specific path of the demographic projections, avoiding the curse of dimensionality by omitting them as explicit state variables. Second, we update the policy functions with a backward pass through time since decisions at t depend on the policy functions at $t+1$, which are a function of population parameters at $t+1$. Appendix B describes the solution method in detail. With the solution in hand, we simulate the model a large number of times to generate the following results.

4 RESULTS

This section illustrates and discusses how demographic dynamics affect when the fiscal limit is projected to hit for each country and the long-run implications for debt, inflation, and the real interest rate. Also, we analyze policy reforms and alternative scenarios focusing on Korea, since it is projected to hit the fiscal limit first and experience the quickest rise in debt and relatively high inflation. Policy reform and scenario analysis for the other countries are qualitatively similar to the results for Korea and are provided in Appendix C.

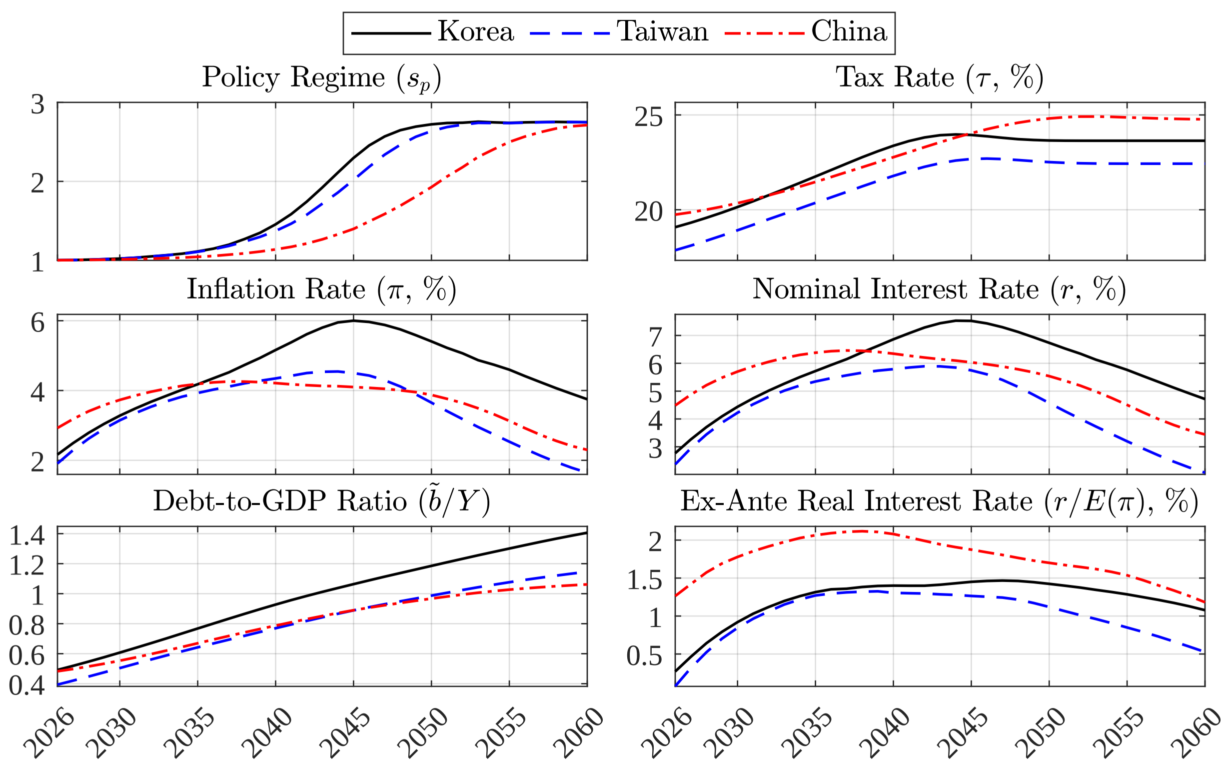
Demographic Projections Figure 2 compares demographic projections across Korea (solid line), Taiwan (dashed line), and China (dash-dotted line). For China, the labor force entrance rate is projected to decline later, but more sharply, than in Korea or Taiwan, with a quick drop after 2035. Thus, the Chinese demographic transition will start later than the other two countries but may be more drastic. In contrast, retirement rates rise gradually across all three countries, reflecting similar aging patterns. However, China is projected to experience a slower outflow of workers if its retirement rate remains lower than those of Korea and Taiwan between 2040 and 2050. A high survival rate reflects either a long life expectancy or a comparatively young retiree population, both of which influence the projected demographic pressures faced by fiscal authorities. The survival rate of retirees remain relatively high and stable for Korea and Taiwan, with only a modest decline after 2040, due to overall aging of the retiree population. But again, China is different in that it begins with a notably lower survival rate, which is projected to remain lower than Korea through 2060 and below Taiwan until 2040.

Figure 2: Demographic Drivers of Fiscal Pressure



Aging populations in all three countries are reflected in rising old-age dependency ratios and will lead to a growing fiscal burden. China's low fertility begins to affect labor force inflows only after 2035, and its retirement rate remains below those of Korea and Taiwan from 2035 to 2050. This younger age structure results in a slower rise in old-age dependency, granting China relatively more fiscal space. In contrast, Korea's higher survival rate, but a similar retirement rate trend as Taiwan, imply a steeper increase in old-age dependency. These demographic pressures will determine when the fiscal limit is hit and how severely it affects macroeconomic outcomes. In the absence of a fiscal limit, higher survival rates are an incentive to increase saving, which tends to lower the real interest rate and inflation. However, under a binding fiscal limit, the same demographic patterns will amplify the burden of public debt and place upward pressure on inflation.

Figure 3: Macroeconomic Outcomes in the Fiscal Limit Model



Note: The projected paths are a mean across 10,000 simulations that all begin in the active monetary/passive fiscal policy regime.

Baseline Comparison Given the demographic projections above, Figure 3 compares macroeconomic outcomes across Korea (solid line), Taiwan (dashed line), and China (dash-dotted line), illustrating how different demographics influence the timing of the fiscal limit and the projected paths of inflation, debt, and real interest rates. For all countries, increasing transfers to retirees pushes up the debt-to-GDP ratio and the tax rate, which will reach the fiscal limit. Also, inflation and the real interest rate all rise, although the timing of the fiscal limit and the degree of inflation differ across countries.

Korea and Taiwan are both projected to reach the fiscal limit within a narrow window (of roughly one to two years apart). Taiwan's labor force entrance rate begins at a lower level and declines less sharply than Korea's, leading to a more gradual rise in the old-age dependency ratio. This demographic pattern provides Taiwan with modestly more fiscal space and helps delay the onset of fiscal stress. In addition, Taiwan enters the projection with a lower government spending-to-GDP ratio, real interest rate, survival rate, and initial debt-to-GDP ratio compared to Korea. These structural advantages combine to keep Taiwan's debt-to-GDP ratio lower than Korea's as the fiscal limit approaches. The increased fiscal space helps contain Taiwan's inflation path, with peak inflation significantly below that of Korea, despite similar retirement dynamics.

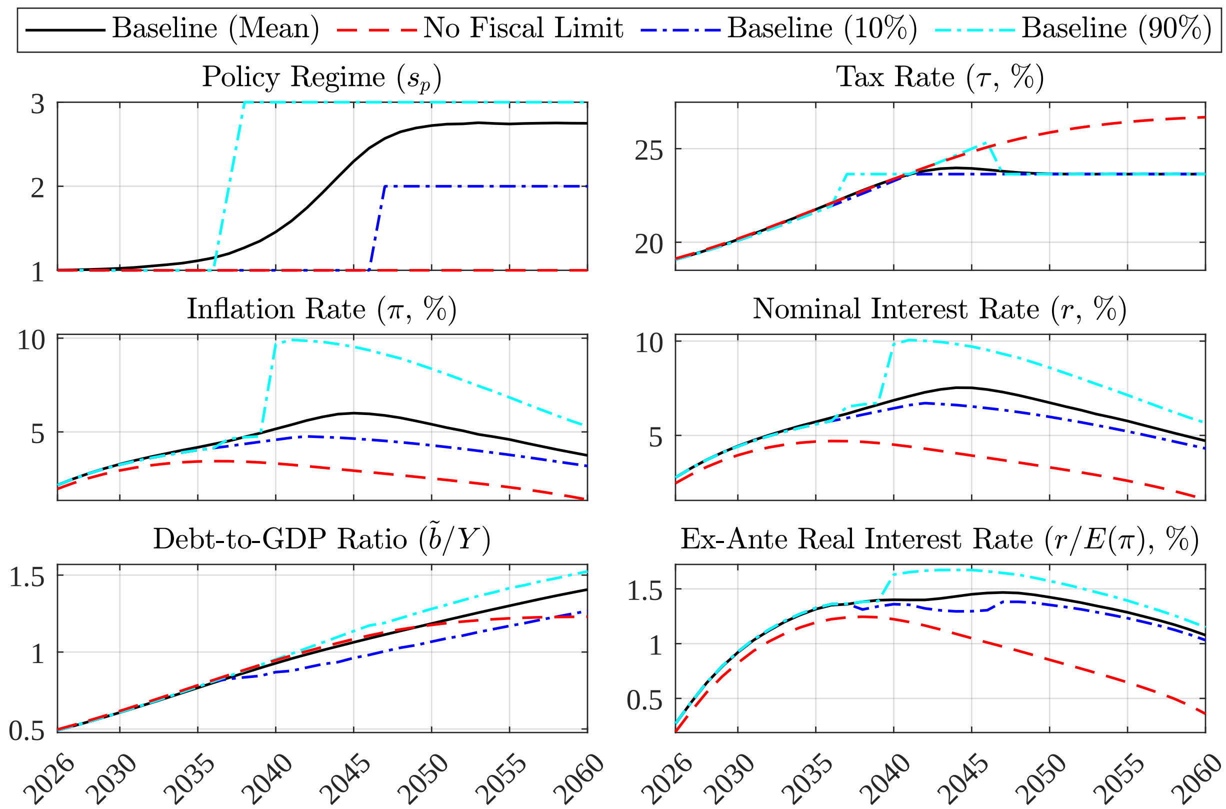
In contrast, China benefits from a delayed demographic transition. Its labor force entrance rate will not decline until after Korea's and Taiwan's, pushing back when the fiscal limit is hit by five or more years. Until 2040, China maintains higher labor force entrance rates and, through 2050, lower retirement rates than Korea. Those demographic advantages slow the rise in the old-age dependency ratio and ease near-term fiscal pressure. As a result, while China's early debt and inflation paths resemble Korea's, its greater demographic slack permits debt to stabilize and inflation to moderate over time. However, relative to Taiwan, China begins the projection with a higher initial debt-to-GDP, government spending-to-GDP ratio, and real interest rate. These structural features compress China's fiscal space and raise the cost of servicing debt, bringing its inflation dynamics closer to Taiwan's by mid-century, despite having a more favorable demographic transition.

