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# **Demographic Changes and Neutral Interest Rates: Evidence from the World's Fastest-Aging Economy**

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# Demographic Changes and Neutral Interest Rates: Evidence from the World's Fastest-Aging Economy\*

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## Abstract

This paper estimates Korea's long-run real neutral interest rate and quantifies the structural forces behind its decline since 1990. Using semiannual data for 12 advanced economies over 1990–2024, we estimate a cross-country panel state-space model that separates country-specific productivity and demographic trends from common global components. Korea's neutral rate falls from about 1.6% in 1990 to roughly 0.7% in 2024. The model attributes this decline mainly to slower trend productivity growth, the post-2014 reversal in the working-age population share, and spillovers from major advanced economies. Safe-asset market forces also contribute, but supply and demand effects partly offset each other. Counterfactual simulations suggest that removing global spillovers would raise the 2024 estimate by about 0.6 percentage points, while holding the working-age share at its 2014 level would raise it by about 0.5 percentage points. Conditional demographic scenarios imply continued downward pressure absent offsetting structural changes, highlighting implications for monetary policy space.

**JEL Classification:** E43; E47; E58; F15; F62

**Keywords:** Neutral interest rate; Demographic changes; Korean economy; Global spillovers; State space model

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# 1 Introduction

The neutral interest rate ( $r^*$ )—the real interest rate consistent with output at potential and stable inflation—is a central benchmark for macroeconomic policy. It determines how policymakers interpret the stance of monetary policy, the degree of accommodation embedded in a given policy rate, and the amount of conventional policy space available in future downturns. Over the past three decades, real interest rates have declined substantially across advanced economies. This broad decline has renewed interest in the structural forces that shape long-run equilibrium real rates, including productivity growth, demographic change, and global financial conditions.

Early discussions of the equilibrium real rate relied on simple calibrations or historical averages. For example, [Taylor \(1993\)](#) assumed a stable link between potential growth and the equilibrium real rate, while [Reifschneider and Williams \(2000\)](#) used a constant real policy rate as a proxy for  $r^*$ . Subsequent work introduced time-varying empirical estimates. Reduced-form filtering approaches, such as [Lubik and Matthes \(2015\)](#) and [Hamilton, Harris, Hatzius and West \(2016\)](#), extract low-frequency components of real interest rates as proxies for the neutral rate. A seminal semi-structural contribution is [Laubach and Williams \(2003\)](#), who develop a state-space framework combining an IS curve and a Phillips curve to jointly estimate potential output and  $r^*$ . The Laubach–Williams framework has since become widely used in both academic and policy settings.

A large and growing literature emphasizes that the long-run neutral rate is shaped by slow-moving structural fundamentals. In particular, productivity growth affects equilibrium real rates through expected income growth, investment demand, and the marginal product of capital. A sustained slowdown in productivity growth can therefore lower the neutral rate by weakening expected returns and reducing desired investment. Demographic structure provides another persistent source of variation. Population aging and a declining working-age population can reduce equilibrium real rates by raising aggregate

saving, slowing labor force growth, and weakening investment demand.

Theoretical and empirical studies—including [Rachel and Smith \(2015\)](#), [Carvalho, Ferrero and Nechio \(2016\)](#), [Turnovsky \(2019\)](#), [Bielecki, Brzoza-Brzezina and Kolasa \(2020\)](#), [Gagnon, Johannsen and Lopez-Salido \(2021\)](#), [Papetti \(2021\)](#), [Benati \(2023\)](#), and [Carvalho, Ferrero, Mazin and Nechio \(2025\)](#)—show that demographic forces can have quantitatively important effects on long-run real interest rates. Some contributions, such as [Hamilton et al. \(2016\)](#) and [Lunsford and West \(2019\)](#), further suggest that demographic variables may provide a more robust explanation for low-frequency movements in  $r^*$  than potential growth alone.

At the same time, equilibrium real rates are not determined solely by domestic fundamentals. In financially open economies, long-run real rates exhibit substantial cross-country comovement. [Holston, Laubach and Williams \(2017\)](#) document a pronounced decline and strong co-movement in  $r^*$  across Canada, the euro area, the United Kingdom, and the United States, pointing to an important role for common forces. Building on this perspective, [Ferreira and Shousha \(2023\)](#) estimate a cross-country state-space model that decomposes neutral-rate movements into contributions from productivity growth, demographic structure, and global safe-asset supply and demand. Similarly, [IMF \(2023\)](#) emphasize the roles of demographic transition and slower productivity growth in accounting for the secular decline in advanced-economy neutral rates. This evidence suggests that credible measurement of  $r^*$ , especially in small open economies, requires distinguishing domestic structural change from global influences.

Korea provides an especially informative setting for studying these mechanisms. It has experienced one of the fastest demographic transitions among advanced economies. Its working-age population share rose steadily through the 1990s and 2000s, peaked around 2014, and has declined sharply since then, reflecting exceptionally low fertility and rapid population aging. This reversal is central to our analysis. Before the mid-2010s, Korea's demographic structure provided support to the neutral rate by expanding the working-

age population. After 2014, the same channel turned into a persistent headwind. The Korean experience therefore offers unusually sharp time-series variation for quantifying how demographic transition affects the long-run real neutral rate.

Korea is also a useful case because demographic change has occurred alongside a marked slowdown in productivity growth. During the 1990s and early 2000s, Korea benefited from rapid productivity growth associated with convergence toward the advanced-economy frontier. More recently, productivity growth has slowed and moved closer to the range observed in other advanced economies. The combination of a productivity slowdown and a demographic reversal makes Korea a natural laboratory for studying how multiple structural forces jointly shape the long-run neutral rate.

A further reason to study Korea is its status as a small and highly open economy. Korea is deeply integrated into global capital markets, but it does not issue a dominant global reserve asset. It is therefore plausibly exposed to global safe-asset conditions and foreign structural trends. Ignoring these external forces could lead researchers to attribute common international movements in long-run real rates to domestic structural change. Moreover, unlike several advanced economies that faced a binding effective lower bound after 2008, Korea did not encounter a binding zero lower bound during our sample period. Observed short-term policy rates therefore remain informative about underlying equilibrium real rates, strengthening identification of  $r^*$  within a state-space framework that links latent trends to observable macroeconomic variables.

Existing empirical work on Korea has made important progress but has generally relied on single-country approaches. [Cho \(2020\)](#) estimates Korea's neutral rate using variants of the Laubach–Williams framework, while [Do, Ahn and Jung \(2024\)](#) extend such methods to a small open economy setting. [Lee, Hahn, Park and Park \(2020\)](#) incorporate financial-cycle indicators into neutral-rate estimation, and [Do and Park \(2025\)](#) analyze the term-structure dimension of Korea's equilibrium rate. In a structural life-cycle open-economy model, [Lee, Park and Hwang \(2025\)](#) show that increases in life expectancy

and declines in fertility can account for Korea's secular decline in  $r^*$ . These studies provide valuable evidence on Korea's equilibrium real rate. However, they typically do not jointly quantify the roles of domestic productivity, domestic demographics, global safe-asset conditions, and international spillovers within a unified cross-country framework.

To address this gap, we estimate a cross-country panel state-space model that embeds Korea in a panel of 12 advanced economies over 1990–2024. The model builds on [Ferreira and Shousha \(2023\)](#) and separates country-specific structural trends from common international components. The panel structure is central to our identification strategy. It disciplines country-specific latent trends using cross-country information and allows us to decompose movements in Korea's neutral rate into contributions from trend productivity growth, the working-age population share, global safe-asset supply, policy-driven safe-asset demand, the convenience yield, and trade-weighted spillovers from foreign productivity and demographics. For a small open economy such as Korea, this approach is useful because a purely single-country model may confound domestic structural change with global movements in equilibrium real rates.

