Gone with the Wind: Monetary Policy and the Global Financial Cycle*

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Abstract

This paper builds and estimates a small open economy New Keynesian DSGE model with an international banking sector, in order to explore the effectiveness of alternative monetary policy regimes to isolate the domestic economy from global financial cycles. Using shocks to US short-term interest rates as a proxy for a global financial cycle shock to a small open economy, I find that the Mundellian policy Trilemma persists. However, even a central bank adopting a floating exchange rate cannot fully buffer the effects of a global financial shock due to the tight integration of global financial markets.

Keywords: exchange rate regimes, financial frictions, global financial cycle, monetary policy, occasionally binding constraints

JEL codes: E32, E37, E44, E52

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1. Introduction

The prevailing perspective on monetary autonomy in international macroeconomics has been the "Impossible Trinity" (Trilemma).[1] That is, independent monetary policy is implementable if exchange rates are allowed to float under free capital mobility, or if exchange rates are managed with controlled capital flows. However, this conventional view has been questioned by researchers and emerging market economy (EME) policymakers. Most notably, this includes the seminal work of Hélène Rey, starting with her 2013 Jackson Hole lecture. Rey and others provide empirical evidence to suggest that even economies with a floating exchange rate are significantly affected by international factors divorced from domestic economic conditions due to the emergence of the global financial cycle. The policy implication is that flexible exchange rates are not sufficient to guarantee monetary autonomy in a world of integrated financial markets.[2] Simply put, the argument put forward by Rey and others is that the monetary policy Trilemma is now a "Dilemma" – the choice of exchange rate regime is no longer relevant as global financial integration has rendered floating exchange rates ineffective as a buffer to global financial shocks.

But the empirical findings by Rey and EME policy makers have sparked debate and slight push-back, best enunciated by Obstfeld (2015) and Obstfeld, Ostry, and Qureshi (2019). Obstfeld's view is that the traditional Trilemma remains – that independent monetary policy is still feasible under flexible exchange rates. However, his study concedes that the integration of global financial markets has altered the trade-offs that policymakers face, stating:

"[...]the monetary trilemma remains, but the difficulty of the trade-offs that alternative choices entail can be worsened by financial globalisation."

In this paper, I answer the question "How do global financial shocks originating from the US affect a small open economy, and what are the macroeconomic effects of financial policies to address these shocks?" Essentially, I assess the Dilemma vs Trilemma argument put forward by Rey and Obstfeld, and the role of macroprudential policy in this discussion.

1. See Obstfeld, Shambaugh, and Taylor (2005) for a historical discussion of the monetary policy trilemma.
2. See for example Rey (2015, 2016), Dedola, Rivolta, and Stracca (2017), Iacoviello and Navarro (2019), and Miranda-Agrippino and Rey (2020).

My analysis follows three main steps. First, using data from the Republic of Korea (RoK), I provide empirical evidence to show that a floating exchange rate is an insufficient buffer to global financial cycles. I then link this evidence to the broader aforementioned literature and empirical evidence on global financial cycles to show that the Korean economy is not an isolated case.

Second, I build a small open economy (SOE) New Keynesian model equipped with a banking sector featuring international borrowing. In my model, the banking sector intermediates funding from domestic and foreign (global) interbank markets, the latter of which is foreign currency denominated debt they owe to the foreign banking sector. A shock to the Federal Funds Rate (FFR), which acts as a proxy to a global financial cycle shock, affects domestic financial conditions of the small open economy. A hike in the FFR causes a sudden rise in borrowing costs, resulting in a sudden withdrawal of cross-border interbank borrowing.[3] This leads to a drop in equity prices, and in turn leads to a proportionally larger drop in domestic bank net worth. The primary mechanism for the collapse in bank net worth is a financial friction and bank balance sheet constraints, and a financial accelerator through asset prices as described in Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999), Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and Gertler and Kiyotaki (2015). This is the distinctive feature of the SOE model in this paper. I conduct a variety of quantitative exercises, testing the model's characteristics under different exchange rate regime assumptions. Then, using Korean and US data, I estimate the model with Bayesian likelihood methods and conduct counterfactual experiments, focusing on the interplay between exchange rate regimes and financial frictions.

Third, with the estimated model, I explore the frequency of financial crises under different exchange rate regimes. Using a non-linear solution method that accounts for precautionary savings, I show that while floating exchange rates reduce the frequency of crises compared to fixed regimes, they cannot eliminate them entirely. This highlights that even with flexible exchange rates, small open economies remain vulnerable to global

3. This can be thought of as an exogenous shock triggering a sudden stop. A hike in country-specific risk-premium and world financial liquidity shock also could be considered. For example, Gertler, Gilchrist, and Natalucci (2007) investigate a rise in the risk premium as a driver of a sudden stop episode in the Korean financial crisis during the 1997 Asian Financial Crisis, and Rey (2016) explains that risk measures in global financial markets play an important role in determining capital inflows into EMEs.

financial cycles, though the regime choice significantly mitigates tail risks. Discussion amongst policymakers after the 2007-08 Global Financial Crisis has highlighted the riskiness of sudden and large capital movements and helped change conventional views on macroprudential policy and capital controls.[4] The concerns of EME policymakers were also covered in Blanchard (2017), who concluded macroprudential tools to be a "natural instrument" in minimising the spillover effects of advanced economy – or, in this case, US – monetary policy changes.

The key contributions of this paper are as follows. First, methodologically, I estimate a small open economy model featuring an occasionally binding constraint. Second, the paper ties the empirical findings of Rey (2015), Kose et al. (2010), Dedola, Rivolta, and Stracca (2017), Iacoviello and Navarro (2019), and Degasperi, Hong, and Ricco (2023), with theoretical SOE macroeconomic models equipped with international financial markets. Third, by analysing the frequency of financial crises under different exchange rate regimes, I show that while floating exchange rates mitigate tail risks, they cannot eliminate them entirely. My paper is closely related to Aoki, Benigno, and Kiyotaki (2020) (ABK); Akinci and Queralto (2023) (AQ); and Cesa-Bianchi, Ferrero, and Li (2023), the latter two of which also empirically test the Trilemma vs Dilemma hypothesis albeit in a two-country framework. The common factor in these studies, and my paper, is a financial friction based on the Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) (GKK) framework to deviate from the Mundell-Fleming-Dornbusch framework and uncovered interest parity (UIP) condition. The existence of this wedge in the UIP condition also leads to the aforementioned financial accelerator between equity prices and real economy activity. This is in contrast to a more common approach to modelling departures from UIP in the literature

4. The August 2010 announcement of then-Chairman of the Federal Reserve Bank, Ben Bernanke, of Quantitative Easing II raised concerns amongst EME policymakers that growth in US credit and financial markets would spill over to the financial markets of the emerging economies. EME policymakers resorted to a variety of macroprudential tools to limit credit growth from large inflows of capital. Conversely, following Bernanke's May 2013 announcement that the Federal Reserve would taper its Quantitative Easing program, international financial markets reacted strongly, with many EMEs seeing large outflows of capital, causing significant currency depreciations and disruption to domestic economic conditions. As Aoki, Benigno, and Kiyotaki (2020) state, large capital inflows turned into large capital outflows following Bernanke's congressional testimony about the Federal Reserve's potential reduction in highly expansionary unconventional monetary policy. Brazil, Indonesia, India, South Africa, and Turkey – the "Fragile Five" – experienced severe turmoil over flows into and out of their capital accounts.

such as including a risk premium based on aggregate holdings of foreign debt, such as in Schmitt-Grohé and Uribe (2003), Blanchard (2017), and Gourinchas (2018) – the latter of which I discuss below.