Korea's Fiscal Limit Figure 4 contrasts Korea's mean baseline projection (solid line, with $10/90$ percentiles shown by the dash-dotted lines) to an alternative scenario without a fiscal limit (dashed line, with $s_p = 1$ always). The baseline includes the possibility of transitioning to a fiscal limit, whereas the alternative assumes passive fiscal policy throughout and no upper bound on the income tax rate. The debt-to-GDP ratio is the lowest when there is no fiscal limit, because the tax rate can keep rising to absorb the increasing transfer burden. The divergence in inflation dynamics between the baseline and no-limit scenarios highlights a key policy tradeoff: political constraints limit the ability to raise taxes, which in turn forces the central bank to accommodate fiscal policy, resulting in higher inflation (and volatility).

In the baseline, the fiscal limit binds around 2044 on average, though the timing is uncertain: only 10% of simulations encounter the limit by 2037, while 90% do so by 2047. Once the fiscal limit is reached, the income tax rate hits a ceiling near 24%[7], inducing a regime change with inflationary pressure. Inflation peaks around 6% in 2045 in the baseline projection, but reaches

[7]Note that we calibrated the probability of fiscal limits to be 15% when the tax rate increases by 5 percent points from the steady state value of 18.6%.

Figure 4: Korea's fiscal limit projections



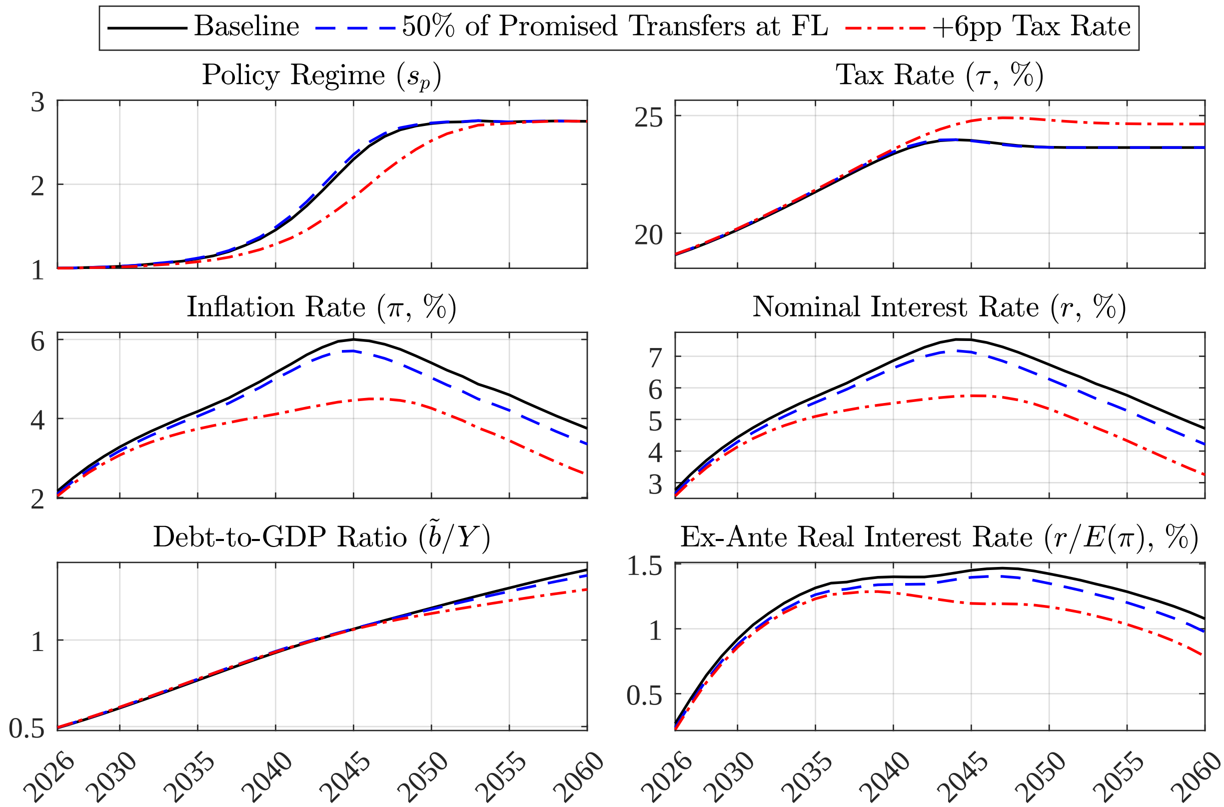
Note: Baseline (Mean) is the mean across 10,000 simulations. The 10th and 90th percentiles of the baseline simulations, depicted with dash-dotted lines, exhibit occasional sharp shifts, reflecting the discrete nature of the underlying three-state Markov process.

over 10% by 2040 in 10% of simulations due to the passive monetary/active fiscal policy regime ($s_p = 2$). While mean inflation remains relatively contained in the baseline, the right tail reveals a non-trivial probability of sustained inflation episodes exceeding 10%, underscoring an asymmetric risk associated with the fiscal limit. In contrast, the no-limit scenario allows the tax rate to continue rising above 24%, averting a regime shift and the associated inflation surge. Inflation in that case peaks at a more modest 3.4% around 2035 before gradually returning to the 2% target. The presence of the fiscal limit is also associated with a higher real interest rate, as it lowers the real price of government bonds.[8]

Tax or Transfer Reforms Figure 5 compares Korea's baseline scenario to two alternatives in which policy adjusts at the fiscal limit—either through reduced transfers (dashed line) or a higher tax ceiling (dash-dotted line). In the transfer reform scenario, only 50% of promised transfers are honored following the fiscal limit, compared to 70% in the baseline. While this adjustment has

[8]See the appendix, specifically Figure A.3 and Figure A.4, for how Taiwan's and China's baseline projections compare to their no-limit scenario.

Figure 5: Tax or Transfer Reforms in Korea



Note: In the baseline, transfers are 70% of their promised level at the fiscal limit and the income tax rate increases by $+5pp$ relative to the pre-fiscal limit tax rate. The projected paths are a mean across $10{,}000$ simulations.

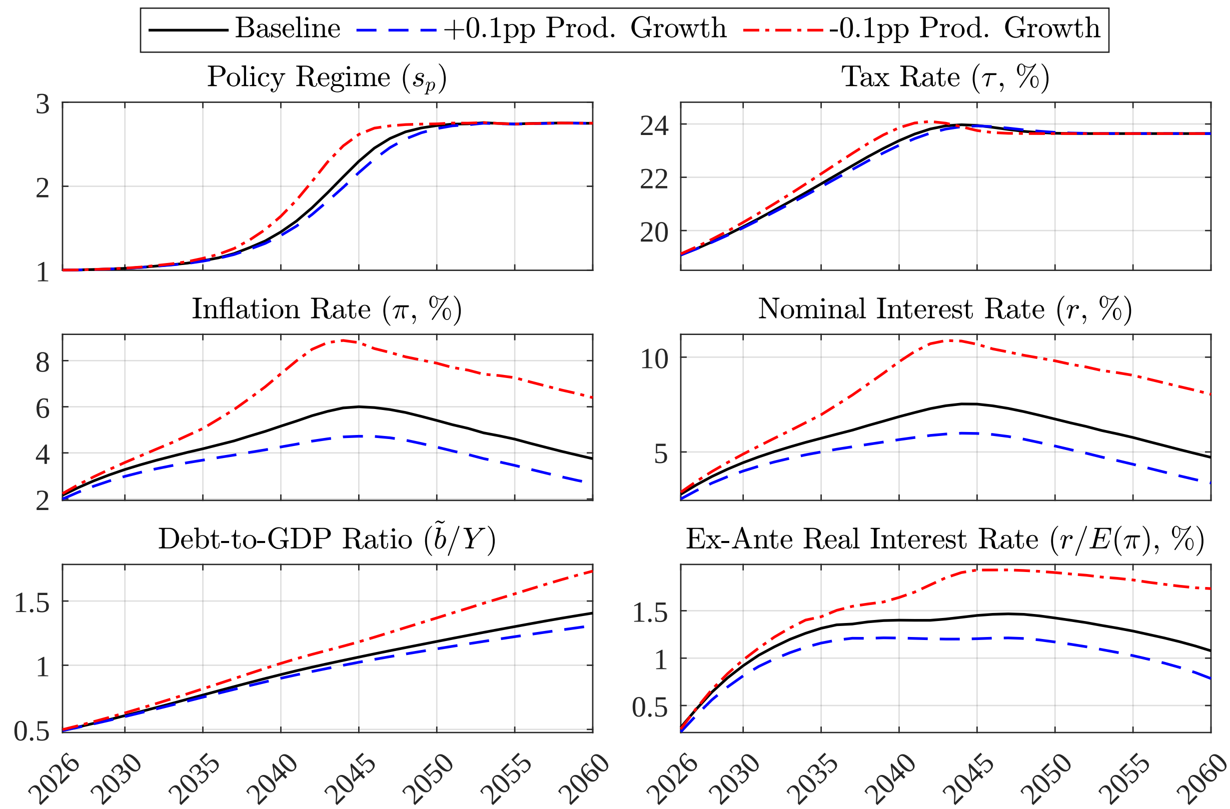
little impact on the timing of the fiscal limit or the tax path, it results in a lower debt trajectory and modestly dampens inflation—by roughly 30 basis points beginning in 2045.