Our estimates show that Korea's long-run real neutral rate declined substantially over the sample period, from about 1.6 percent in 1990 to roughly 0.7 percent in 2024. We emphasize the evolution and structural drivers of  $r^*$  rather than point estimates alone. The model-implied decomposition attributes most of Korea's long-run decline to three forces: a sustained slowdown in trend productivity growth, a sharp post-2014 reversal in the working-age population share, and persistent spillovers from major advanced economies. Global safe-asset supply and demand forces partly offset each other over the sample. Counterfactual simulations indicate that both external spillovers and Korea's domestic demographic transition have materially lowered the level of  $r^*$ . Eliminating global spillovers would raise Korea's neutral rate in 2024 by roughly 0.6 percentage points, while holding the working-age population share at its 2014 level would raise it by about 0.5 percentage points. Conditional demographic scenarios based on United Nations projections

suggest continued downward pressure on Korea's neutral rate absent offsetting structural improvements.

This paper contributes to the macroeconomic literature in three ways. First, it provides a structural estimate of Korea's long-run neutral rate in a cross-country framework that jointly incorporates domestic productivity, demographic structure, global safe-asset market conditions, and international spillovers. Second, it uses Korea's unusually sharp demographic reversal to provide quantitative evidence on the role of working-age population dynamics in shaping long-run real interest rates. Third, it highlights the implications of rapid aging for monetary policy space in an advanced small open economy. The results suggest that assessments of the monetary policy stance in Korea should account not only for domestic cyclical conditions but also for slow-moving demographic trends, productivity dynamics, and global forces that influence the long-run equilibrium real rate.

## **2 Structural Determinants of the Long-Run Neutral Interest Rate**

The long-run real neutral interest rate reflects structural forces that shape desired saving and investment. In the long run, these forces are closely linked to productivity growth, demographic structure, and the international environment in which domestic saving and investment decisions take place. Our empirical specification is organized around two broad channels. The first is a domestic growth-fundamentals channel, through which productivity and demographics affect expected returns to capital, labor supply, and desired saving. The second is a global financial channel, through which safe-asset market conditions and foreign structural trends influence equilibrium real rates in financially integrated economies.

**Growth fundamentals: productivity and demographics.** Productivity growth affects the equilibrium real interest rate through investment demand and expected income growth. When productivity growth slows, the marginal product of capital and expected returns to investment decline, reducing firms' incentives for capital formation. Lower expected income growth may also increase precautionary saving by households. Both mechanisms tend to reduce the real interest rate consistent with long-run macroeconomic balance.

Demographic structure provides another persistent determinant of the neutral rate. A decline in the working-age population reduces labor input growth and raises the capital–labor ratio, lowering the marginal product of capital and equilibrium real returns. Population aging can also increase desired saving at the aggregate level, especially when longer life expectancy and retirement motives dominate dissaving by older cohorts. At the same time, slower labor force growth weakens investment demand by reducing the need for capital deepening and expansion. Because demographic transitions unfold gradually but persistently, they are particularly relevant for explaining low-frequency movements in long-run real interest rates.

These mechanisms are especially important in Korea. The working-age population share rose for much of the post-1990 period, providing support to the neutral rate during Korea's convergence phase. Around the mid-2010s, however, this trend reversed. The subsequent decline in the working-age share represents a structural demographic headwind that is likely to exert persistent downward pressure on the long-run neutral rate. This reversal motivates our focus on demographic changes as a central driver of Korea's equilibrium real interest rate.

**Global financial conditions and safe-asset markets.** Although productivity and demographics are central domestic determinants of the neutral rate, equilibrium real rates in small open economies are also shaped by global financial conditions. With integrated capital markets, domestic real rates need not be pinned down solely by domestic saving and

investment. Instead, they may comove with global real rates through cross-border capital flows, common discount-rate movements, and international transmission of structural shocks.

Safe-asset markets provide one important channel through which global financial conditions affect long-run real rates. Investors value highly rated government securities not only for their expected pecuniary returns but also for the safety and liquidity services they provide. An increase in the demand for safe and liquid assets—whether driven by reserve accumulation, regulatory requirements, or changes in global risk appetite—raises safe-asset prices and lowers their yields, placing downward pressure on equilibrium real rates. Conversely, an expansion in the supply of safe assets can ease safe-asset scarcity and work in the opposite direction.

In our empirical framework, we therefore distinguish global safe-asset supply from policy-driven safe-asset demand, following [Ferreira and Shousha \(2023\)](#). We measure safe-asset supply using U.S. marketable Treasuries, reflecting the central role of U.S. government securities in global financial markets. We use a policy-driven demand proxy based on Treasury holdings by agents with institutional mandates, including foreign official reserve managers and regulated financial intermediaries. The convenience yield captures the broader market valuation of safety and liquidity services, while the policy-driven demand proxy isolates demand shifts arising from institutional and regulatory motives rather than cyclical fluctuations.

For Korea, these global financial channels are relevant because Korea is a small and financially open economy that does not issue a dominant global reserve asset. Domestic estimates of the neutral rate may therefore reflect not only Korean productivity and demographic trends but also common movements in global real rates. Incorporating safe-asset market conditions and international spillovers helps separate domestic structural forces from global influences when measuring Korea's long-run neutral interest rate.

## 3 Empirical Model and Data

### 3.1 Empirical framework

We estimate a cross-country panel state-space model to identify the long-run real neutral interest rate and its structural determinants. The framework builds on the global model of [Ferreira and Shousha \(2023\)](#) and is designed to capture low-frequency movements in equilibrium real rates across financially integrated advanced economies. The panel dimension is central to our empirical strategy. It disciplines country-specific latent trends using information from other economies and allows us to separate domestic structural forces from common international components that would be difficult to identify in a single-country model.

Although the model is estimated on a panel of advanced economies, Korea is the primary focus of the empirical analysis. Korea is informative for three reasons. First, its demographic transition is unusually sharp: the working-age population share rose rapidly through the 2000s, peaked around 2014, and has since declined markedly. This reversal provides high-contrast variation for assessing the contribution of demographics to  $r^*$ . Second, Korea is a small and financially open economy. As a result, its long-run real rate may reflect not only domestic productivity and demographic trends but also global safe-asset conditions and foreign structural developments. Third, Korea did not encounter a binding zero lower bound during our sample period. This mitigates concerns that observed short-term interest rates are mechanically truncated ([Pescatori and Turunen, 2016](#)) and helps identify the neutral rate in a state-space system linking latent trends to observed macroeconomic variables.

### 3.2 State-space representation

For country  $j$  at semiannual period  $t$ , observed unemployment  $u_{j,t}$ , inflation  $\pi_{j,t}$ , and the short-term policy rate  $i_{j,t}$  are decomposed into cyclical components and latent trends:

$$\begin{pmatrix} u_{j,t} \\ \pi_{j,t} \\ i_{j,t} \end{pmatrix} = \begin{pmatrix} \hat{u}_{j,t} \\ \hat{\pi}_{j,t} \\ \hat{i}_{j,t} \end{pmatrix} + \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \end{pmatrix} \begin{pmatrix} X_{j,t}^u \\ X_{j,t}^m \\ X_{j,t}^r \end{pmatrix}. \quad (1)$$

Here  $X_{j,t}^u$  denotes the natural rate of unemployment,  $X_{j,t}^m$  is a monetary trend common to inflation and the nominal interest rate, and  $X_{j,t}^r$  is the long-run real neutral interest rate, our main object of interest. Equation (1) implies that the nominal policy rate contains both the inflation trend and the long-run real neutral rate, while unemployment loads on its own natural-rate trend.

The unemployment and monetary trends follow random walks:

$$X_{j,t}^s = X_{j,t-1}^s + x_{j,t}^s, \quad s \in \{u, m\}, \quad (2)$$

where  $x_{j,t}^s$  denotes a permanent innovation to the corresponding trend.

Cyclical components evolve according to a VAR(1):

$$\hat{Y}_{j,t} = B\hat{Y}_{j,t-1} + CZ_{j,t}, \quad \hat{Y}_{j,t} = \begin{pmatrix} \hat{u}_{j,t} \\ \hat{\pi}_{j,t} \\ \hat{i}_{j,t} \end{pmatrix}, \quad (3)$$

where  $B$  is a  $3 \times 3$  matrix of autoregressive coefficients and  $C$  maps structural shocks  $Z_{j,t}$  into the cyclical innovations.