Gourinchas (2018) estimates an SOE New Keynesian model to test the Mundellian Trilemma with Chilean and US data. In that study, Gourinchas finds empirical evidence in favour of flexible exchange rates; such that their role is even more important than in a textbook Mundell-Fleming-Dornbusch case. Through the lens of the model, this depends on the extent to which financial frictions amplify spillovers. The primary financial friction in his study is a borrowing constraint on the part of impatient households who discount future utility more than their patient counterparts, as in Kiyotaki and Moore (1997) and Iacoviello (2005). These impatient households hold debt balances that evolve according to a law of motion which also feature fluctuations in the real exchange rate. A real depreciation of the domestic currency, for instance, limits the ability of the domestic financial sector to issue loans in domestic currency if financial markets are vulnerable to international spillovers – the degree of which is governed by a sensitivity parameter (which is estimated later in the paper). Additional differences between our papers are: the role of the dominant currency pricing paradigm, the assumption of the domestic SOE as a commodity exporter, and market structure[5] of domestic firms in the Gourinchas study. I abstract from these departures of standard open-economy New Keynesian models and focus on cross-border banking flows, and also consider the role of macroprudential policy in line with the IMF's Integrated Policy Framework (Adrian et al., 2020). As such, my paper is complementary to Gourinchas' work.

The structure of the paper is as follows. Section 2 provides a brief review of empirical evidence of global financial cycles using Korean and US data; Section 3 outlines model equations and equilibrium; Section 4 features the bulk of the analysis including baseline model simulations, the estimation strategy, features of the data, and Bayesian estimation results; Section 5 discusses the interaction between FX policies and financial stability; while Section 6 concludes the paper.

5. Specifically, Gourinchas assumes varied firm markups via Kimball aggregation, whereas I use a standard Dixit-Stiglitz aggregator as is standard in the New Keynesian literature (Blanchard and Kiyotaki, 1987).

2. Empirical Evidence on the Global Financial Cycle

I now present empirical evidence on Global Financial Cycles using data from Korea and the US with simple vector autoregression (VAR) analysis, the results of which are in line with more thorough studies such as by Dedola, Rivolta, and Stracca (2017), Iacoviello and Navarro (2019), and Degasperi, Hong, and Ricco (2023). The data covers monthly data from January 1999 to June 2019. The data series covered are: 1-year US Treasury Bill (T-Bill) rates (i_t^*), the US excess bond premium (EBP) from Gilchrist and Zakrajšek (2012) (EBP_t^*), US real GDP growth (Δy_t^*), RoK real GDP growth (Δy_t), RoK inflation rate (π_t), RoK real exports (Δex_t), the percent change in the Won-Dollar nominal exchange quoted on a direct basis ($\Delta \mathcal{E}_t$),[6] RoK 3-month interbank interest rates (i_t), and spreads of RoK 3-year corporate AA- and government bond yields ($\mathcal{S}_t$).[7] The matrix of endogenous variables for the VAR to be estimated is then given by

$$\boldsymbol{Y} = \begin{bmatrix} \boldsymbol{i}^* & \boldsymbol{EBP}^* & \boldsymbol{\Delta y}^* & \boldsymbol{\Delta y} & \boldsymbol{\pi} & \boldsymbol{ex} & \boldsymbol{\mathcal{E}} & \boldsymbol{i} & \boldsymbol{\mathcal{S}} \end{bmatrix},$$

with the VAR model of order p to be estimated specified as

$$\boldsymbol{Y}_t = \boldsymbol{\alpha} + \sum_{j=1}^{p} \boldsymbol{Y}_{t-j}\boldsymbol{\Phi}_j + \boldsymbol{U}_t, \quad \boldsymbol{U}_t \sim \mathrm{IID}(\boldsymbol{0}, \boldsymbol{\Sigma}),$$

for the t-th observation. To clarify the notation: $\boldsymbol{Y}_t$ is the $1 \times g$ vector of endogenous variables, $\boldsymbol{\alpha}$ is a $1 \times g$ vector of constants, $\boldsymbol{\Phi}_j$ for $j = 1, \ldots, p$ are $g \times g$ matrices of coefficients, and $\boldsymbol{U}_t$ is a $1 \times g$ vector of reduced-form error terms with variance-covariance matrix $\boldsymbol{\Sigma}$; where g is the number of endogenous variables.

In order to identify US monetary policy shocks and avoid problems of deformation (Canova and Ferroni, 2022), I use the series of US monetary policy surprises ($\varepsilon_{m,t}^*$) from Jarociński and Karadi (2020) as an external instrument, following the two-stage identifi-

6. To be clear, a depreciation of the US dollar relative to the RoK Won corresponds to a decrease in the exchange rate.

7. Details of the data series can be found in Appendix C.1.

cation strategy in Gertler and Karadi (2015).[8] Also, as in Gertler and Karadi (2015) and Cesa-Bianchi, Ferrero, and Li (2023), I include the US EBP in the vector of endogenous variables as it corresponds to real economic activity and it outperforms other financial indicators when it comes to forecasting ability of economic conditions. In other words, its inclusion assists with the correct specification of this relatively small-scale, simple VAR(p) model.

Figure 1 plots the impulse response functions (IRFs) of the endogenous variables to a surprise US monetary policy tightening. The Hannan-Quinn information criterion suggests $p = 3$.[9] The IRFs are scaled so that the increase in the short-term US interest rate upon impact is 1% (annual). The blue line is the point estimate from the VAR model while the dashed red lines represent the 90% confidence bands about the point estimate.

A contractionary US monetary policy shock leads to an increase of the EBP as domestic economic and financial conditions in the US deteriorate, leading to the standard empirical hump-shaped response of real GDP (Christiano, Eichenbaum, and Evans, 2005; Gertler and Karadi, 2015). The spillover responses in the Korean variables are of primary focus in this section and set up the modelling choices of this paper: The economic contraction and deterioration of financial conditions in the US sees a drop in Korean GDP growth as exports significantly decline. This is despite a strong depreciation of the Korean Won. Inflation initially rises slightly – most likely driven by said depreciation of the Won, which increases the cost of imported goods and services – but is then followed by a period of deflation as the collapse in exports leads to an economic slowdown. Meanwhile, short-term nominal interest rates in Korea are cut in response to the fall in output and inflation. Finally, the VAR model's point estimate of the Korean corporate bond spread increases in the short-run, however the model does find the response to not be statistically significant.[10]

The results of this exercise echo the empirical findings on the Global Financial Cycle from in-depth studies such as Dedola, Rivolta, and Stracca (2017) and Rey (2013) and Miranda-Agrippino and Rey (2020). That is, a shock to US monetary policy has international spillover effects that are unable to be buffered despite the significant adjustment in exchange

8. That is, I assume that the instrument $\varepsilon^*_{m,t}$ is correlated only with the US short-term interest rate shocks and not the other structural shocks in the VAR system.