In the tax reform scenario, the maximum allowable tax rate at the fiscal limit is increased by 6 percentage points above its pre-limit value, one percentage point more than in the baseline. This seemingly small adjustment meaningfully delays the onset of the fiscal limit by several years, reduces the inflation peak from 6% to 4.5%, and flattens the projected debt path beyond 2050. While both reforms reduce inflation and improve debt sustainability, only the higher tax ceiling meaningfully extends fiscal space and postpones the regime switch.[9]

Productivity Growth Scenarios Low fertility is generally associated with slower productivity growth. In standard endogenous growth models (Romer, 1990), technological progress depends on the size and quality of the research workforce, both of which decline with falling fertility. A lower fertility rate also accelerates labor force aging, further dampening productivity. At the same

[9]See the appendix for how Taiwan's (Figure A.5) and China's (Figure A.6) baseline projections compare to their tax and transfer reform scenarios.

Figure 6: Alternative productivity growth scenarios for Korea



Note: In the baseline, productivity grows at 0.5% per year. The projected paths are a mean across $10{,}000$ simulations.

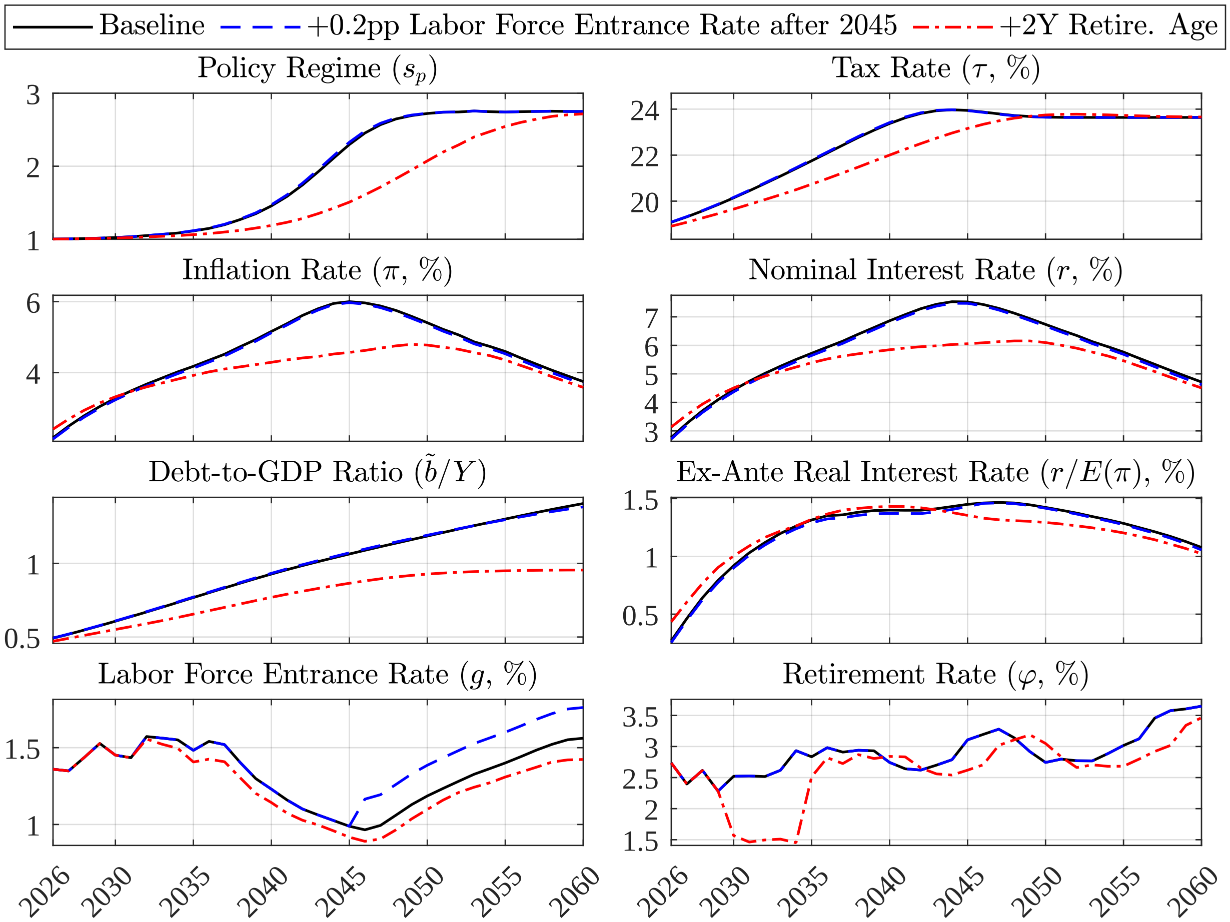
time, rapid advances in AI could mitigate or even reverse these effects by boosting innovation independent of demographic trends. To assess this possibility, we consider scenarios in which technology grows faster or slower than in the baseline projection.

Figure 6 shows how a persistent change in productivity growth might affect fiscal space and macroeconomic outcomes in Korea. The baseline assumes productivity grows at 0.5% annually, while the alternative scenarios feature growth that is always either 0.1pp higher (dashed line) or lower (dash-dotted line). Slower productivity growth compresses fiscal space, leading to an earlier transition to the fiscal limit, higher real debt accumulation, and a pronounced surge in inflation, peaking at nearly 9% by 2045. Thus, persistently lower productivity growth increases the likelihood of inflation rising above 10%, an outcome that was rare in the baseline.

In contrast, faster productivity growth delays the regime switch, flattens the debt trajectory, and dampens inflation pressures, keeping it below 5% throughout. Overall, changes in productivity growth compound over time leading to meaningful differences in the timing of the regime switch and the resulting projections for inflation and the real interest rate.[10]

[10] See the appendix for how Taiwan's (Figure A.7) and China's (Figure A.8) baseline projections compare to their

Figure 7: Alternative labor force entrance and retirement rate scenarios in Korea



Note: In the retirement rate alternative, the retirement age is delayed until age 66 implemented gradually from 2030 to 2035. The worker and retiree populations in each year are the same as the baseline, and the labor force entrance rate, by construction, must decline to offset the increase in workers from delayed retirement. The projected paths are a mean across 10,000 simulations.

Alternative Demographic Scenarios Figure 7 compares the baseline scenario to two demographic policy alternatives: a permanent increase in the labor force entrance rate by 0.2pp beginning in 2045 (dashed line) and a gradual increase in the retirement age from 64 to 66 between 2030 and 2035 (dash-dotted line). The timing of the labor force entrance rate increase reflects a 20-year delay before demographic changes translate into labor market effects, as individuals born in 2025 do not enter the labor force until 2045. Because the economy is already at the fiscal limit by 2045, this policy has minimal impact on the timing of the fiscal limit or the paths of debt and inflation, both of which closely track the baseline. In contrast, delaying the retirement age expands the labor force sooner and generates substantial fiscal space. This policy postpones the transi-

productivity growth scenarios.

tion to the fiscal limit by several years, flattens the projected debt path, and reduces inflationary pressures, with inflation peaking at 4.7% compared to 6% in the baseline. These results highlight that while fertility-driven policies may influence long-run demographics, their delayed effects limit their usefulness in addressing nearer-term fiscal constraints.[11]

5 CONCLUSION

We find that the current very low fertility rates of East Asian countries can result in significant future inflation, particularly because the large spending needs required to support an aging population might push governments toward a fiscal limit. That result has the following policy implications. For monetary policy, central banks in the region generally have been able to manage inflation from 2% to 3% in recent decades. However, future inflationary pressures resulting from structural demographic changes could challenge their ability to effectively control inflation. This situation calls for a deeper understanding of how low fertility rates will impact the macroeconomic environment in a more detailed context, including the areas of productivity, labor markets, and fiscal capacity. Central banks should also be prepared to implement contingent monetary policy actions to address these challenges, which include coordinating with fiscal authorities, managing inflation expectations, and potentially adjusting the target inflation rate. As for fiscal policy, our results indicate several options to alleviate economic pressures resulting from fiscal burdens. These options encompass direct measures, such as raising taxes or reducing transfers, as well as indirect measures, such as delaying the retirement age and enhancing productivity growth. However, our results also show that the effectiveness of these reforms is sensitive to their timing. Fiscal authorities should be proactive in enacting reforms despite the anticipated political resistance they may face.