The vector  $Z_{j,t}$  collects six shocks:

$$Z_{j,t} = \begin{pmatrix} x_{j,t}^m \\ x_{j,t}^u \\ x_{j,t}^r \\ z_{j,t}^p \\ z_{j,t}^d \\ z_{j,t}^s \end{pmatrix}. \quad (4)$$

Here  $x_{j,t}^m$  and  $x_{j,t}^u$  are permanent monetary and unemployment shocks,  $x_{j,t}^r$  is the permanent shock to the real neutral rate, and  $z_{j,t}^p$ ,  $z_{j,t}^d$ , and  $z_{j,t}^s$  are temporary monetary-policy, demand, and supply shocks, respectively. All shocks are assumed to be normally distributed and independent across countries and time, except for  $z_{j,t}^d$ , which follows an AR(1) process.

### 3.3 Determinants of the neutral rate

Motivated by theories of long-run real interest rates, we model innovations to the neutral rate as functions of slow-moving structural determinants:

$$x_{j,t}^r = \beta_{pt}\Delta pt_{j,t} + \beta_{ws}\Delta ws_{j,t} + \beta_{cy}\Delta cy_t + \beta_{ss}\Delta ss_t + \beta_{sd}\Delta sd_t + \beta_{gs}g_{j,t-1} + \varepsilon_{j,t}. \quad (5)$$

In equation (5),  $\Delta pt_{j,t}$  is the change in trend productivity growth,  $\Delta ws_{j,t}$  is the change in the working-age population share,  $\Delta cy_t$  is the change in the trend convenience yield,  $\Delta ss_t$  is the change in the global supply of safe assets,  $\Delta sd_t$  is the change in policy-driven demand for safe assets, and  $g_{j,t-1}$  captures trade-weighted global spillovers from foreign productivity and demographic trends. The residual  $\varepsilon_{j,t}$  captures country-specific innovations to the neutral rate not explained by these observed structural determinants.

Because  $X_{j,t}^r$  follows a random walk, its innovation is modeled as a function of changes

in structural trends rather than their levels. This specification links persistent movements in the neutral rate to innovations in productivity growth, demographic structure, and global financial conditions. It also provides a transparent accounting framework for decomposing changes in  $r^*$  into economically interpretable components.

Global spillovers enter through

$$g_{j,t-1} = \sum_{i \neq j} \omega_i^j (\beta_{pt} \Delta pt_{i,t-1} + \beta_{ws} \Delta ws_{i,t-1}), \quad (6)$$

where  $\omega_i^j$  denotes the trade weight of country  $i$  in country  $j$ 's external exposure. This term captures the idea that foreign productivity and demographic trends may affect domestic equilibrium real rates through international linkages. It also allows us to separate the contribution of domestic productivity and demographics from that of rest-of-the-world structural developments.

The slow-moving determinants  $\Delta pt_{j,t}$ ,  $\Delta ws_{j,t}$ ,  $\Delta cy_t$ ,  $\Delta ss_t$ , and  $\Delta sd_t$  are assumed to be mutually uncorrelated and independent of the cyclical state of the economy. This assumption is a modeling device that facilitates a transparent decomposition of long-run forces; it should not be interpreted as a literal claim that productivity, demographics, and safe-asset conditions are economically unrelated.<sup>1</sup>

### 3.4 Identification of shocks

Identification is achieved by placing zero and sign restrictions on the impact matrix  $C$  in (3). Thus, the columns of  $C$  correspond one-for-one to the elements of  $Z_{j,t}$  and the rows correspond to the cyclical innovations in  $(\hat{u}_{j,t}, \hat{\pi}_{j,t}, \hat{l}_{j,t})'$ .

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<sup>1</sup>Relaxing this assumption would require a richer joint model of long-run structural trends. Our objective is more limited: to quantify the contribution of observed slow-moving determinants to neutral-rate innovations within a parsimonious state-space framework.

We write

$$C = \begin{array}{c|cccccc} & x_{j,t}^m & x_{j,t}^u & x_{j,t}^r & z_{j,t}^p & z_{j,t}^d & z_{j,t}^s \\ \hline \cdot & \cdot & C_{13} = 0 & C_{14} \geq 0 & C_{15} = -1 & C_{16} \geq 0 & \\ \cdot & \cdot & C_{23} = 0 & C_{24} \leq 0 & C_{25} \geq 0 & C_{26} = 1 & \\ \cdot & \cdot & C_{33} = -1 & C_{34} = 1 & \cdot & \cdot & \end{array}. \quad (7)$$

These restrictions have a straightforward interpretation. A unit increase in the long-run real neutral rate shock  $x_{j,t}^r$  leaves unemployment and inflation unchanged on impact ( $C_{13} = C_{23} = 0$ ) and is offset one-for-one by a decline in the cyclical policy rate ( $C_{33} = -1$ ). Temporary monetary shocks raise the policy rate by one percentage point ( $C_{34} = 1$ ), may increase unemployment ( $C_{14} \geq 0$ ), and may reduce inflation ( $C_{24} \leq 0$ ). Temporary demand shocks lower unemployment contemporaneously ( $C_{15} = -1$ ) and may raise inflation ( $C_{25} \geq 0$ ), while the contemporaneous policy response is left unrestricted ( $C_{35}$  free). Temporary supply shocks increase inflation on impact ( $C_{26} = 1$ ) and may raise unemployment ( $C_{16} \geq 0$ ), while the contemporaneous policy response is left unrestricted.

### 3.5 Estimation and measurement equations

To link the latent variables to observables, we use the measurement relationships implied by (1)–(2). First, changes in unemployment are given by

$$\Delta u_{j,t} = \hat{u}_{j,t} - \hat{u}_{j,t-1} + x_{j,t}^u. \quad (8)$$

Let the ex-post real interest rate be  $r_{j,t} \equiv i_{j,t} - \pi_{j,t}$ . Then changes in the real interest rate satisfy

$$\Delta r_{j,t} = (\hat{i}_{j,t} - \hat{i}_{j,t-1}) - (\hat{\pi}_{j,t} - \hat{\pi}_{j,t-1}) + x_{j,t}^r, \quad (9)$$

and changes in the nominal policy rate are given by

$$\Delta i_{j,t} = \hat{i}_{j,t} - \hat{i}_{j,t-1} + x_{j,t}^m + x_{j,t}^r. \quad (10)$$

These equations follow directly from the decomposition of the nominal policy rate into a cyclical component, an inflation trend, and the long-run real neutral rate.

Finally, the cyclical inflation component equals actual inflation minus the monetary trend:

$$\hat{\pi}_{j,t} = \pi_{j,t} - X_{j,t}^m. \quad (11)$$

We use long-term inflation expectations to discipline the monetary trend  $X_{j,t}^m$ .<sup>2</sup>

Equations (1)–(11) define a linear Gaussian state-space system, which we estimate with the Kalman filter. We follow a Bayesian approach and specify priors for the parameters in  $B$  and  $C$ , as well as for the coefficients  $\beta_{pt}$ ,  $\beta_{ws}$ ,  $\beta_{cy}$ ,  $\beta_{ss}$ ,  $\beta_{sd}$ , and  $\beta_{gs}$  in the neutral-rate equation. The priors on the determinants of neutral-rate innovations are centered at zero, allowing the data to determine whether productivity, demographics, safe-asset variables, and spillovers play quantitatively meaningful roles. The exception is the global spillover coefficient, which follows a diffuse beta distribution on  $[0, 1]$ .

Posterior distributions are obtained using a Metropolis–Hastings Markov chain Monte Carlo algorithm with 1.5 million draws, discarding the first 25 percent as burn-in. We use posterior moments to construct estimated paths for long-run neutral rates and to decompose changes in the neutral rate into structural contributions from productivity, demographics, global safe-asset conditions, international spillovers, and residual country-specific factors.