9. The qualitative results of the VAR do not change even with higher order lags.

10. This is also a challenge in the panel-VAR study of Dedola, Rivolta, and Stracca (2017).

FIGURE 1. VAR impulse responses to contractionary US monetary policy change

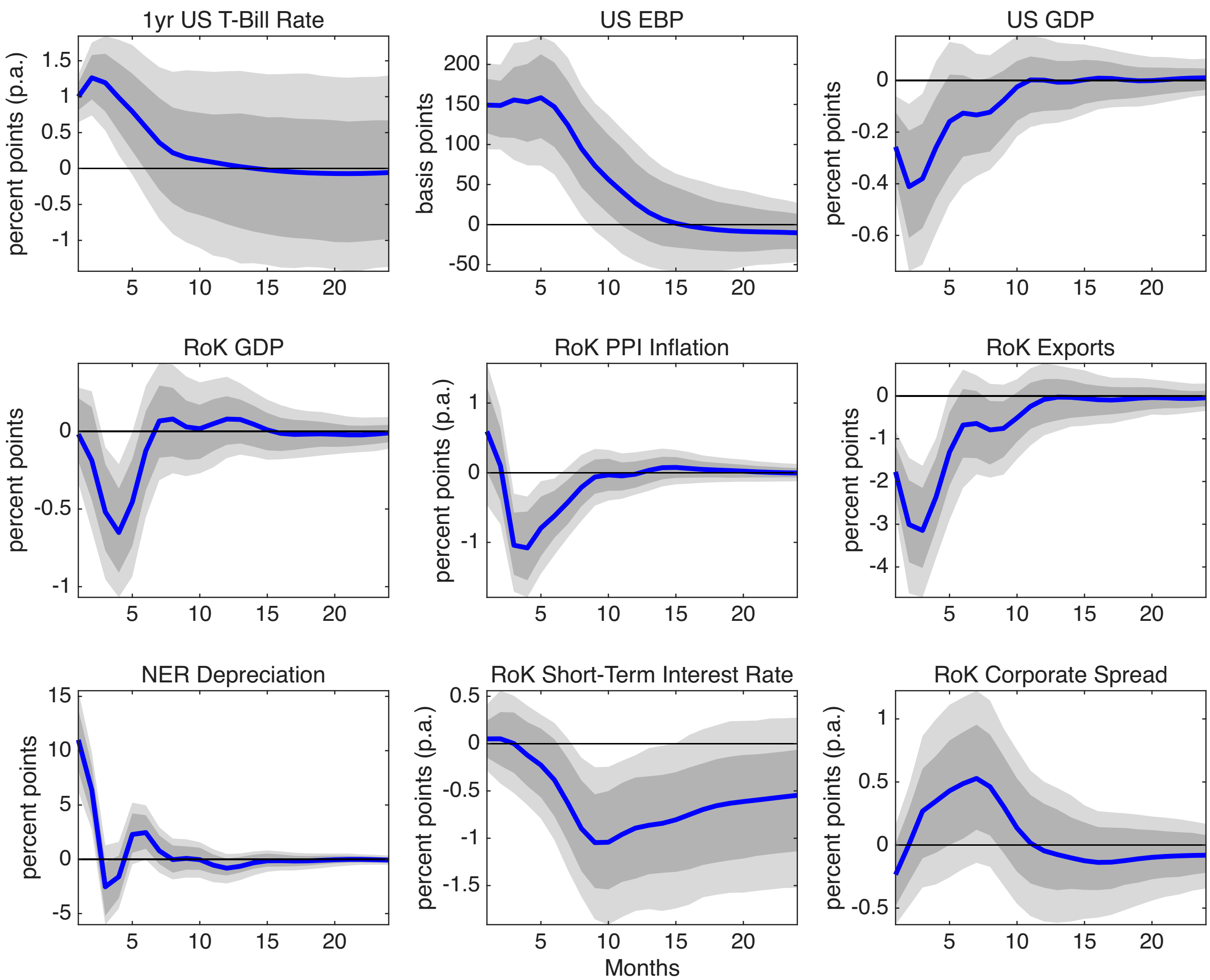


Figure plots impulse responses to a surprise monetary policy contraction of the US 1-year Treasury Bill rate, US external bond premium, US real GDP growth rate, RoK real GDP growth rate, RoK inflation rate, RoK real exports rate, US-RoK nominal exchange rate change (direct quote), RoK nominal short-term interest rate, and the RoK spread on 3-year corporate bonds and government bonds. Interest rates, the external bond premium, and inflation rates are expressed in annualised terms. The blue line is the point estimate, and the shaded grey regions are the 70% (darker grey) and 90% (lighter grey) confidence bands. Responses are scaled so as to get a 1% annual increase in the US short-term nominal interest rate.

rates – the crux of Rey's Dilemma argument. Here in the case of Korea, and the advanced economies in the study of Dedola, Rivolta, and Stracca (2017), contractionary US monetary policy leads to a pronounced decline in domestic inflation and output, leading to reductions of short-term nominal interest rates. Additionally, this simple exercise highlights financial conditions in the US as an important channel for the transmission of shocks.

3. Theoretical Model

I build a small open economy model equipped with a banking sector and cross-border interbank borrowing as one of the funding sources for domestic banks. At its core is a New Keynesian dynamic stochastic general equilibrium (DSGE) framework as in Galí (2015), but with capital and investment adjustment costs, like Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2007), to improve its quantitative performance. I build on this foundation by including small open economy features from Galí and Monacelli (2005), ABK, and AQ,[11] and for the purposes of model estimation I include elements from Christiano, Trabandt, and Walentin (2011).

The model features a banking sector which can raise funds from both domestic households and international banking sectors. For example, a rise in foreign interest rates charged on cross-border interbank borrowing causes an immediate rise in the borrowing costs and leads to a reversal of interbank borrowing. Open economy features in the model also contain elements from Gertler, Gilchrist, and Natalucci (2007) (GGN), which provides similar intuition on the interaction between monetary policy and exchange rate regimes, and the effects of financial stress periods. GGN describe a calibrated small open economy setup to describe the development of the Korean economy during the 1997 Asian Financial Crisis, while I suggest an estimated model that matches the empirical findings of a decline in cross-border borrowing after a US monetary policy shock.[12]

11. The primary difference between the ABK and AQ models is that the former is a SOE setup, while the latter is a two-country setup. ABK also restrict their analysis to capital controls, while AQ consider the effect of exchange rate regimes during global financial cycles.