Our results are confined within a model of a closed economy, whereas economies in East Asia exhibit a significant degree of openness. As emphasized by Carvalho et al. (2023), the real interest rate of an open economy is influenced by the global real interest rate. If the global real interest rate continues to decline, as predicted by much of the literature, it may counter the effects of any fiscal limit. However, a combination of higher government debt and lower savings stemming from a declining worker population is likely to worsen their net foreign assets. This deterioration is typically associated with a higher real interest rate, which means that an upward projection for the real interest rate could still be relevant. It would, therefore, be beneficial for future studies to explore lower fertility and the fiscal limit in an open economy. Additionally, while our model assumes that government bonds have a maturity of only one year, the existence of long-term bonds could mitigate and delay the effects of fiscal limits, as suggested by Richter (2015).

[11] See the appendix for how Taiwan's (Figure A.9) and China's (Figure A.10) baseline projections compare to their alternative demographic scenarios.

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A Institutional background

This section provides an overview of the monetary and fiscal policy systems of South Korea, Taiwan, and China. The overview of the fiscal policy is focused on old-age transfers systems, which is relevant to our research.

A.1 Monetary policy

A.1.1 South Korea The Bank of Korea also adopts an inflation targeting system that aims to stabilize CPI inflation at around 2 percent. Its monetary policy is interest rate-based, and the policy rate is the Bank of South Korea Base Rate, the reference rate for the central bank's open market operations. Those open market operations control liquidity conditions in the short-term money market, keeping the interbank overnight call rate close to the policy rate. Panel (b) of Figure A.1 plots South Korean CPI inflation and the overnight call Rate, suggesting that the South Korean policy rate responds actively to inflation dynamics. Numerous studies, including Kim (2014), Kang and Suh (2017), suggest that a Taylor rule well approximates South Korean monetary policy.

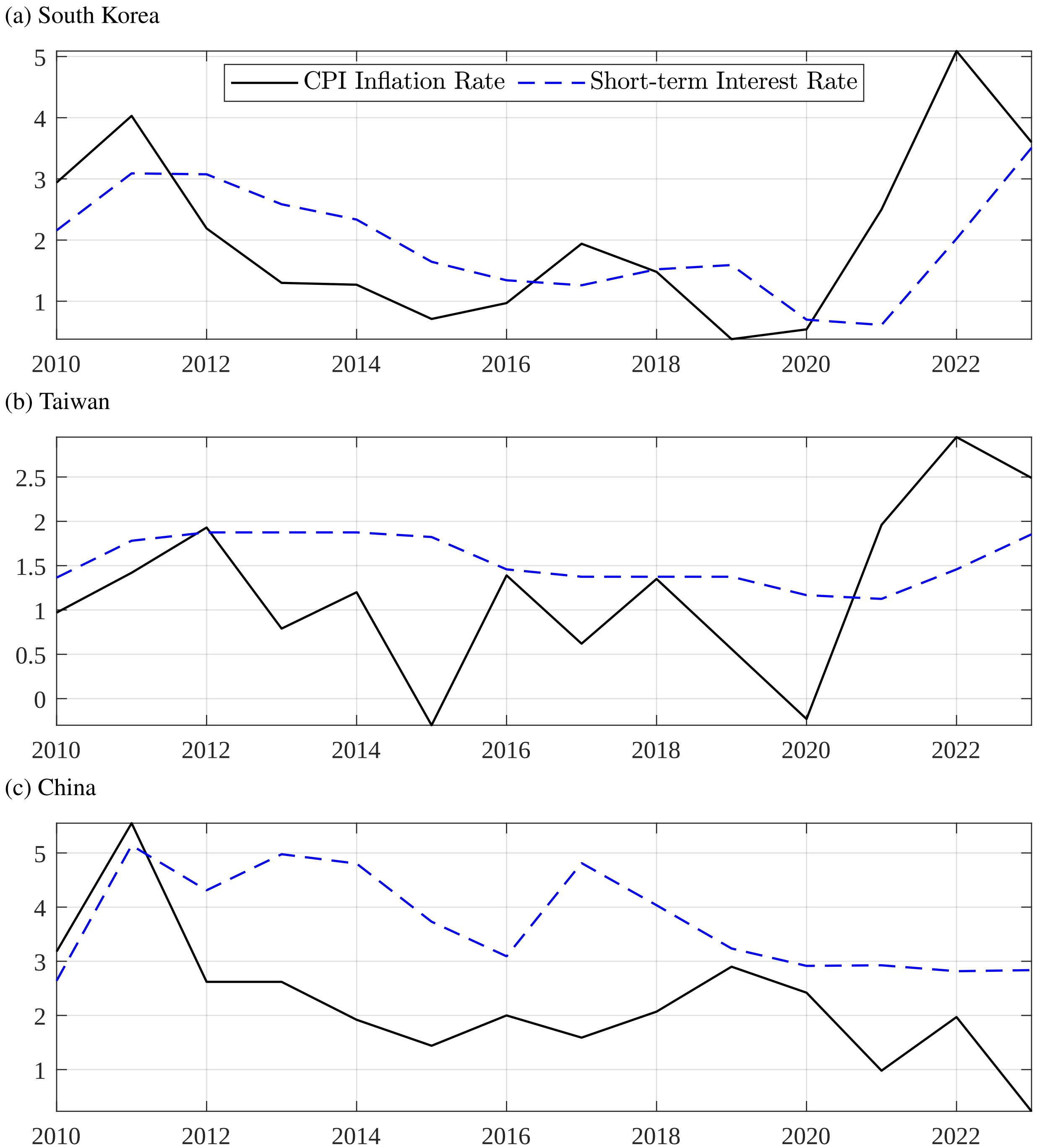
A.1.2 Taiwan The Central Bank of the Republic of China states that the goal of monetary policy is financial and banking stability, as well as the stability of domestic and external currency value. It sets the inflation target range below 2 percent and uses the intermediate target of the M2 growth rate. The central bank sets the policy rate, such as the central bank rediscount rate, to control the short-term interest rate and to affect monetary aggregates. Panel (c) of Figure A.1 plots CPI inflation and the policy rate of Taiwan. It suggests that the change in the Taiwanese policy rate has been modest relative to that of CPI inflation. This can be explained by the central bank's use of M2 as the intermediate target and its commitment to exchange rate stabilization.

A.1.3 China The People's Bank of China (PBoC) states that the main objective of Chinese monetary policy is to maintain the stability of the currency value and promote economic growth. The central bank uses M2 growth as an intermediate target of monetary policy (Chen et al., 2018; Li and Liu, 2017). While it uses a mix of monetary policy tools, including open market operations and lending and discount facilities, its primary policy instruments are the reserve requirement ratio and open market operations that aim to affect the interbank interest rate. Although M2 growth is an intermediate target, Li and Liu (2017) suggests that the Chinese monetary policy rule can be approximated by an expanded Taylor rule, including money stock, and the interest rate's reaction to inflation is estimated to be greater than one. Panel (a) of Figure A.1 presents the trends of Chinese CPI inflation and the short-term interbank rate as a proxy of its monetary policy.[12] It suggests that

[12]The short-term interbank rate generally follows the PBoC's lending facility rate, which is the reference rate for its open market operation.

the Chinese short-term rate exhibits active responses to stabilize inflation.

Figure A.1: CPI Inflation and Short-term interest rate



Note: Short-term interest rate refers to the overnight call interbank rate for Japan and South Korea, the one-month interbank rate for China, and the central bank rediscount rate for Taiwan.

Source: Federal Reserve Economic Database, People's Bank of China, Central Bank of the Republic of China, National Statistics of Taiwan.

A.2 OLD-AGE SOCIAL WELFARE POLICY

A.2.1 CHINA The public pension of China consists of multiple systems. There is the Basic Social Pension for Urban and Rural Residents, designed for those not covered by formal employment schemes, especially rural residents and informal workers. It is financed by government budgets, with minimal individual contributions. Also, the Urban Employees' Basic Pension Scheme covers formal sector employees in urban areas. It operates on a partially government-funded, pay-as-you-go system. Fang and Feng (2018) suggest the amount of government subsidy for those public pension systems is about 0.9 percent of GDP in 2015 but is expected to increase as the pension fund deficit increases to 2 percent of GDP in 2030. For health insurance, the Urban Employee Basic Medical Insurance is mandatory for formal sector workers, financed by employer and employee contributions. Also, there is the Urban and Rural Residents Basic Medical Insurance for informal workers, children, elderly, and rural residents. According to Wu et al. (2023), healthcare spending in China is about 7 percent of the GDP, of which about 30 percent is subsidized by the government.