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<sup>2</sup>Specifically, we treat survey-based five-year-ahead inflation expectations as direct measures of the inflation trend. This approach reduces reliance on purely statistical filtering and improves identification of the real neutral rate.

### 3.6 Data

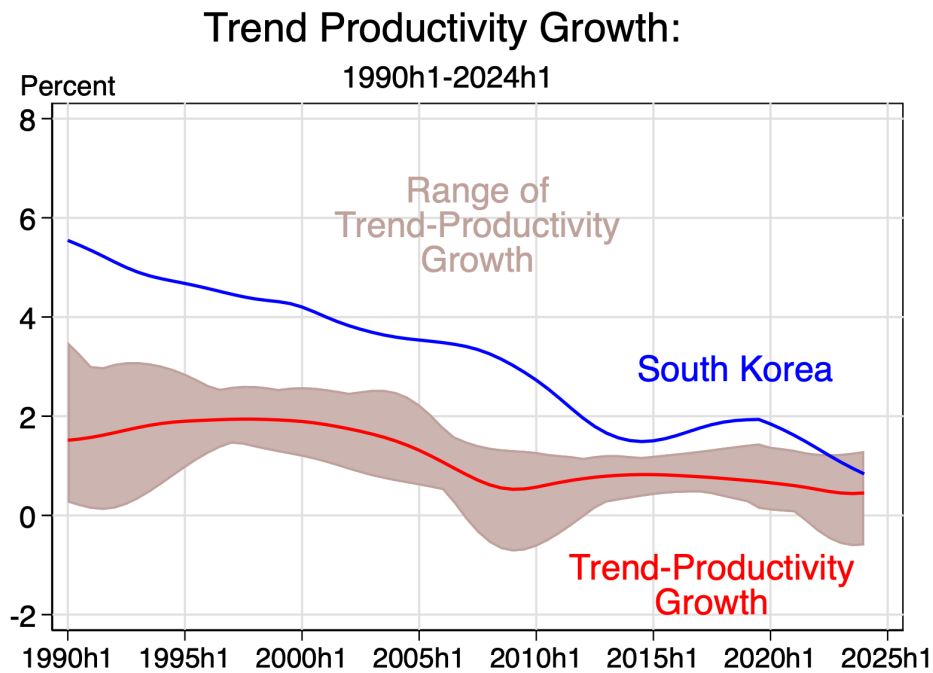
Our dataset consists of semiannual observations for 12 advanced economies from 1990 to 2024. The panel includes Australia, Canada, Denmark, the euro area, Japan, Norway, New Zealand, Sweden, Switzerland, the United Kingdom, the United States, and Korea. We begin the sample in 1990 for two reasons. First, Korean macroeconomic data become more reliable and more comparable with those of other advanced economies from this period onward. Second, the post-1990 period captures Korea's transition into a mature and financially integrated economy, making it appropriate for studying the joint roles of domestic structural change and global forces in neutral-rate determination. We construct the variables following [Ferreira and Shousha \(2023\)](#) and convert higher-frequency series to semiannual observations by taking period averages.

**Macroeconomic variables.** Unemployment rates and consumer price inflation are obtained from national statistical agencies and the OECD. The policy rate corresponds to each country's main short-term monetary policy instrument. For Korea, we use the Bank of Korea base rate from 1999 onward and the discount rate for earlier periods. Inflation is expressed at annualized rates. Long-term inflation expectations are taken from *Consensus Economics* surveys and correspond to five-year-ahead expectations. These expectations discipline the monetary trend in the state-space model and help identify the real neutral rate separately from the inflation trend.

**Productivity.** Trend productivity growth is constructed using data from the Conference Board Total Economy Database. We compute productivity growth as the average of real GDP per employed person growth, real GDP per hour worked growth, and total factor productivity growth. To isolate the low-frequency component relevant for long-run real interest rates, we extract the slow-moving trend using a high-smoothing filter.

Figure 1 illustrates the evolution of trend productivity growth in Korea relative to the

Figure 1: Trend Productivity Growth



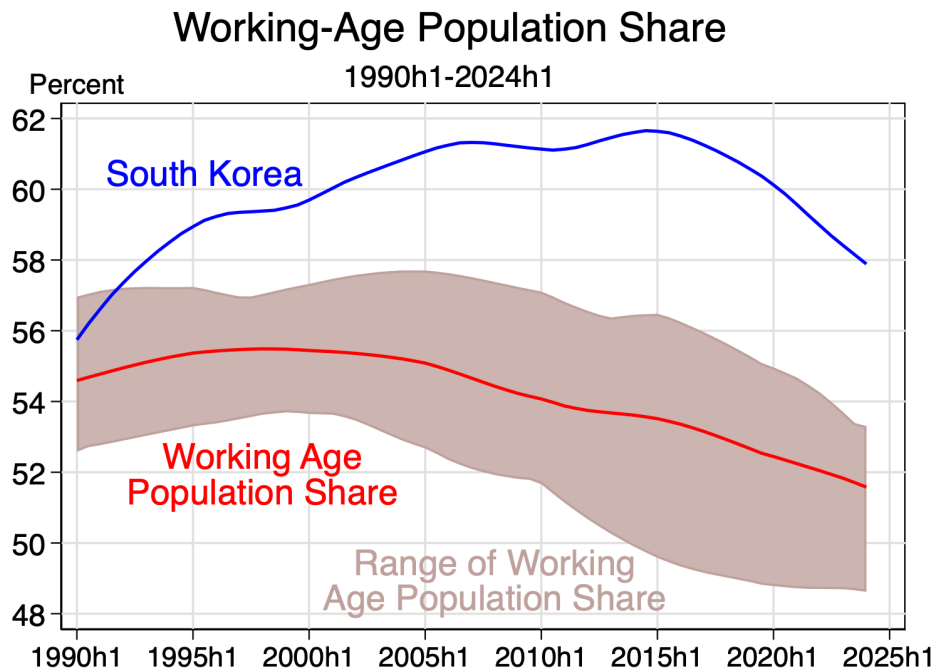
Note: Author's calculation based on productivity trends for Korea and 11 other advanced economies, 1990:H1–2024:H1. The red line denotes the mean across the 11 other economies, and the shaded area indicates the range between the minimum and maximum values.

other advanced economies in the sample. Korea experienced rapid productivity growth during the 1990s and early 2000s, reflecting convergence toward the advanced-economy frontier. Since then, productivity growth has declined markedly and moved closer to the range observed in other advanced economies. This rise and subsequent slowdown make Korea a useful case for examining how changes in trend productivity growth affect the long-run neutral rate.

**Demographics.** Demographic developments are measured by the working-age population share, defined as the ratio of individuals aged 20–60 to the total population, using United Nations data. This definition ensures cross-country comparability while focusing on the age group most closely linked to labor supply and saving behavior.

Figure 2 shows that Korea stands out for the speed and timing of its demographic

Figure 2: Working-Age Population Ratio



Note: Author's calculation based on United Nations data for Korea and 11 other advanced economies, 1990:H1–2024:H1. The red line denotes the mean across the 11 other economies, and the shaded area indicates the range between the minimum and maximum values.

transition. The working-age population share rose through the 1990s and 2000s, peaked around 2014, and then began to decline sharply. This turning point is central to our empirical analysis because it implies that demographics supported Korea's neutral rate before the mid-2010s but became a persistent headwind thereafter.

**Safe-asset variables and convenience yield.** We construct measures of global safe-asset supply and policy-driven safe-asset demand following [Glick \(2020\)](#) and [Ferreira and Shousha \(2023\)](#). Both variables are scaled by world GDP to remove the effect of secular growth in the global economy. The supply measure captures the stock of government debt issued by advanced economies that is widely perceived as safe and liquid. The demand measure captures institutional and policy-related sources of safe-asset demand, including reserve accumulation and regulatory motives, that are less directly tied to do-

mestic business-cycle conditions.