12. The notable differences in the models are as follows:
(i) GGN do not introduce a banking sector, and the households directly play a role in borrowing from foreign banks. In contrast, I describe a banking sector which plays a role in intermediating cross-border interbank borrowing to local entrepreneurs.

3.1. Households

The setup of the representative household is based on GKK. The representative household contains a continuum of bankers and workers, and features perfect insurance within the household so that all agents consume the same amount. The household collectively chooses consumption C_t, labour supply L_t, and deposits[13] held at the bank D_t to maximise the present value discounted sum of expected utility,

$$\max_{\{C_t, L_t, D_t\}} \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \xi^h_{t+s} \left[\frac{1}{1+\sigma} \left(C_{t+s} - \frac{\chi \varphi_0}{1+\varphi} L_{t+s}^{1+\varphi} \right)^{1+\sigma} - \frac{(1-\chi)\varphi_0}{1+\varphi} L_{t+s}^{1+\varphi} \right],$$

subject to the period budget constraint,

$$C_t + D_t = w_t L_t + \Pi_t^P + RR_t^d D_{t-1} + \tau_t,$$

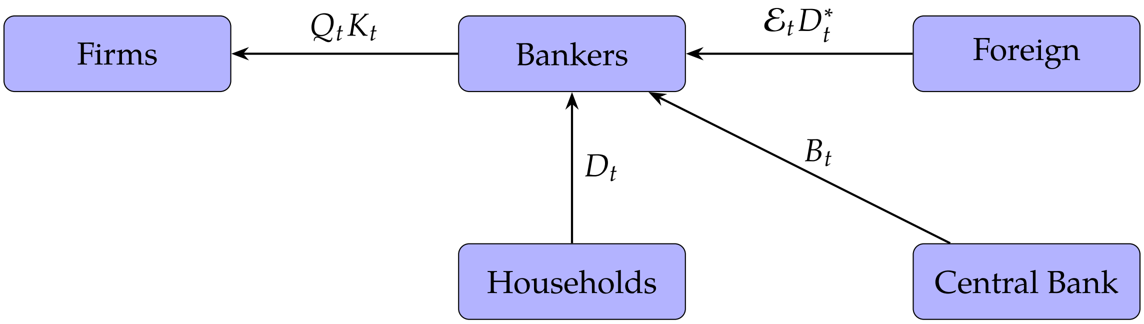
where w_t are real wages in terms of final goods; Π_t^P are real profits earned by the household from the production of intermediate goods, production of investment goods, and banking; $RR_t^d = R_{t-1}^d / \pi_t$ is the gross real interest rate earned on deposits, where R_t^d is the gross nominal deposit interest rate, $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross domestic inflation rate, and P_t is the domestic price level; and τ_t are lump-sum taxes levied on the household by the government to address market distortions. ξ_t^h is an exogenous household preference shock which follows a stationary AR(1) process. The parameters σ, β, φ_0, and φ are the household's risk aversion, discount factor, weight on labour supply, and the inverse-Frisch elasticity of

(ii) GGN considers 300 basis point increases in the country risk-premium as an external shock to the Korean economy. In contrast, I examine the influences of an annualised 100 basis point rise in the FFR which determines the borrowing costs for cross-border interbank borrowing.
(iii) GGN do not provide quantitative responses of the foreign borrowing in the face of external shocks, while I provide a full description of the response of cross-border interbank borrowing to external shocks.
In spite of these differences, I provide the same intuition as GGN: Countries in the position of having to defend an exchange rate peg are more likely to suffer severe financial distress.

13. Technically, the household chooses nominal deposits, D_t^n, which are deflated by the domestic consumer price index, P_t:

$$D_t = \frac{D_t^n}{P_t}.$$

FIGURE 2. Graphical flow of funds



labour supply parameters.

The functional form of the household's utility function are "GHH+" preferences from Auclert, Bardóczy, and Rognlie (2023), which are a modification of the original Greenwood, Hercowitz, and Huffman (1988) preferences. As evident, the weighting parameter $\chi \in (0, 1)$ allows for the possibility of consumption-leisure substitution, and can embed either standard CRRA or GHH preferences. Shchapov (2025) explains that GHH+ preferences assists the model in matching the fall in consumption during periods of financial stress.

The interaction between workers and bankers within the representative household is as follows. The composition of workers and bankers is normalised such that their combined population is a unit density. Let σ_b denote the continuation probability of a banker remaining in employment through to the next period, such that they may retire with probability $1 - \sigma_b$ in each period. The number of bankers retiring in each period is matched by the number of workers transitioning into banking, and thus the population of workers and bankers is stable.

Workers cannot access foreign savings or equity directly, and foreign households cannot directly hold domestic equity. All interactions between equity markets and households – both domestic and foreign – must be intermediated by the domestic banking sector. This of course implies that the domestic banks are exposed to foreign exchange rate risk. Figure 2 provides an overview of agents and resource flows in this model.

3.2. Banks

Among the population of bankers, each j-th banker owns and operates their own bank. The bankers are indexed on a continuum of measure one. A banker will facilitate financial services between households and firms by providing loans to firms of market value $Q_t K_{j,t}$, funded by domestic deposits, foreign deposits $\mathcal{E}_t D^*_{j,t}$, and their own net worth, $N_{j,t}$. But, financial frictions may limit the ability of the banker to raise deposits from households. In addition, bankers hold central bank reserves $B_{j,t}$ as assets on their balance sheets.

As mentioned, for model tractability, the population of bankers is stable. New bankers start up their franchise with fraction γ of total assets of the collective household. Upon retirement, a banker will exit with their net worth, bringing the balance back to the household in the form of a dividend. Therefore, a banker will seek to maximise their franchise value, $\mathbb{V}^b_{j,t}$, which is the expected present discount value of future dividends:

$$\mathbb{V}^b_{j,t} = \mathbb{E}_t \sum_{s=0}^{\infty} \sigma_b^s \left(\Lambda_{t,t+1+s}(1-\sigma_b) N_{j,t+1+s} + \Lambda_{t,t+s} \zeta_{t+s} B_{j,t+s} \right),$$

by choosing quantities $K_{j,t}$, $B_{j,t}$, $D_{j,t}$, and $D^*_{j,t}$. Here ζ_t is an exogenous process with mean $\bar{\zeta} > 0$ capturing the non-pecuniary benefits of holding central bank reserves. As stated in Akinci et al. (2023), these utility benefits are not significant for the qualitative performance of the model, instead they help the model to match the empirical moments of credit spreads. The time varying nature of these benefits are akin to banks' preference for safe assets as in Krishnamurthy and Vissing-Jorgensen (2012).