A.2.2 SOUTH KOREA South Korea also has two public pension systems: the Basic Old-age Pension and the National Pension System (NPS). The government budget directly finances the Basic Old-age Pension. NPS is a government agency that requires every worker to contribute a certain fraction of their income, functioning as a mandatory saving. However, its payment does not entirely rely on personal contributions but has some redistributive features within the pension system. Currently, NPS's outstanding funds are positive from accumulated workers' contributions. Although NPS does not yet require a government subsidy, future projections suggest that the fund will be drained around 2055. The law states that the government budget should take the payment burden thereafter, meaning a transition to a complete pay-as-you-go system. Also, South Korea has a national health insurance system. It is financed by mandatory contributions from workers and the government. During the 2020s, government contributions account for about 10 percent of the total budget. The insurance covers a significant part of South Korean medical expenditure, about 40 percent of which is spent on patients aged 64 or more. As of 2022, government spending on Basic Old-age Pension and national health insurance is approximately 1.5 percent of GDP.

A.2.3 TAIWAN Similarly, Taiwan operates two public pension schemes. The first is the National Pension Scheme, which is the foundational safety net for those not covered by other pension systems. The second scheme is the Labor Pension, which is mandatory for all workers. Workers and employers contribute a percentage of wages, and the government also contributes a share. As for health insurance, Taiwan operates the consolidated National Health Insurance (NHI) program, funded through mandatory premiums from individuals and employers and government subsidies for low-income households. In 2023, the government subsidy on old-age pension and medical insurance accounts for about 1 percent of GDP.

B Solving the model

B.1 Policy function iteration

1. Define $\Omega_t \equiv \{\varphi_{t-1}, \varphi_t, \xi_{t-1}, \xi_t, g_t, g_{t+1}, N_{t-1}, N^R_{t-1}\}$ as the time-varying demographic parameters for a specific country and scenario.

2. Define $\tilde{b}_t \equiv \tilde{B}_t/P_{t-1}$, $\tilde{K}_t$, Δ^R_t as state variables and $\tilde{K}_{t+1}$, l_t, π_t, C^R_t as policy variables. The policy function H_t is defined as $(\tilde{K}_{t+1}, l_t, \pi_t, C^R_t) \equiv H_t(\tilde{b}_t, \tilde{K}_t, \Delta^R_t; \Omega_t)$.

3. Given a guess for the policy function H_t, solve the following equations for time t for each policy regime.

$$N_t = (1 + g_t - \varphi_{t-1})N_{t-1} \tag{B.1}$$

$$N^R_t = \xi_{t-1}N^R_{t-1} + \varphi_{t-1}N_{t-1} \tag{B.2}$$

$$L_t = l_t N_t \tag{B.3}$$

$$Y_t = \tilde{K}^\alpha_t(\varkappa_t L_t)^{1-\alpha} \tag{B.4}$$

$$I_t = \tilde{K}_{t+1} - (1-\delta)\tilde{K}_t \tag{B.5}$$

$$C_t = Y_t - Adj_t - I_t - G_t - C^R_t \tag{B.6}$$

$$r^k_t = \left[\frac{\alpha}{1-\alpha} \cdot \frac{\chi l_t^{1+\eta}}{(1-\tau_t)\tilde{K}_t}\right] C_t \tag{B.7}$$

$$w_t = \frac{(C_t/N_t)\chi l^\eta_t}{1-\tau_t} \tag{B.8}$$

$$\Psi_t = \frac{w_t^{1-\alpha}(r^k_t)^\alpha}{\varkappa_t^{1-\alpha}(1-\alpha)^{1-\alpha}\alpha^\alpha} \tag{B.9}$$

$$\tilde{b}_{t+1} = \left[G_t + \lambda_t z_t N^R_t + \frac{\tilde{b}_t}{\pi_t} - \tau_t(w_t L_t + r^k_t \tilde{K}_t)\right] / P^B_t \tag{B.10}$$

$$\begin{aligned}
&\Delta^R_{t+1}(\tilde{K}_{t+1} + P^B_t \tilde{b}_{t+1}) = A^R_{t+1} = \\
&\left(\Delta^R_t + (1-\Delta^R_t)\varphi_{t-1}\right)\left[\{(1-\delta) + (1-\tau_t)r^k_t\}\tilde{K}_t + \tilde{b}_t/\pi_t\right] + \lambda_t z_t N^R_t \\
&-C^R_t - \frac{\mu}{2}\left(\frac{A^R_{t+1} - A^R_t}{N^R_t}\right)^2
\end{aligned} \tag{B.11}$$

4. Also, given time $t+1$ policy function $H_{t+1}(\tilde{b}_{t+1}, \tilde{K}_{t+1}, \Delta^R_{t+1}; \Omega_{t+1})$, solve the following equations for $t+1$.

$$N_{t+1} = (1 + g_{t+1} - \varphi_t)N_t \tag{B.12}$$

$$N^R_{t+1} = \xi_t N^R_t + \varphi_t N_t \tag{B.13}$$

$$L_{t+1} = l_{t+1}N_{t+1} \tag{B.14}$$

$$Y_{t+1} = \tilde{K}^\alpha_{t+1}(\varkappa_{t+1}L_{t+1})^{1-\alpha}_{t+1} \tag{B.15}$$

$$I_t = \tilde{K}_{t+2} - (1-\delta)\tilde{K}_{t+1} \tag{B.16}$$

$$C_{t+1} = Y_{t+1} - Adj_{t+1} - I_{t+1} - G_{t+1} - C^R_{t+1} \tag{B.17}$$

$$r^k_{t+1} = \frac{\alpha}{1-\alpha} \cdot \frac{\chi l^{1+\eta}_{t+1}}{(1-\tau_{t+1})\tilde{K}_{t+1}} C_{t+1} \tag{B.18}$$

$$\begin{aligned} A^R_{t+2} = &\left(\Delta^R_{t+1} + (1-\Delta^R_{t+1})\varphi_t\right)\left[\{(1-\delta) + (1-\tau_{t+1})r^k_{t+1}\}\tilde{K}_{t+1} + \tilde{b}_{t+1}/\pi_{t+1}\right] \\ &+ \lambda_{t+1}z_{t+1}N^R_{t+1} - C^R_{t+1} - \frac{\mu}{2}\left(\frac{A^R_{t+2} - A^R_{t+1}}{N^R_{t+1}}\right)^2 \end{aligned} \tag{B.19}$$

5. Find the values of $\tilde{K}_{t+1}$, l_t, P^M_t, π_t, C^R_t that solve the following optimality conditions, of which expectations are calculated using the probability of each regime.

$$\frac{1 + \mu(A^R_{t+1} - A^R_t)/N^R_t}{C^R} = \beta^R \xi_t E_t\left\{\frac{R^A_{t+1} + \mu(A^R_{t+2} - A^R_{t+1})/N^R_{t+1}}{C^R_{t+1}}\right\} \tag{B.20}$$

$$1 = \beta C_t E\left\{\left[(1-\tau_{t+1})r^k_{t+1} + (1-\delta)\right]\left[(1-\varphi_t)\frac{N_{t+1}}{N_t}\frac{1}{C_{t+1}} + \varphi^2_t\frac{1}{C^R_{t+1}}\right]\right\} \tag{B.21}$$

$$\frac{1}{R_t} = P^B_t = \beta C_t E\left\{\left[(1-\varphi_t)\frac{N_{t+1}}{N_t}\frac{1}{C_{t+1}} + \varphi^2_t\frac{1}{C^R_{t+1}}\right]\frac{1}{\pi_{t+1}}\right\} = E\left\{\frac{Q_{t,t+1}}{\pi_{t+1}}\right\} \tag{B.22}$$

$$\kappa\left(\frac{\pi_t}{\bar{\pi}} - 1\right)\frac{\pi_t}{\bar{\pi}} = (1-\theta) + \theta\Psi_t + \kappa E_t\left[Q_{t,t+1}\left(\frac{\pi_{t+1}}{\bar{\pi}} - 1\right)\frac{\pi_{t+1}}{\bar{\pi}}\frac{Y_{t+1}}{Y_t}\right] \tag{B.23}$$

6. Update the policy function with new solutions for $\tilde{K}_{t+1}$, l_t, π_t, C^R_t and repeat steps (3)-(5) until the policy function converges.

B.2 BACKWARD INDUCTION

1. Set the terminal date T where we assume $H_T(\Omega_T) = H_{T+1}(\Omega_{T+1})$, and guess the grids for $(\tilde{b}_T, \tilde{K}_T, \Delta^R_T)$.