We measure the convenience yield as the spread between yields on high-grade corporate bonds and government bonds of comparable maturity. This spread proxies for the non-pecuniary safety and liquidity services associated with sovereign debt. To focus on structural movements in safe-asset valuation, we use its low-frequency component, filtering out high-frequency variation driven by cyclical risk premia or temporary financial stress.

**Trade weights and global spillovers.** To construct global spillovers, we use bilateral trade weights from the Korea International Trade Association. These weights proxy Korea’s exposure to foreign structural trends. In the empirical model, they allow us to separate the contribution of Korea’s own productivity and demographic changes from the contribution of rest-of-the-world productivity and demographic developments through (6).

## 4 Empirical Results

### 4.1 Estimates of the long-run neutral rate

Table 1 reports posterior estimates of the cross-country state-space model for 12 advanced economies, including Korea. For comparison, Posterior I reproduces the estimates in [Ferreira and Shousha \(2023\)](#), based on 11 advanced economies over 1960–2019. Posterior II reports our re-estimates, which extend the sample through 2024, restrict the estimation period to 1990 onward, and incorporate Korea into the panel.

The estimates in Posterior II are broadly consistent with Posterior I in sign and order of magnitude, suggesting that the expanded sample delivers qualitatively similar inference under the same identifying structure. The estimated coefficients also have expected signs. Increases in safe-asset supply are associated with higher neutral rates, while

Table 1: Prior and Posterior Distributions of Parameters

Parameter	Variable	Prior			Posterior I		Posterior II	
		Distribution	Mean	SD	Mean	SD	Mean	SD
$\beta_{ss}$	SA Supply	Normal	0	0.08	0.12	0.06	0.08	0.05
$\beta_{sd}$	SA Demand	Normal	0	0.08	-0.07	0.07	-0.11	0.07
$\beta_{cy}$	Convenience Yield	Normal	0	1	-2.29	0.86	-2.05	0.91
$\beta_{pt}$	Productivity	Normal	0	0.5	0.62	0.21	0.22	0.18
$\beta_{ws}$	Working-Age Share	Normal	0	0.25	0.13	0.11	0.12	0.10
$\beta_{gs}$	Global Spillovers	Beta	0.5	0.29	0.81	0.20	0.73	0.27

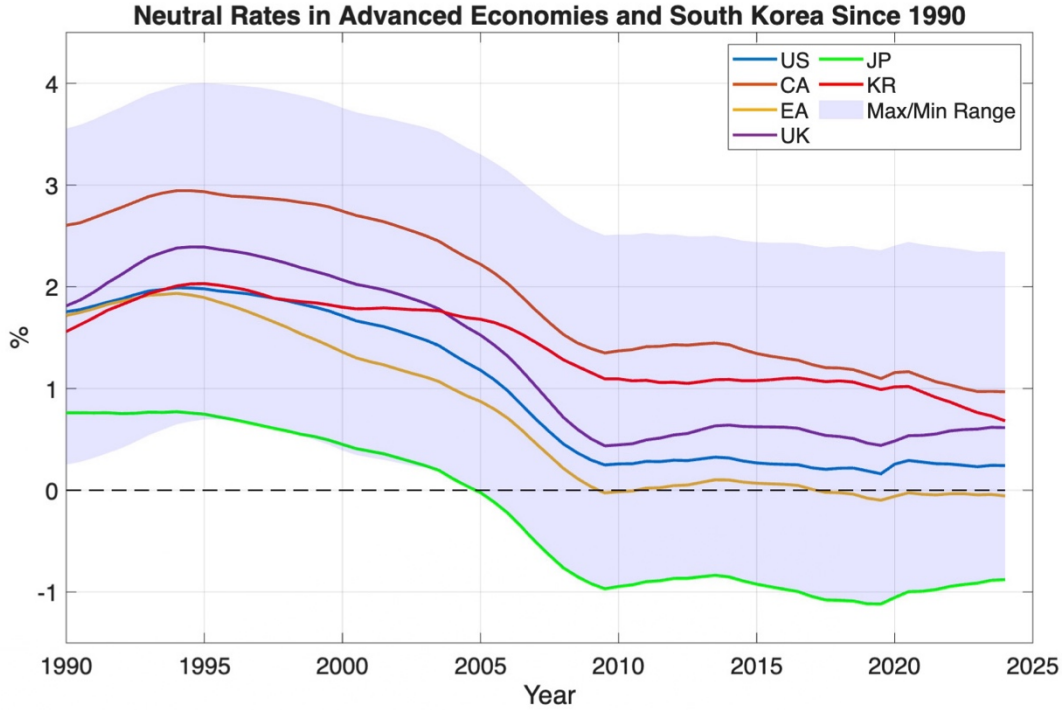
Note: The table reports prior distributions and posterior means and standard deviations of selected structural parameters. Posterior I reproduces the estimates in [Ferreira and Shousha \(2023\)](#), based on 11 advanced economies over 1960–2019. Posterior II presents re-estimates that extend the sample through 2024, restrict estimation to 1990 onward, and include Korea in the panel.

stronger policy-driven safe-asset demand and a higher convenience yield are associated with lower neutral rates. Productivity growth and the working-age population share enter positively, consistent with the view that stronger trend growth and a larger working-age population support equilibrium real returns. The main quantitative difference relative to Posterior I is the smaller coefficient on trend productivity growth: the posterior mean of  $\beta_{pt}$  declines from 0.62 to 0.22. This attenuation is consistent with the relative stabilization and cross-country convergence of productivity growth since the 1990s, as shown in [Figure 1](#).<sup>3</sup>

[Figure 3](#) plots the estimated long-run neutral rate for Korea together with the United States, Japan, the euro area, the United Kingdom, and Canada over 1990:H1–2024:H1. All economies exhibit a secular decline in the posterior mean of  $r^*$ . Korea’s estimated neutral rate falls from about 1.6 percent in 1990 to about 0.7 percent in 2024, a cumulative decline of roughly 0.9 percentage points. This estimate is consistent with recent evidence on Korea’s declining equilibrium real rate in [Do et al. \(2024\)](#) and [Lee et al. \(2025\)](#). Extending the sample through the COVID-19 period reveals a temporary rebound in several economies in 2020–2021, whereas Korea’s neutral rate continues to decline gradually. Given the un-

<sup>3</sup>Because Posterior II differs from Posterior I in sample period, end date, and country coverage, the change in  $\beta_{pt}$  should be interpreted as reflecting the combined effect of these modifications rather than any single adjustment.

Figure 3: Estimated Long-run Neutral Rates



Note: The figure plots the posterior mean of the estimated long-run real neutral interest rate for selected economies over 1990:H1–2024:H1. Estimates are obtained from the cross-country state-space model described in Section 3.