Since bankers have access to foreign deposits, they face exchange rate risk, whereby the real exchange rate is defined as

$$\mathcal{E}_t = \frac{E_t P^*_t}{P_t},$$

where E_t is the nominal exchange rate defined as the quantity of domestic currency units per one unit of foreign currency.[14]

A financial friction in line with GKK is used to limit a banker's ability to raise funds,

14. Thus, an increase (decrease) in $\mathcal{E}_t$ and E_t is a domestic currency depreciation (appreciation).

whereby a banker faces a moral hazard problem: they can either abscond with the funds they have raised from depositors, or they can operate honestly and pay out their obligations. Absconding is costly, however, and so the banker can only divert a fraction $\Theta(\cdot) > 0$ of assets they have accumulated.

The caveat to absconding, in addition to only being able to take a fraction of assets away, is that it takes time – in other words, it takes a full period for the banker to abscond. Thus, the banker must decide to abscond in period t, in addition to announcing what value of amount of deposits they will choose and prior to realising next period's rental rate of capital. If a banker chooses to abscond in period t, their creditors will force the bank to shutdown in period $t+1$, causing the banker's franchise value to become zero.

Therefore, the banker will choose to abscond in period t if and only if the return to absconding is greater than the franchise value of the bank at the end of period t, $\mathbb{V}^b_{j,t}$. It is assumed that the depositors act rationally, and that no rational depositor will supply funds to the bank if they clearly have an incentive to abscond.[15] In other words, bankers face the following incentive compatibility constraint (ICC):

$$\mathbb{V}^b_{j,t} \geq \Theta_j(x_{j,t}, x^b_{j,t})\left(Q_t K_{j,t} + B_{j,t}\right), \tag{1}$$

where $\Theta_j(x_{j,t}, x^b_{j,t})$ is bank j's absconding fraction and the functional form is based on AQ,

$$\Theta_j(x_{j,t}, x^b_{j,t}) = \theta_0\left(1 + \frac{\theta}{2}x^2_{j,t} - \frac{\theta_b}{2}(x^b_{j,t})^2\right), \quad \{\theta_0, \theta, \theta_b\} > 0,$$

with $x_{j,t}$ being the fraction of a banker's assets financed by foreign borrowing and is defined

15. Consider a simple GKK setup absent of inflation and foreign deposits. Recall that the banker seeks to maximise profits and that it will choose to abscond if and only if:

$$\underbrace{R^k(D+N) - R \times D}_{\text{Profit from operating honestly}} < \underbrace{\theta R^k(D+N).}_{\text{Absconding payoff}}$$

If the banker wants to abscond, they will set their demand for deposits such that the above inequality holds, or,

$$R > \frac{(1-\theta)R^k(D+N)}{D}.$$

TABLE 1. Bank j's balance sheet

Assets	Liabilities + Equity
Loans $Q_t K_{j,t}$	Deposits $D_{j,t}$
Central bank reserves $B_{j,t}$	Foreign debt $\mathcal{E}_t D^*_{j,t}$
	Net worth $N_{j,t}$

as:

$$x_{j,t} = \frac{\mathcal{E}_t D^*_{j,t}}{Q_t K_{j,t} + B_{j,t}},$$

and $x^b_{j,t}$ is the reserve-assets ratio:

$$x^b_{j,t} = \frac{B_{j,t}}{Q_t K_{j,t} + B_{j,t}}. \tag{2}$$

Also, define $\phi_{j,t}$ as the asset-to-net worth ratio or the leverage ratio of a bank:

$$\phi_{j,t} = \frac{Q_t K_{j,t} + B_{j,t}}{N_{j,t}}.$$

Table 1 represents the balance sheet of a typical banker, and so the balance sheet constraint that the banker faces is:[16]

$$Q_t K_{j,t} + B_{j,t} = D_{j,t} + \mathcal{E}_t D^*_{j,t} + N_{j,t}.$$

We can write the flow of funds constraint for a banker as

$$N_{j,t} = R^k_t Q_{t-1} K_{j,t-1} + RR_t B_{j,t-1} - RR^d_t D_{j,t-1} - RR^*_t \mathcal{E}_t D^*_{j,t-1},$$

where R^k_t is the gross return on capital or loans to firms, $RR_t = R_{t-1}/\pi_t$ is the gross real

16. Note that for the case of a new banker, the net worth is the startup fund given by the household (fraction γ of the household's assets):

$$N_t = \gamma R^k_t Q_{t-1} K_{t-1}.$$

interest rate on safe assets, R_t is the gross nominal interest rate set by the central bank, $RR^*_t = R^*_{t-1}/\pi^*_t$ is the ex-post foreign gross real interest rate.

Since interest rates are identical across banks, we can omit bank-specific notation on bank returns, leverage, and ratios. Additionally, define $\Omega_{t,t+1}$ as the stochastic discount factor of the banker, μ_t as the excess return on capital over deposits, μ^b_t as the excess return on reserves over deposits, μ^*_t as the cost advantage of foreign currency deposits over home deposits, and υ_t as the marginal cost of deposits. Then total excess returns $\tilde{\mu}_t$ can be defined as:

$$\tilde{\mu}_t \equiv \mu_t \left(1 - x^b_t\right) + \left(\mu^b_t + \zeta_t\right) x^b_t + \mu^*_t x_t.$$

In Appendix A.3 I show that the banker's problem can then be written as the following:

$$\psi_t = \max_{\phi_t, x_t, x^b_t} \left\{\tilde{\mu}_t \phi_t + \upsilon_t\right\}, \tag{3}$$

subject to

$$\psi_t \geq \Theta(x_t, x^b_t)\phi_t, \tag{4}$$

and where

$$\begin{aligned}
\mu_t &= \mathbb{E}_t\, \Omega_{t,t+1} \left(R^k_{t+1} - RR^d_{t+1}\right), \\
\mu^b_t &= \mathbb{E}_t\, \Omega_{t,t+1} \left(RR_{t+1} - RR^d_{t+1}\right), \\
\mu^*_t &= \mathbb{E}_t\, \Omega_{t,t+1} \left(RR^d_{t+1} - \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} RR^*_{t+1}\right), \\
\upsilon_t &= \mathbb{E}_t\, \Omega_{t,t+1} RR^d_{t+1},
\end{aligned}$$

with

$$\Omega_{t,t+1} = \Lambda_{t,t+1}\left(1 - \sigma_b + \sigma_b \psi_{t+1}\right).$$