2. Solve for $H_T(\Omega_T)$ using the policy function iteration.

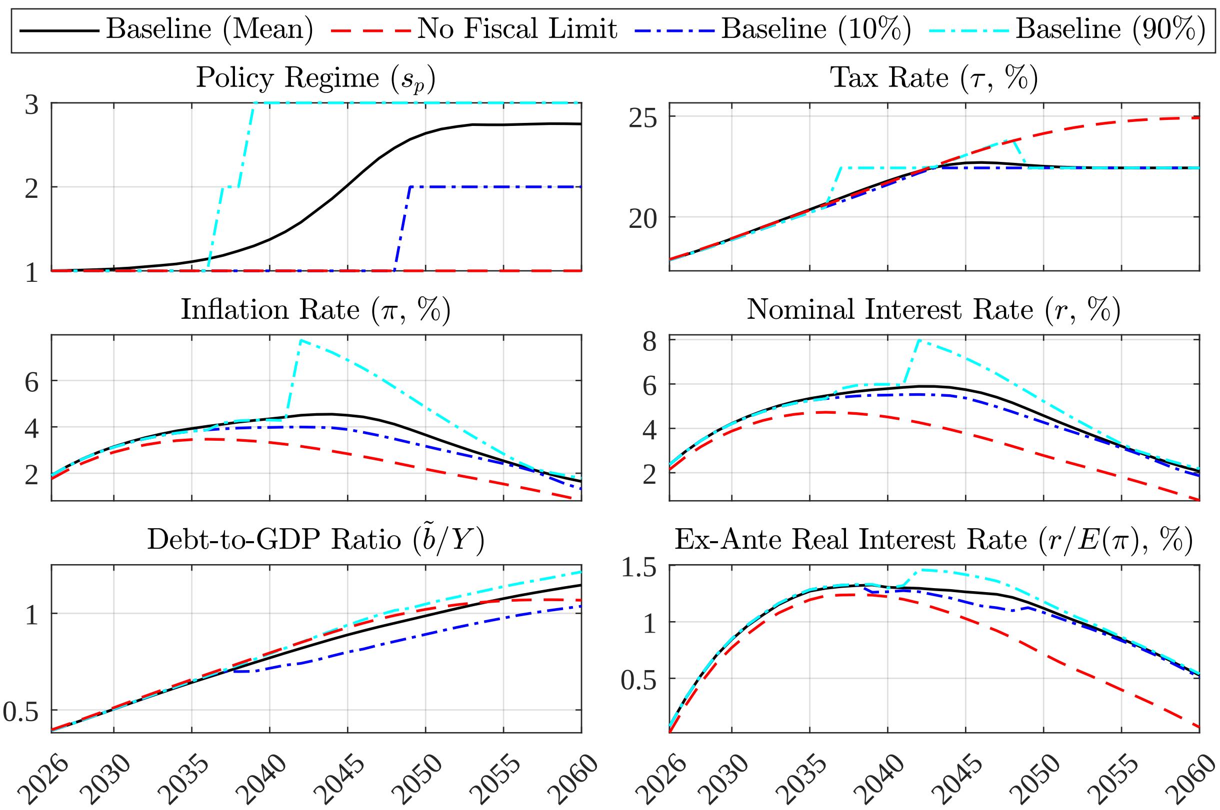
3. Conduct the policy function iteration for $H_{T-1}, H_{T-2}, ..., H_1$ by using $H_T, H_{T-1}, ..., H_2$.

4. Set the initial values for the state variables $(\tilde{b}_1, \tilde{K}_1, \Delta_1^R)$, to be their steady state value. Simulate the paths for $(\tilde{b}_t, \tilde{K}_t, \Delta_t^R)$ for all $t = 2, 3, .., T$ using the set of policy functions.

5. Verify that the mean values for $(\tilde{b}_t, \tilde{K}_t, \Delta_t^R)$ locate in the domain grid for H_t for each $t = 1, 2, ..., T$.

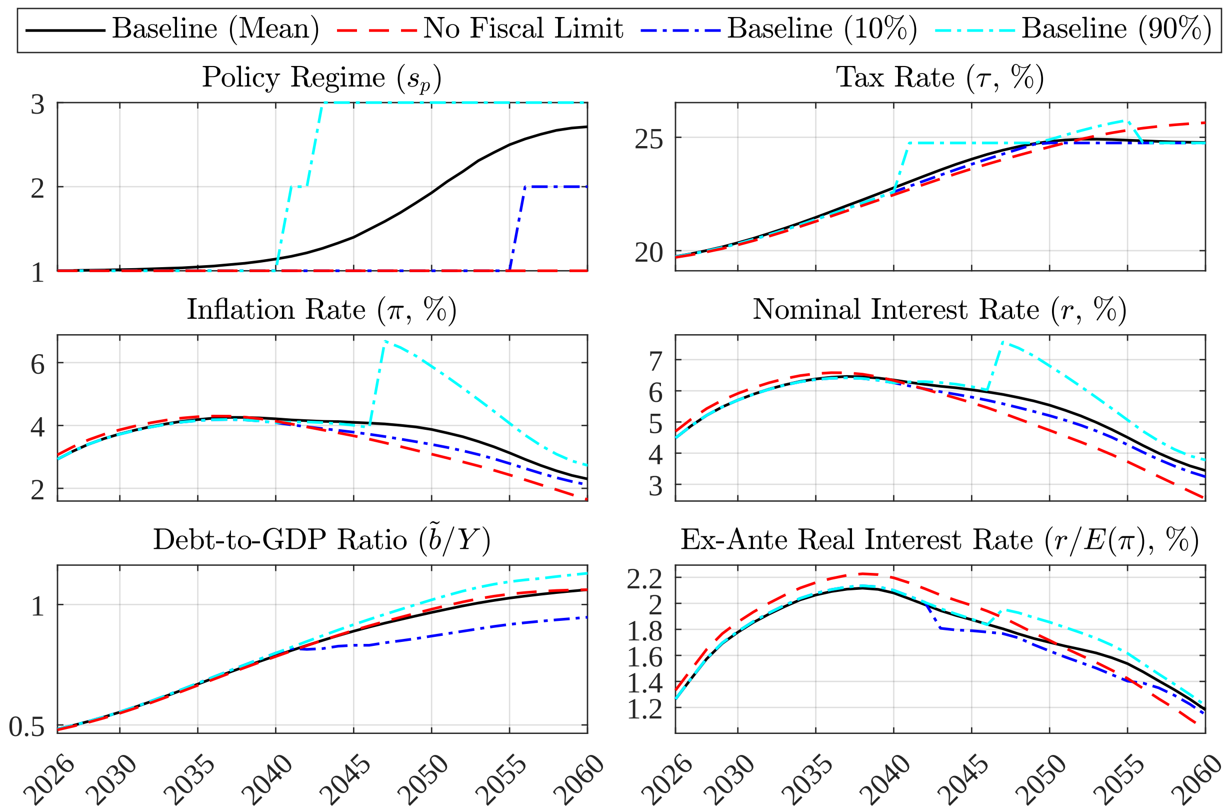
C ADDITIONAL RESULTS

Figure A.3: Taiwan's fiscal limit projections



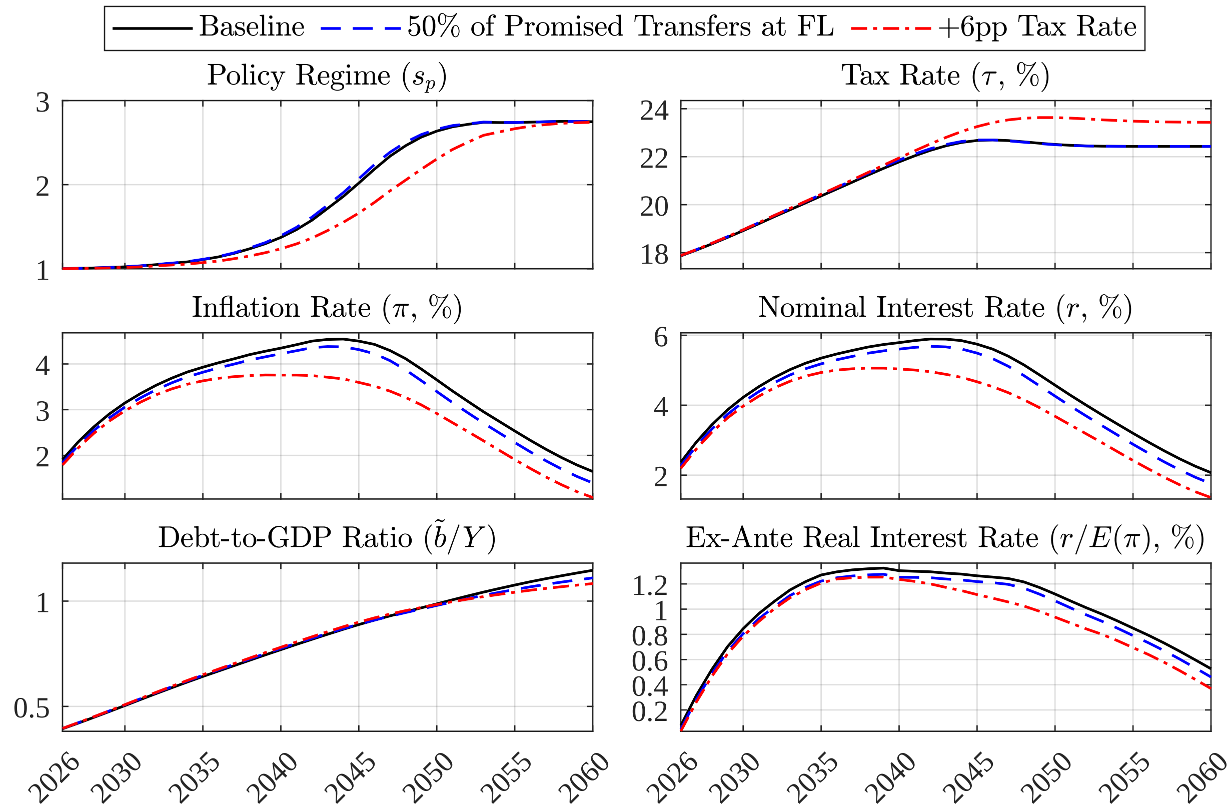
Note: Baseline (Mean) is the mean across 10,000 simulations. The 10th and 90th percentiles of the baseline simulations, depicted with dash-dotted lines, exhibit occasional sharp shifts, reflecting the discrete nature of the underlying three-state Markov process.