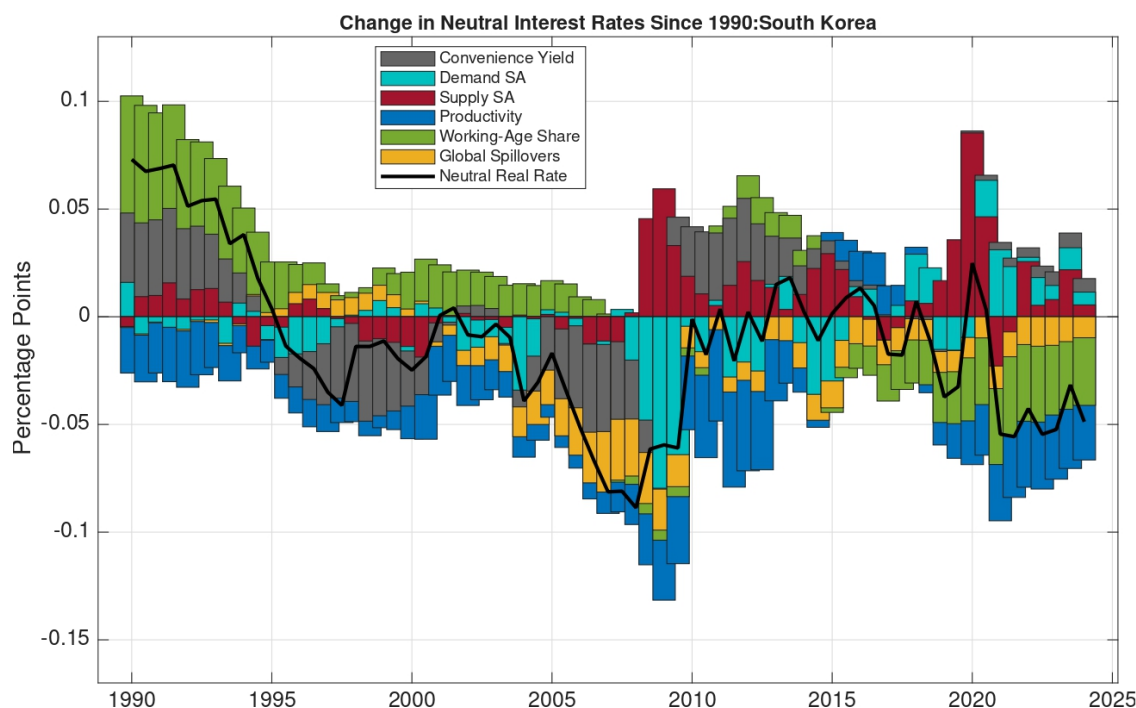
certainty inherent in neutral-rate estimation, the analysis below focuses on the time profile and structural decomposition of  $r^*$  rather than on any single point estimate.

## 4.2 Drivers of changes in the long-run neutral rate

We next quantify the drivers of changes in Korea’s long-run neutral rate using the model-implied decomposition of innovations in (5). Figure 4 reports the cumulative contribution of productivity, demographics, safe-asset market variables, and global spillovers to changes in Korea’s estimated  $r^*$  over 1990:H1–2024:H1. Because the contributions are accumulated over time, the figure shows how successive innovations to each structural component build up to generate the observed movement in the neutral rate.

The decomposition points to three main forces. First, the slowdown in trend produc-

Figure 4: Decomposition of Changes in Korea’s Long-Run Neutral Rate



Note: The figure decomposes changes in Korea’s estimated long-run neutral rate into contributions from productivity, working-age share, global safe-asset supply and demand, convenience yield, and global spillovers. Contributions are computed using posterior mean structural coefficients and are expressed in percentage points. Sample period: 1990:H1–2024:H1.

tivity growth is a persistent downward driver over much of the sample. This channel is especially important in the earlier part of the period, when Korea’s convergence-driven productivity growth was decelerating from high initial levels. Second, demographic forces are strongly time-varying. Increases in the working-age population share support  $r^*$  before the mid-2010s, but the post-2014 decline in the working-age share generates a steadily accumulating drag. Third, global spillovers exert sustained downward pressure from the early 2000s onward, indicating that Korea’s long-run real rate is affected by structural developments in other advanced economies. In contrast, safe-asset market variables partly offset each other. Stronger demand for safe assets lowers  $r^*$ , while expansions in safe-asset supply work in the opposite direction by easing safe-asset scarcity. Their net contribution is therefore more limited than the contributions of productivity,

demographics, and spillovers.

Table 2 summarizes cumulative contributions over two subperiods split at 2015, when Korea’s working-age population share begins to decline. The table highlights a clear rebalancing of structural forces. Over 1990–2014, productivity reduces the neutral rate by 0.9 percentage points, while demographics provide a sizable positive offset of 0.8 percentage points. Thus, before the demographic turning point, the decline in Korea’s neutral rate is driven mainly by productivity slowdown and external factors, partly offset by favorable working-age population dynamics. Over 2015–2024, the productivity contribution becomes smaller at -0.2 percentage points, while the demographic contribution reverses sign and lowers the neutral rate by 0.5 percentage points. This reversal is central to the Korean experience: the same demographic channel that supported  $r^*$  during the earlier period becomes a material headwind after the mid-2010s. Global spillovers remain negative in both subperiods, suggesting that external forces continue to matter even when domestic demographic pressures intensify.

Table 2: Drivers of Changes in Korea’s Long-Run Neutral Rate (pp)

	1990–2014	2015–2024
SA Supply	0.2	0.3
SA Demand	-0.5	0.1
Convenience Yield	-0.1	0.1
Productivity	-0.9	-0.2
Working-Age Share	0.8	-0.5
Global Spillover	-0.3	-0.2
Other Factors	0.4	0.1
Total Change	-0.4	-0.4

Note: Entries denote cumulative contributions, in percentage points, to changes in Korea’s estimated long-run neutral rate over the indicated subperiods. Contributions are computed from the model-implied decomposition of innovations to the neutral rate using posterior mean coefficients. The two subperiods are split at 2015, when Korea’s working-age population share begins to decline. Entries are rounded to one decimal place; totals may not sum exactly due to rounding.

### 4.3 Cross-country variance decomposition

To benchmark the Korean experience, Table 3 reports a variance decomposition of changes in the estimated long-run neutral rate across the 12 economies. Korea stands out in the relative importance of demographic shocks. Innovations to the working-age population share account for 26 percent of the variance of changes in Korea’s neutral rate, compared with a cross-country average of 9 percent. By contrast, productivity shocks account for 9 percent of the variance in Korea, below the cross-country average of 18 percent. This pattern is consistent with Korea’s distinctive demographic trajectory: a rapid increase in the working-age share through the early 2010s followed by a sharp and sustained decline beginning around 2014. The cross-country comparison therefore reinforces the central message of the decomposition: Korea’s neutral-rate dynamics are unusually sensitive to demographic change.

Table 3: Variance Decomposition of Changes in the Long-Run Neutral Rate by Country

	AL	CA	DN	EA	JA	NO	NZ	SD	SZ	UK	US	KR	AVG
SA Supply	20	18	19	24	16	15	22	18	20	20	22	17	19
SA Demand	20	18	19	24	17	15	23	18	20	21	22	17	20
Convenience Yield	28	26	26	34	23	21	32	25	28	29	31	24	27
Productivity	17	22	19	4	24	39	6	30	18	18	13	9	18
Working-age Share	6	6	11	7	15	5	9	4	7	5	5	26	9
Global Spillover	5	6	2	2	2	2	4	2	3	3	3	4	3
Other Factors	4	4	4	5	3	3	4	3	4	4	4	3	4

Note: Entries denote the percentage contribution of each structural shock to the variance of changes in the estimated long-run neutral rate over the sample period 1990:H1–2024H1. Country abbreviations are as follows: AL (Australia), CA (Canada), DN (Denmark), EA (Euro Area), JA (Japan), NO (Norway), NZ (New Zealand), SD (Sweden), SZ (Switzerland), UK (United Kingdom), US (United States), KR (Korea), and AVG (simple cross-country average). Variance shares are computed using posterior mean parameter estimates.