Additionally, from the FOCs, we obtain a bank's maximum leverage ratio $\bar{\phi}_t$:

$$\bar{\phi}_t = \frac{\upsilon_t}{\Theta(x_t, x^b_t) - \tilde{\mu}_t}.$$

Following the literature on financial stress episodes (Bocola, 2016; Holden, Levine, and Swarbrick, 2019; Akinci and Queralto, 2022; Akinci et al., 2023), when the constraint (4) binds with equality the economy can be thought of as being in a state of financial stress or financial crisis.[17] This financial stress period sees a rise in spreads:

$$\mathbb{E}_t\, \Omega_{t,t+1} \left(R^k_{t+1} - RR_{t+1} \right) > \zeta_t.$$

Conversely, when the constraint is slack, then financial intermediation can be thought of as being frictionless and banks do not earn any excess returns and spreads are driven by the idiosyncratic preference for safe assets:

$$\mathbb{E}_t\, \Omega_{t,t+1} \left(R^k_{t+1} - RR_{t+1} \right) = \zeta_t.$$

More concretely, in the non-binding/frictionless equilibrium a bank's leverage is below its maximum leverage ratio. I thus define $\tilde{\phi}_t$ as a bank's "leverage gap":

$$\tilde{\phi}_t = \bar{\phi}_t - \phi_t.$$

In other words, in the non-binding/frictionless equilibrium $\tilde{\phi}_t > 0$, or equivalently, $\mu_t = \mu^*_t = 0$; $\mu^b_t = -\zeta_t$. Thus, the slackness condition for occasionally binding constraint is:

$$0 = \min\left\{ \tilde{\mu}_t, \tilde{\phi}_t \right\}. \tag{5}$$

3.3. Firms

Final good firms. Firms and production in the model are standard, following a Dixit-Stiglitz aggregator setup. Final goods are produced by perfectly competitive firms using

17. In this paper I use the terms "financial stress" and "financial crisis" interchangeably, much like in Akinci and Queralto (2022) and Akinci et al. (2023). However, I acknowledge that there are many definitions in the literature about the severity and signals of a financial crisis – see, for example, Mendoza (2010).

intermediate goods as inputs into production:

$$Y_t = \left(\int_0^1 Y_{i,t}^{\frac{\eta-1}{\eta}} di \right)^{\frac{\eta}{\eta-1}},$$

where $Y_{i,t}$, $i \in [0,1]$, are differentiated intermediate goods and $\eta > 0$ is an elasticity of demand parameter. Final good firms maximise their profits by selecting how much of each intermediate good to purchase.

Intermediate good firms. Each differentiated intermediate good is produced by a constant returns to scale technology given as follows:

$$Y_{i,t} = A_t \left(\frac{K_{i,t-1}}{\alpha_K} \right)^{\alpha_K} \left(\frac{M_{i,t}}{\alpha_M} \right)^{\alpha_M} \left(\frac{L_{i,t}}{\alpha_L} \right)^{\alpha_L}, \quad \alpha_K + \alpha_M + \alpha_L = 1,$$

where $K_{i,t}$, $M_{i,t}$, and $L_{i,t}$ are capital, imports, and labour inputs into production, respectively, by intermediate good producer i, and A_t is total factor productivity (TFP) following an AR(1) process.

Solving the intermediate firm's minimisation problem yields real marginal cost, MC_t, in the symmetric equilibrium:

$$MC_t = \frac{1}{A_t} (z_t^k)^{\alpha_K} \mathcal{E}_t^{\alpha_M} {w_t}^{\alpha_L}, \tag{6}$$

and

$$Y_t = A_t \left(\frac{K_{t-1}}{\alpha_K} \right)^{\alpha_K} \left(\frac{M_t}{\alpha_M} \right)^{\alpha_M} \left(\frac{L_t}{\alpha_L} \right)^{\alpha_L}, \tag{7}$$

where

$$K_{t-1} = \int_0^1 K_{i,t-1} di, \quad M_t = \int_0^1 M_{i,t} di, \quad L_t = \int_0^1 L_{i,t} di,$$

is aggregate capital, imports, and labour inputs used in production during period t, respectively. From the FOCs,[18] one also yields the following expenditure shares:

$$\frac{z_t^k K_{t-1}}{w_t L_t} = \frac{\alpha_K}{\alpha_L}, \tag{8}$$

$$\frac{z_t^k K_{t-1}}{\mathcal{E}_t M_t} = \frac{\alpha_K}{\alpha_M}. \tag{9}$$

Inherent to each intermediate firm i's problem – in addition to selecting input quantities to minimise costs – is the choice of $P_{i,t}$. Under Rotemberg (1982) pricing, firm i maximises the net present value of profits,

$$\max_{P_{i,t}} \mathbb{V}_{i,t}^I = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left[\left(\frac{P_{i,t+s}}{P_{t+s}} - MC_{t+s} \right) Y_{i,t+s} - \frac{\kappa}{2} \left(\frac{P_{i,t+s}}{P_{i,t-1+s}} - 1 \right)^2 Y_{t+s} \right].$$

Evaluating at the symmetric equilibrium where intermediate firms optimally price their output at $P_{i,t} = P_t, \forall i$, gives[19]

$$(\pi_t - 1)\pi_t = \frac{1}{\kappa} \left[1 - \eta + (\eta - 1)\mathcal{M}_t MC_t \right] + \mathbb{E}_t \Lambda_{t,t+1} \frac{Y_{t+1}}{Y_t} (\pi_{t+1} - 1)\pi_{t+1}, \tag{10}$$

where $\mathcal{M}_t$ is a time-varying markup charged by firms and in steady state is given by $\mathcal{M} = \eta/(\eta - 1)$.

Investment good firms. Investment goods are produced by perfectly competitive firms, and that the aggregate capital stock grows according to a law of motion of capital:

$$K_t = \lambda K_{t-1} \xi_t^K + I_t \xi_t^I,$$

where ξ_t^K is a quality of capital shock and ξ_t^I is a marginal efficiency of investment (MEI) shock (Greenwood, Hercowitz, and Huffman, 1988; Justiniano, Primiceri, and Tambalotti, 2010, 2011) which each follow a stationary AR(1) process, and so the gross return on

18. Intermediate firm FOCs are shown in Appendix A.2.
19. A standard expression for the New Keynesian Phillips Curve (NKPC) can be written by log linearising (10) about the non-inflationary steady state. For details see Appendix A.2.

capital is given by:

$$R_t^k = \frac{\left(z_t^k + \lambda Q_t\right) \xi_t^K}{Q_{t-1}},$$

where z_t^k is the net rate of return on capital and $\lambda = 1 - \delta$ is one minus the depreciation rate. Total investment costs are given by:[20]

$$I_t \left[1 + \Phi\left(\frac{I_t}{I_{t-1}}\right)\right].$$

Thus, the representative investment good firm wishes to maximise its profits:

$$\max_{I_t} \left\{Q_t I_t \xi_t^I - I_t - \Phi\left(\frac{I_t}{I_{t-1}}\right) I_t\right\}.$$

Differentiating with respect to I_t gives the following FOC:

$$Q_t \xi_t^I = 1 + \Phi\left(\frac{I_t}{I_{t-1}}\right) + \left(\frac{I_t}{I_{t-1}}\right) \Phi'\left(\frac{I_t}{I_{t-1}}\right) - \mathbb{E}_t \Lambda_{t,t+1} \left(\frac{I_{t+1}}{I_t}\right)^2 \Phi'\left(\frac{I_{t+1}}{I_t}\right) \xi_{t+1}^I. \quad (11)$$

3.4. Foreign exchange

This Section describes the role of foreign output, inflation, and interest rates. In what follows, starred variables denote the corresponding foreign version of a variable.