Figure A.4: China's fiscal limit projections



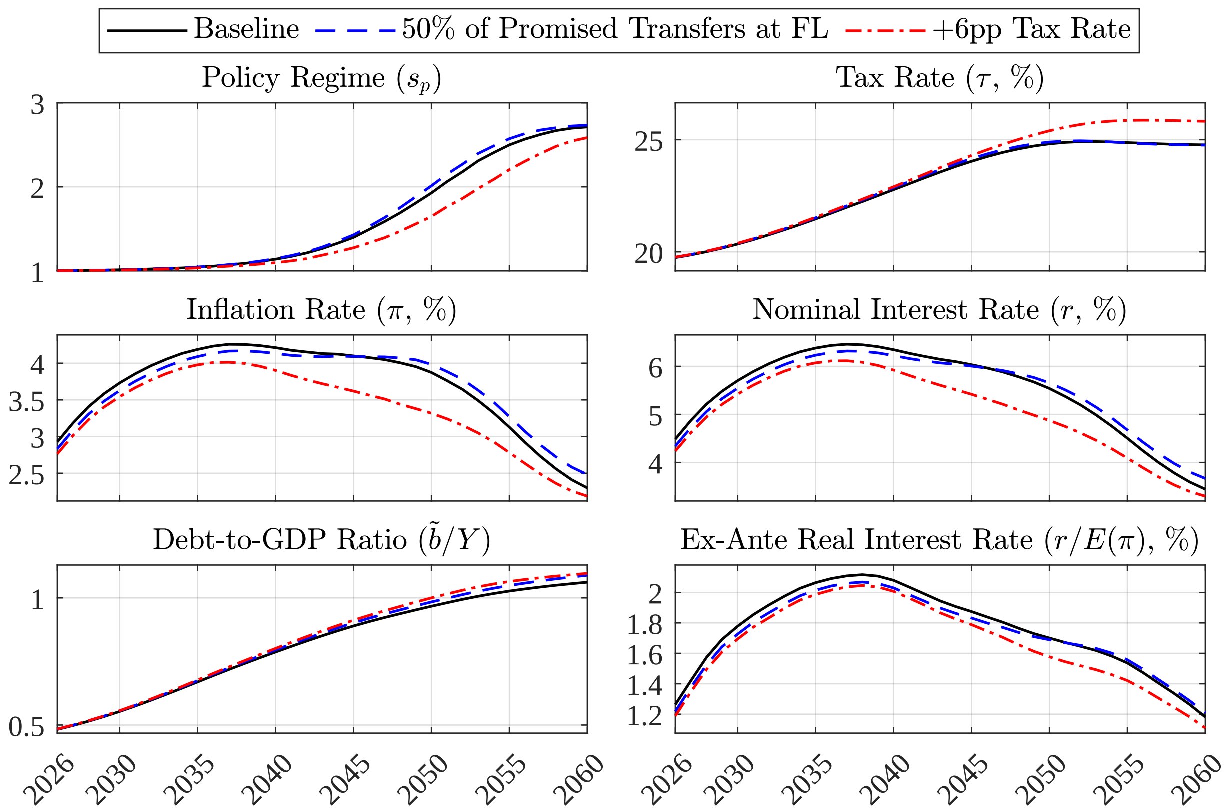
Note: Baseline (Mean) is the mean across 10,000 simulations. The 10th and 90th percentiles of the baseline simulations, depicted with dash-dotted lines, exhibit occasional sharp shifts, reflecting the discrete nature of the underlying three-state Markov process.

Figure A.5: Tax or Transfer Reforms in Taiwan



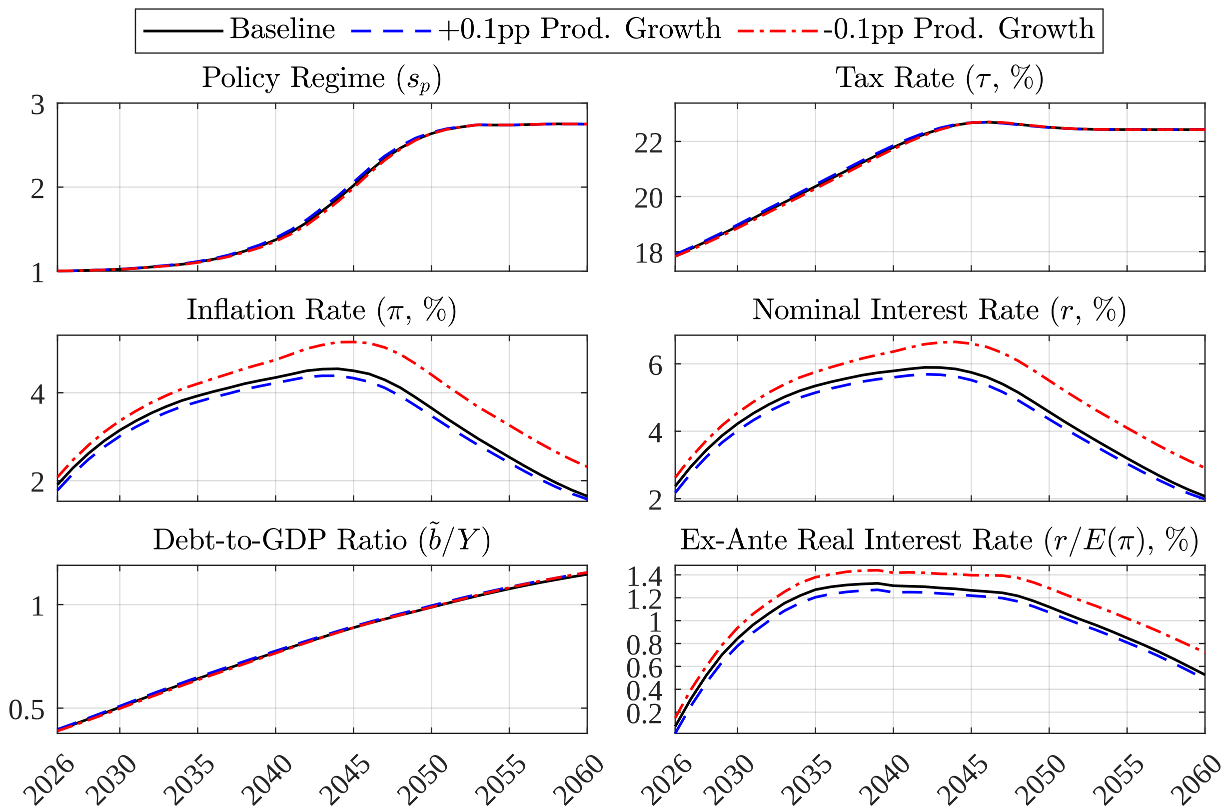
Note: In the baseline, transfers are 70% of their promised level at the fiscal limit and the income tax rate increases by $+5pp$ relative to the pre-fiscal limit tax rate. The projected paths are a mean across 10,000 simulations.

Figure A.6: Tax or Transfer Reforms in China



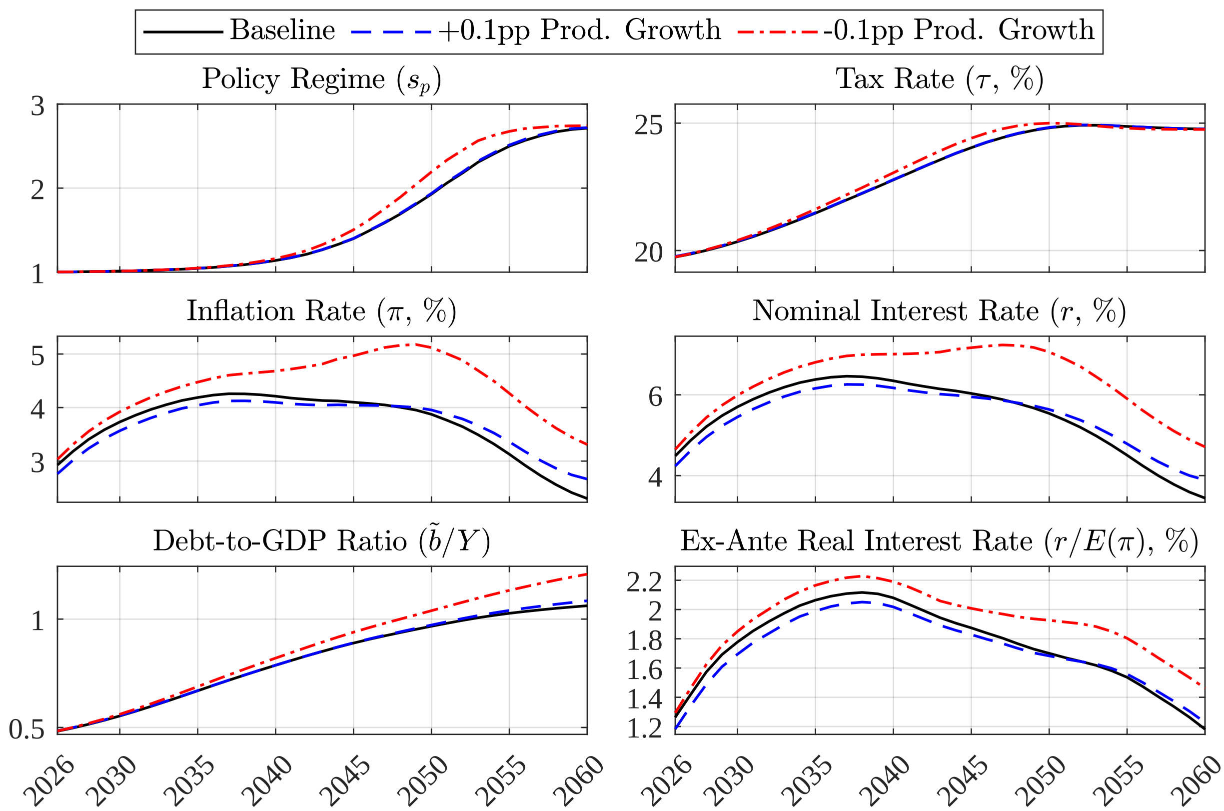
Note: In the baseline, transfers are 70% of their promised level at the fiscal limit and the income tax rate increases by $+5pp$ relative to the pre-fiscal limit tax rate. The projected paths are a mean across 10,000 simulations.