## 4.4 Counterfactual analysis

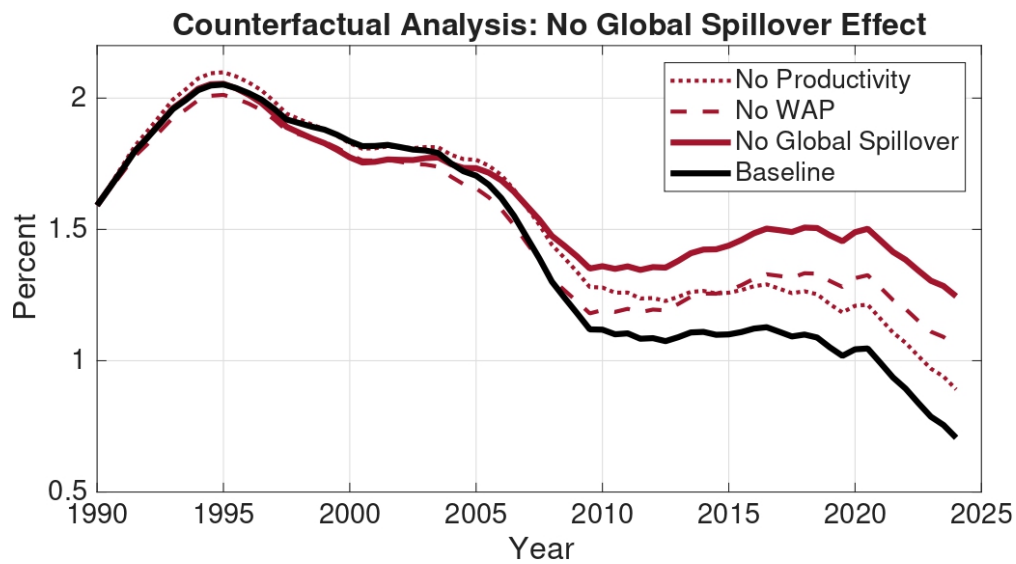
The previous results show that both external spillovers and domestic demographic change are important for Korea's neutral-rate dynamics. We next conduct counterfactual simulations to quantify their contribution to the level of the long-run neutral rate. These exercises are conditional simulations that hold structural parameters fixed at their posterior means. We do not re-estimate the model. The resulting paths should therefore be interpreted as partial-equilibrium counterfactuals that isolate specific channels within the estimated structure.

**Global spillovers.** In the first experiment, we shut down the global transmission channel by setting the trade-weighted spillover term  $g_{j,t}$  in (6) to zero, leaving all other determinants unchanged. Figure 5 compares the baseline estimate with this counterfactual path. In the absence of global spillovers, Korea's neutral rate in 2024 would have been approximately 0.6 percentage points higher. The baseline and counterfactual paths are similar until the mid-2000s, after which a gap opens gradually and stabilizes at roughly 0.6 percentage points during the 2010s. This timing coincides with the period in which neutral rates declined markedly across major advanced economies.

To distinguish the sources of external pressure, we also set to zero the foreign productivity component and the foreign demographic component within  $g_{j,t}$  in turn, again holding parameters fixed. The results indicate that productivity spillovers account for a larger share of the downward pressure before 2015, whereas demographic spillovers become more important thereafter. This pattern is consistent with the idea that population aging across advanced economies increasingly contributes to common downward pressure on long-run real rates.

**Domestic demographic channel.** We next isolate the contribution of Korea's post-2014 demographic deterioration by holding the working-age population share fixed at its 2014

Figure 5: Korea's Long-Run Neutral Rate with and without Global Spillovers



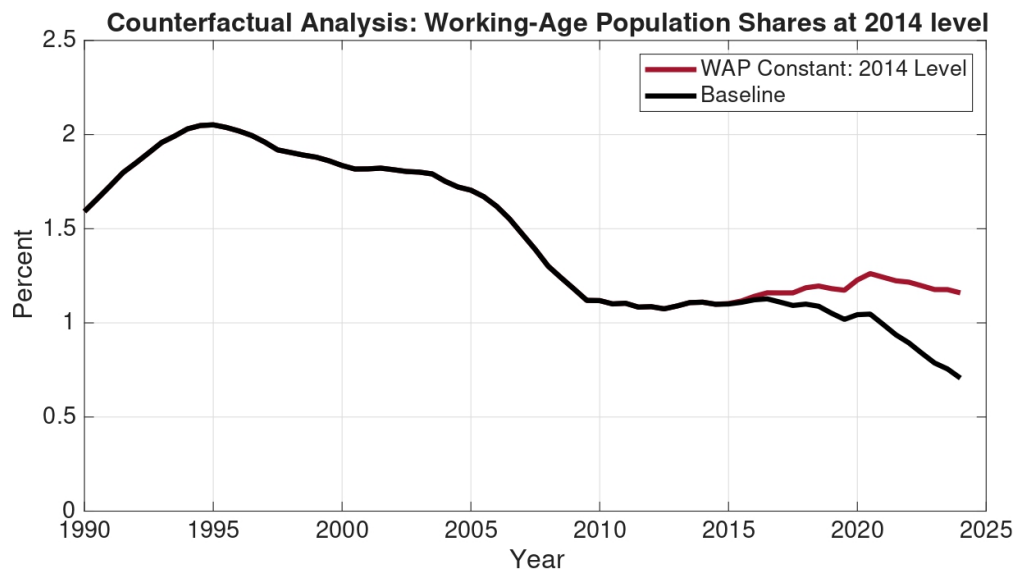
Note: The figure compares the baseline estimate of Korea's long-run neutral rate with counterfactual paths obtained by setting the trade-weighted spillover term to zero. Additional counterfactual paths separately remove foreign productivity and foreign demographic components of the spillover term. Structural parameters are fixed at their posterior means. Sample period: 1990:H1–2024:H1.

level, while leaving all other variables and structural parameters unchanged. Figure 6 shows that Korea's neutral rate in 2024 would have been approximately 0.5 percentage points higher under this counterfactual. Unlike the spillover counterfactual, the gap widens steadily over time, reflecting the persistent decline in Korea's working-age share since its peak. This result confirms that domestic demographic change is not only a source of variation in the growth rate of  $r^*$  but also a quantitatively important determinant of its level.

#### 4.5 Demographic changes and the future path of the neutral rate

Finally, we project the implications of expected demographic changes for Korea's long-run neutral rate. The projections are conditional on the posterior mean structural coefficients. All non-demographic determinants are held fixed at their latest observed values, so the exercise should be interpreted as scenario analysis rather than a full general-

Figure 6: Korea’s Long-Run Neutral Rate under a Constant 2014 Working-Age Share



Note: The figure compares the baseline estimate of Korea’s long-run neutral rate with a counterfactual path that holds Korea’s working-age population share fixed at its 2014 level. Structural parameters and all other determinants are held constant at their estimated values. Sample period: 1990:H1–2024:H1.

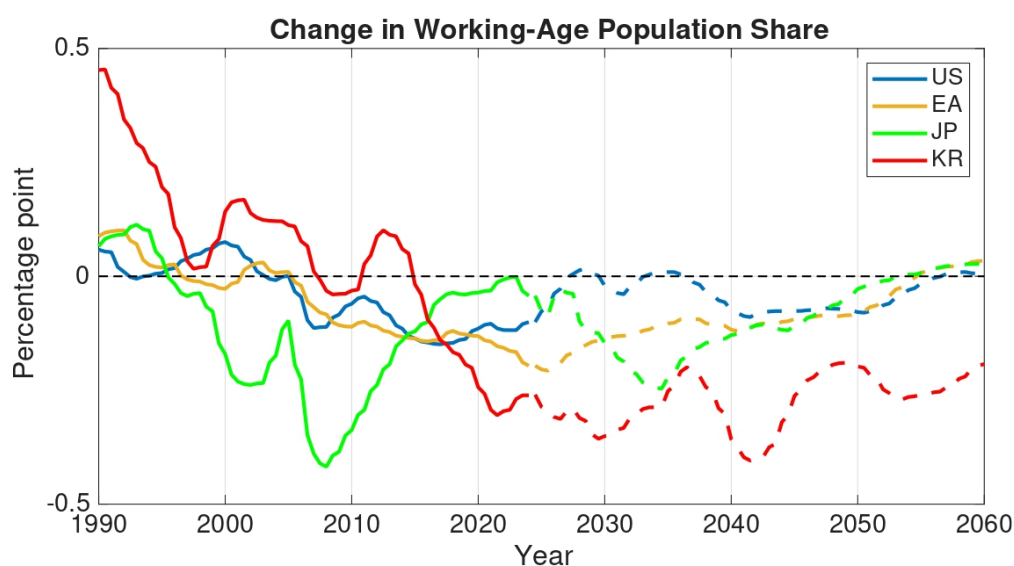
equilibrium forecast.