I assume that exports are a function of foreign output, and are given as:

$$EX_t = \left(\frac{P_t}{E_t P_t^*}\right)^{-\eta_x} Y_t^* = \mathcal{E}_t^{\eta_x} Y_t^*, \quad (12)$$

where η_x is the price elasticity of foreign demand.

20. $\Phi(\cdot)$ are investment adjustment costs as in Christiano, Eichenbaum, and Evans (2005), and are defined as:

$$\Phi\left(\frac{I_t}{I_{t-1}}\right) = \frac{\kappa_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2,$$

with $\Phi(1) = \Phi'(1) = 0$ and $\Phi''\left(\frac{I_t}{I}\right) > 0$.

To pin down the nominal exchange rate, first take logarithms of the definition for the real exchange rate, and then take first-differences:

$$\ln \mathcal{E}_t - \ln \mathcal{E}_{t-1} = \ln E_t - \ln E_{t-1} + \ln P_t^* - \ln P_{t-1}^* - (\ln P_t - \ln P_{t-1}).$$

This is simplified as:

$$\Delta \ln \mathcal{E}_t = \Delta \ln E_t + \hat{\pi}_t^* - \hat{\pi}_t.$$

A VARX structure similar to the VAR system in Christiano, Trabandt, and Walentin (2011) is imposed on the foreign variables, where the system of equations which describe foreign output, inflation, and interest rates are given as:

$$\begin{bmatrix} \ln\left(\frac{Y_t^*}{Y^*}\right) \\ \pi_t^* - \pi^* \\ R_t^* - R^* \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} \ln\left(\frac{Y_{t-1}^*}{Y^*}\right) \\ \pi_{t-1}^* - \pi^* \\ R_{t-1}^* - R^* \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \kappa_b \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ e^{x_t - x} - 1 \end{bmatrix} + \begin{bmatrix} \sigma_{y^*} & 0 & 0 \\ c_{21} & \sigma_{\pi^*} & 0 \\ c_{31} & c_{32} & \sigma_{R^*} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{Y^*} \\ \varepsilon_t^{\pi^*} \\ \varepsilon_t^{R^*} \end{bmatrix},$$

or in compact matrix form as:

$$\boldsymbol{Y}_t = \boldsymbol{A}\boldsymbol{Y}_{t-1} + \boldsymbol{B}\boldsymbol{X}_t + \boldsymbol{C}\boldsymbol{\varepsilon}_t, \quad \boldsymbol{\varepsilon}_t \overset{iid}{\sim} \mathcal{N}(\boldsymbol{0}, \boldsymbol{I}).$$

With this setup it is assumed that a foreign demand shock $\varepsilon_t^{Y^*}$ affects the foreign inflation rate and nominal interest rates on foreign deposits contemporaneously, a foreign inflationary shock $\varepsilon_t^{\pi^*}$ affects the nominal interest rate on foreign deposits contemporaneously, and the shock to nominal interest rates on foreign deposits $\varepsilon_t^{R^*}$ does not affect the foreign inflation rate or foreign demand contemporaneously. These assumptions are a simple recursive structure (Erceg and Levin, 2006), whereby foreign output and inflation are predetermined relative to the foreign monetary policy shock.

Finally, note that R_t^* follow contains a "debt-elasticity" term for model stationarity as in Schmitt-Grohé and Uribe (2003) and Akinci and Queralto (2022). Here, the nominal interest rate paid to foreign depositors scales with the deviation in the foreign deposit-asset ratio from its steady state level.

3.5. Fiscal and monetary policy

I assume that the policymaker operates a balanced budget repaying interest on reserves by levying lump-sum taxes on households:

$$RR_t B_{t-1} = B_t + \tau_t, \tag{13}$$

and the total quantity of reserves in the economy is given by the following rule:

$$B_t = \Gamma(K_t).$$

Meanwhile, the domestic central bank is assumed to operate an inertial Taylor-type rule. Let hatted lower case variables denote log deviations of the variable from its deterministic steady state level. Then, for ease of exposition, the monetary policy rule can be written as:

$$\hat{i}_t = \rho_R \hat{i}_{t-1} + (1 - \rho_R)\left[\phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t + \phi_E \hat{e}_t\right] + \varepsilon_t^R, \tag{14}$$

where the central bank responds to fluctuations in the inflation and the output gap, fluctuations in the nominal exchange rate, and ε_t^R is a monetary policy shock. This particular formulation of the Taylor rule takes cues from Galí and Monacelli (2016) and AQ. However, (14) eases the trade-off between inflation and exchange rate stabilisation.[21] Note that the central bank operates a standard feedback rule (Taylor, 1993) as $\phi_E \to 0$, and an exchange rate peg as $\phi_E \to \infty$.

21. In Galí and Monacelli (2016) and AQ, the Taylor rule takes the form:

$$\hat{i}_t = \rho_R \hat{i}_{t-1} + (1 - \rho_R)\left(\frac{1 - \omega_E}{\omega_E}\hat{\pi}_t + \frac{\omega_E}{1 - \omega_E}\hat{e}_t\right),$$

where $\omega_E \in (0, 1)$ is a sensitivity parameter depicting how strongly the central bank reacts to exchange rate fluctuations. I ease this specification to assist estimation and as a robustness check as many central banks also stabilise the output gap. Broadly, however, the qualitative implications of the model do not change.

3.6. Equilibrium

The aggregate resource constraint of the domestic economy is

$$Y_t = C_t + \left[1 + \Phi\left(\frac{I_t}{I_{t-1}}\right)\right] I_t + EX_t + \frac{\kappa}{2}(\pi_t - 1)^2 Y_t, \tag{15}$$

which states that output must be consumed, invested, exported, and used to pay for adjustments.[22]

The law of motion of aggregate net foreign debt is given as:

$$D_t^* = RR_t^* D_{t-1}^* + M_t - \frac{1}{\mathcal{E}_t} EX_t, \tag{16}$$

the aggregate net worth of the bankers is:

$$N_t = \sigma\left(R_t^k Q_{t-1} K_{t-1} + RR_t B_{t-1} - RR_t^d D_{t-1} - \mathcal{E}_t RR_t^* D_{t-1}^*\right) + \gamma R_t^k Q_{t-1} K_{t-1},$$

and the aggregate balance sheet of the banking sector is given by the following:

$$Q_t K_t + B_t = D_t + \mathcal{E}_t D_t^* + N_t.$$

The other aggregate bank variables are given as:

$$\begin{aligned} \phi_t &= \frac{Q_t K_t + B_t}{N_t}, \\ x_t &= \frac{\mathcal{E}_t D_t^*}{Q_t K_t + B_t}, \\ x_t^b &= \frac{B_t}{Q_t K_t + B_t}. \end{aligned} \tag{17}$$