Figure A.7: Alternative productivity growth scenarios for Taiwan



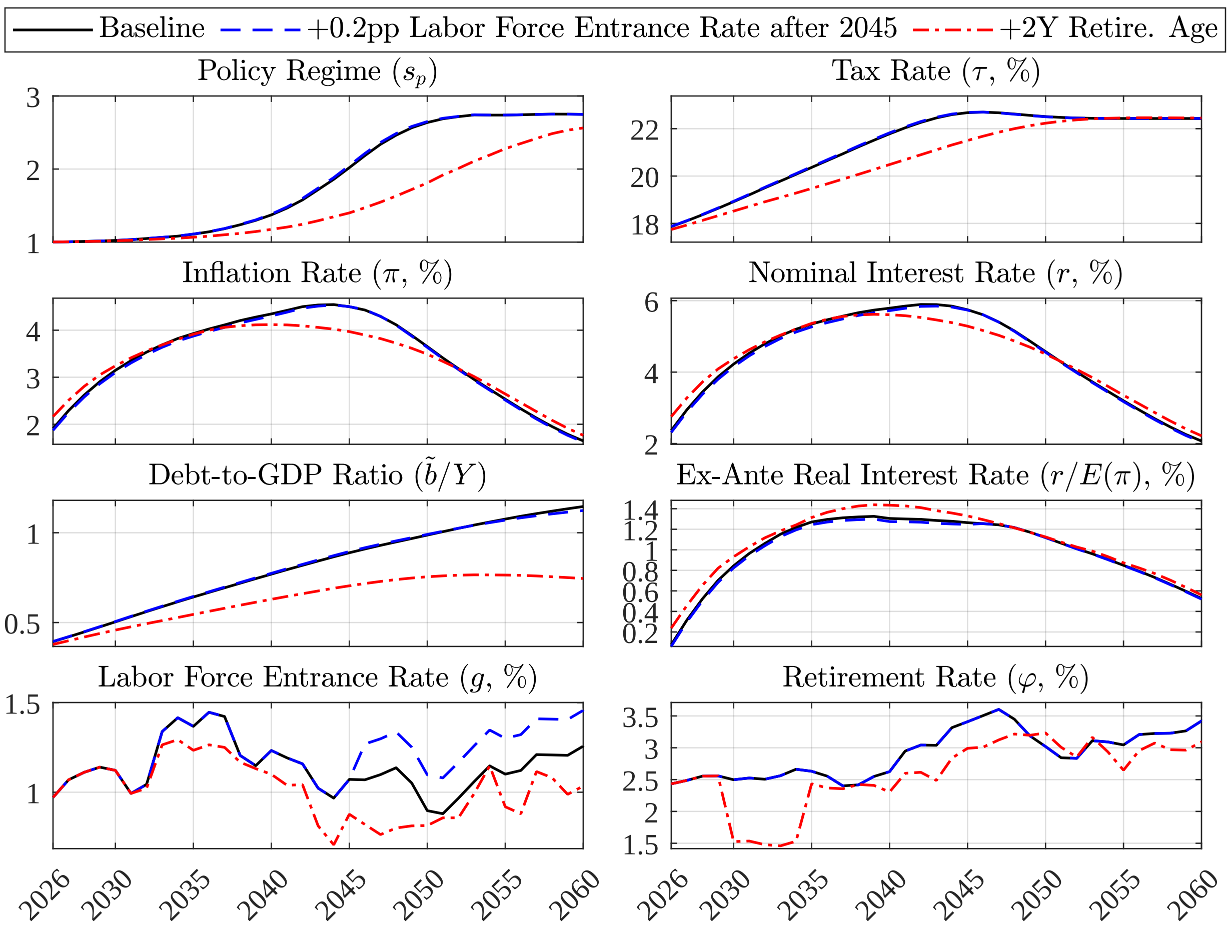
Note: In the baseline, productivity grows at 0.5% per year. The projected paths are a mean across $10{,}000$ simulations.

Figure A.8: Alternative productivity growth scenarios for China



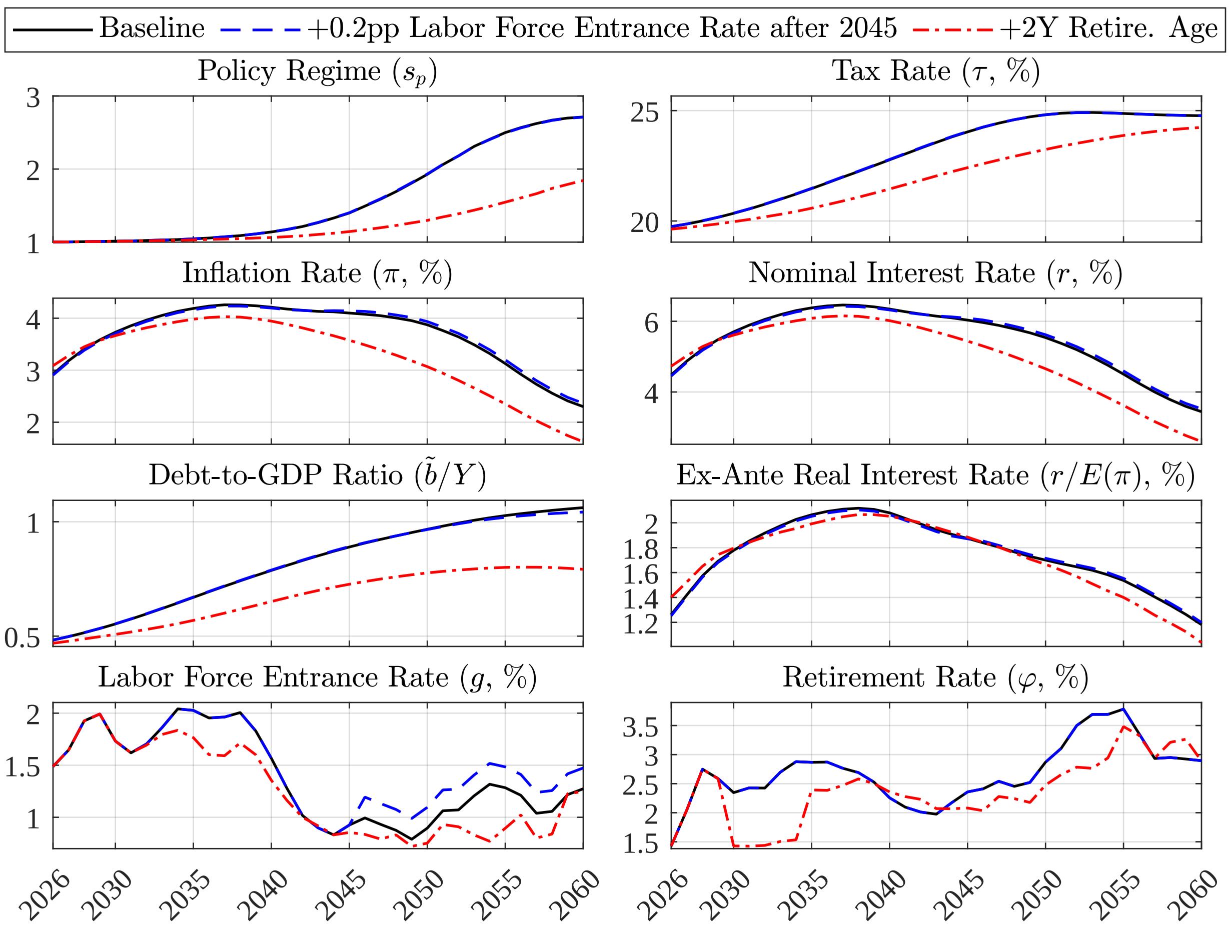
Note: In the baseline, productivity grows at 0.5% per year. The projected paths are a mean across $10{,}000$ simulations.

Figure A.9: Alternative labor force entrance and retirement rate scenarios in Taiwan



Note: In the retirement rate alternative, the retirement age is delayed until age 66 implemented gradually from 2030 to 2035. The worker and retiree populations in each year are the same as the baseline, and the labor force entrance rate, by construction, must decline to offset the increase in workers from delayed retirement. The projected paths are a mean across 10,000 simulations.

Figure A.10: Alternative labor force entrance and retirement rate scenarios in China



Note: In the retirement rate alternative, the retirement age is delayed until age 66 implemented gradually from 2030 to 2035. The worker and retiree populations in each year are the same as the baseline, and the labor force entrance rate, by construction, must decline to offset the increase in workers from delayed retirement. The projected paths are a mean across 10,000 simulations.