Using the United Nations *World Population Prospects 2024*, we construct projected paths for the working-age population share in Figure 7. We consider two scenarios. In the first, only Korea’s demographic path evolves according to the UN projections, while foreign demographics are held fixed. In the second, demographic projections for Korea’s major trading partners are also incorporated, so that foreign working-age shares enter dynamically through the spillover term in (6).

Figure 8 reports the implied path of Korea’s neutral rate under these scenarios. When only Korea’s demographic structure evolves, the neutral rate declines steadily, turns negative around 2050, and reaches approximately  $-1.7$  percent by 2060. Incorporating projected demographic changes in major advanced economies lowers the projected neutral rate by an additional roughly 0.3 percentage points through the spillover channel.

These projections should be interpreted cautiously. They assume that the historical relationship between demographics and the neutral rate continues to hold and abstract

Figure 7: Projected Working-Age Population Ratios, 2020–2060



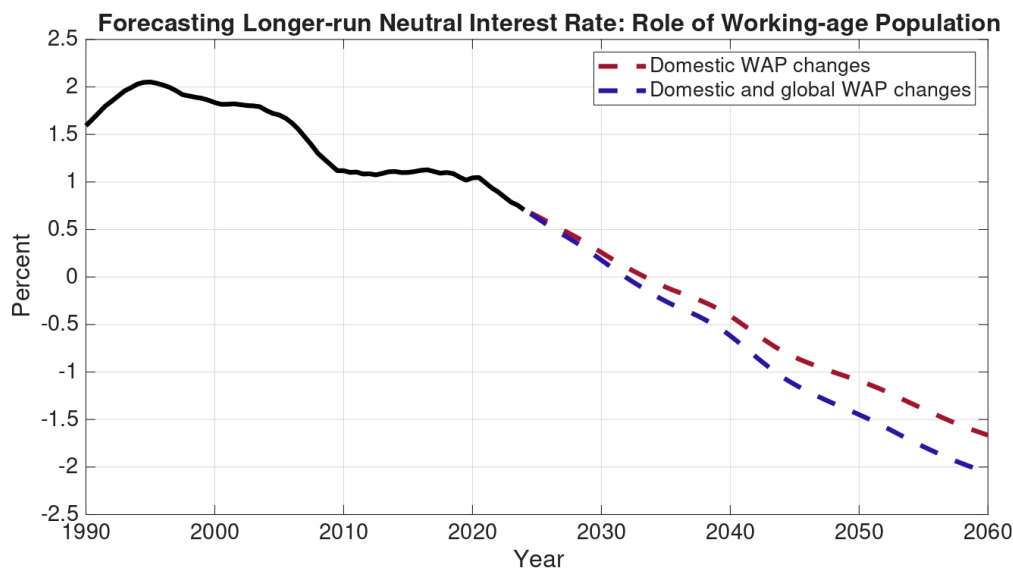
Note: The figure plots projected working-age population shares based on the UN *World Population Prospects 2024*. The working-age population is defined as ages 20–60.

from potentially offsetting forces, including endogenous productivity responses, fiscal adjustment, labor-market adaptation, immigration, and technological change. Nevertheless, the results illustrate the magnitude of demographic headwinds facing Korea’s long-run real rate and their potential implications for future monetary policy space.

## 5 Conclusion

This paper estimates Korea’s long-run equilibrium real interest rate in a cross-country state-space framework that links neutral-rate movements to productivity growth, demographic structure, global safe-asset market conditions, and international spillovers. The panel structure disciplines country-specific latent trends using information from other advanced economies and helps separate domestic structural forces from common global components. This distinction is particularly important for Korea, a small and financially open economy in which single-country estimates may confound domestic changes in productivity or demographics with broader movements in world real interest rates.

Figure 8: Projected Impact of Demographic Change on Korea’s Long-Run Neutral Interest Rate



Note: The figure plots projected paths of Korea’s long-run neutral rate under demographic scenarios based on UN population projections. Structural parameters are fixed at posterior mean estimates. Non-demographic determinants are held constant.

We document a sustained decline in Korea’s long-run real neutral rate over 1990–2024, from about 1.6 percent in 1990 to roughly 0.7 percent in 2024. The model-implied decomposition attributes this decline mainly to a slowdown in trend productivity growth, a reversal in the working-age population share after 2014, and persistent spillovers from major advanced economies. Safe-asset market variables also matter, but their effects partly offset each other: stronger policy-driven demand for safe assets lowers equilibrium real rates, while increases in safe-asset supply work in the opposite direction. A central finding is that demographics change sign over time: before the mid-2010s, rising working-age shares supported the neutral rate, whereas after the 2014 peak, demographic change became a persistent headwind.

Counterfactual exercises show that both domestic demographics and external spillovers have quantitatively important effects on Korea’s neutral rate. Eliminating global spillovers would raise the 2024 estimate by roughly 0.6 percentage points, while holding the working-

age population share fixed at its 2014 level would raise it by about 0.5 percentage points. Conditional demographic scenarios based on United Nations projections suggest that continued population aging could place further downward pressure on Korea's long-run real neutral rate over the coming decades absent offsetting structural changes.

These results have implications for macroeconomic policy, but they should be interpreted with appropriate caution. A persistently lower neutral rate may reduce the space for conventional monetary policy by bringing policy rates closer to their effective lower bound in downturns. At the same time, the projected demographic effects are conditional scenarios rather than unconditional forecasts. They abstract from potential offsetting forces such as productivity improvements, labor-market adaptation, immigration, fiscal adjustment, and technological change. The results therefore point less to a mechanical prediction than to a structural policy challenge: in a rapidly aging economy, sustaining productivity growth and monitoring global real-rate conditions are likely to remain important for assessing the stance and future capacity of monetary policy.

## **Declaration of Generative AI and AI-assisted Technologies in the Manuscript Preparation Process.**

During the preparation of this work the author(s) used [ChatGPT-5.2] in order to proofread the draft. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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# Appendix

## A Data on 11 Advanced Economies

Unemployment rates, inflation rates, and policy interest rates are obtained from national statistical offices and the OECD. Long-term inflation expectations are taken from the *Consensus Economics* survey of expected inflation five years ahead (April and October issues). Data on global foreign exchange reserves and their currency composition are drawn from the IMF's *Currency Composition of Official Foreign Exchange Reserves* (COFER) statistics, which distinguish eight major currencies: the U.S. dollar, euro, Chinese renminbi, Japanese yen, British pound sterling, Australian dollar, Canadian dollar, and Swiss franc.

The supply of safe assets is measured by the stock of U.S. marketable government debt, excluding nonmarketable securities, obtained from the U.S. Treasury's *Monthly Statement of the Public Debt* (MPSD). The holdings of U.S. safe assets by foreign governments are estimated using IMF COFER data for 1960–1984 and the U.S. Treasury's *Treasury International Capital* (TIC) system thereafter, following the adjustment method of [Bertaut and Judson \(2014\)](#).

Productivity growth is defined as the trend growth rate of productivity, calculated as the average of four indicators: total factor productivity (TFP), GDP per employed person, and GDP per hour worked. Data are obtained from the *Long-Term Productivity Database* (LPD) and the *Conference Board Total Economy Database* (TED). Following [Ferreira and Shousha \(2023\)](#), the long-term trend component is extracted using the HP filter with a smoothing parameter of 2,500. The resulting trend exhibits a high level in the 1960s, a sharp decline in the early 1970s, and a gradual moderation with another decline beginning in the early 2000s.

The convenience yield is defined as the yield spread between corporate bonds and U.S.

Treasury securities of the same maturity, following the method of [Gilchrist and Zakrajšek \(2012\)](#). Post-1973 data are based on Lehman/Warga and Merrill Lynch indices, while pre-1973 data are based on the yield differential between Moody's Aaa bonds and 20-year U.S. Treasuries. The long-term trend of this variable is also extracted using the HP filter with a smoothing parameter of 10,000. Finally, the demographic variable is measured as the share of the working-age population (ages 20–60) in total population using data from the United Nations *World Population Prospects* (2024). The projection of this ratio up to 2060 is used to forecast the neutral rate.