22. Note that GDP is given as:

$$Y_t^{GDP} = Y_t - \mathcal{E}_t M_t.$$

Finally, the shock processes are given as:

$$\begin{aligned}
\ln A_t &= \rho_A \ln A_{t-1} + \sigma_A \varepsilon_t^A, \\
\xi_t^h &= \rho_h \xi_{t-1}^h + \sigma_h \varepsilon_t^h, \\
\xi_t^I &= \rho_I \xi_{t-1}^I + \sigma_I \varepsilon_t^I, \\
\xi_t^K &= \rho_K \xi_{t-1}^K + \sigma_K \varepsilon_t^K, \\
\xi_t^L &= \rho_L \xi_{t-1}^L + \sigma_L \varepsilon_t^L, \\
\ln \mathcal{M}_t &= (1-\rho_{\mathcal{M}}) \ln \mathcal{M} + \rho_{\mathcal{M}} \ln \mathcal{M}_{t-1} + \sigma_{\mathcal{M}} \varepsilon_t^{\mathcal{M}}, \\
\zeta_t &= \zeta + \sigma_\zeta \varepsilon_t^\zeta,
\end{aligned}$$

with innovations $\varepsilon_t^i \overset{iid}{\sim} \mathcal{N}(0,1)$ for $i \in \{A, h, I, K, L, \mathcal{M}, \zeta\}$.

A competitive equilibrium is a set of 12 prices, $\{\, E_t, \mathcal{E}_t, MC_t, Q_t, RR_t, R_t, RR_t^d, R_t^d, w_t, z_t^k, R_t^k, \pi_t \,\}$; 12 quantity variables, $\{\, B_t, C_t, D_t, D_t^*, EX_t, I_t, K_t, L_t, M_t, N_t, Y_t, Y_t^{GDP} \,\}$; 11 bank variables, $\{\, x_t, x_t^b, \psi_t, \phi_t, \bar{\phi}_t, \hat{\phi}_t, \upsilon_t, \mu_t, \mu_t^b, \mu_t^*, \tilde{\mu}_t \,\}$; four foreign variables, $\{\, Y_t^*, RR_t^*, R_t^*, \pi_t^* \,\}$; and seven exogenous variables, $\{\, A_t, \xi_t^h, \xi_t^I, \xi_t^K, \xi_t^L, \mathcal{M}_t, \zeta_t \,\}$, which satisfy 46 equations.

4. Estimation and The Mundellian Trilemma

I estimate the model using Bayesian likelihood maximisation methods outlined in An and Schorfheide (2007) and Del Negro (2012). This section provides a description of the parameters which have been either calibrated or estimated, as well as the data used for model estimation.

I estimate the model using Korean and US data between 1999-Q1 and 2019-Q4. I use nine observable time series. A plot of the time series and data sources can be found in Appendix C.1. The following time series are in percent annualised form: Korean PPI inflation, Korean 90-day deposit nominal interest rates, Korean corporate spreads, US inflation (using the GDP deflator), and US 12-month Treasury Bill (TBill) interest rates. For the following time series I take logs and first differences: Korean real GDP, Korean real exports, US real GDP, and the Dollar-Won nominal exchange rate.

Throughout the rest of this paper, I interchangeably refer to the Korean economy as the

TABLE 2. Calibrated parameter values

Parameter	Value	Description
β	0.991	Discount rate based on data
σ	2	Risk aversion coefficient
φ	1/3	Inverse-Frisch elasticity
φ_0	3	Labour disutility
σ_b	0.94	Bank survival probability
θ_0	0.1307	Absconding fraction parameter
γ	0.00956	Fraction of total assets inherited by new banks
x	0.25	Steady state foreign deposit-asset ratio
x^b	0.20	Steady state reserve-asset ratio
ζ	0.002	Steady state discounted corporate spread
α_K	0.3	Cost share of capital
α_M	0.18	Cost share of imported intermediate goods
α_L	0.52	Cost share of labour
λ	0.98	One minus the depreciation rate
η	6	Elasticity of demand
ω	0.75	Calvo parameter

"domestic" or "home" economy, and the US economy as the "foreign" economy.

4.1. Calibration and prior selection

Table 2 shows the calibrated parameter values for the model. The value for β is chosen to match the average annual nominal interest rate in Korea for three-month yields of approximately 3.62% per annum. A value for the coefficient of risk aversion of $\sigma = 2$ is standard in most of the macroeconomic DSGE literature. Meanwhile, the inverse-Frisch elasticity and labour disutility parameters, φ and φ_0, are set to 1/3 and 3, respectively to target a steady state labour supply of 1/3.

The bank survival probability σ_b is set to 0.94 following ABK and Akinci and Queralto (2022), and $\gamma = 0.00956$ and $\theta_0 = 0.1307$ so that the steady state bank leverage ratio ϕ is approximately 7 and $\hat{\phi} = 0.35$ (five percent above steady state leverage). The steady state ratios x and x^b are set to ensure realistic costs to the banker for domestic and foreign borrowing, respectively, and are also from ABK, AQ, and Akinci et al. (2023). The steady state discounted corporate spread ζ is calibrated from Korean data to be 25% of the discounted mean corporate spread.

The parameters which pertain to production and supply are set in line with standard macroeconomic literature (Smets and Wouters, 2007; Galí, 2015). For example, the cost share of capital, α_K, is equal to approximately one-third. A quarterly depreciation rate of $\delta = 0.02 \Rightarrow \lambda = 0.98$ is standard too. Since this model is relatively simple compared to medium-scale DSGE models, I use a value of $\eta = 6$ for the elasticity of demand, which is below the standard value of nine or 10, in order to better match the volatile and high inflation in South Korea. The fraction of firms which do not adjust their prices each period, $\omega = 0.75$, is based on a value higher than the baseline calibration in ABK, due to price adjustment evidence found by Apel, Friberg, and Hallsten (2005) and Nakamura and Steinsson (2008).[23]

4.2. Priors, computational methods, and estimation results

Tables 3 and 4 show estimated parameters, including information about their prior and posterior distributions. I estimate 10 structural parameters, 12 VAR parameters for the FOREX market, five AR(1) coefficients, and 10 shock standard deviations. The priors are assumed to be independent for different parameters; a common assumption in Bayesian estimation of DSGE models. Prior selection follows the sequential Bayesian learning strategy outlined in Christiano, Trabandt, and Walentin (2011). This "endogenous priors" approach is formulated so that the priors chosen are a function of observed data – different to the method described by Del Negro and Schorfheide (2008). This is in order to avoid the problem of overpredicting the variances implied by the model (relative to the data), and so I use actual sample data to compute the standard deviations of the observed variables.

The key methodological contribution of this paper is the Bayesian estimation of the model featuring an occasionally binding constraint. This has historically proven to be a computationally infeasible task for even modestly sized DSGE models as even a few

23. Nakamura and Steinsson (2008) find that the average duration of prices of US firms is between 8-11 months. However Gouvea (2007) finds that firms in Brazil adjust prices between 2.7 and 3.8 months, suggesting that prices adjust more quickly in developing and emerging market economies – which would suggest a smaller value of ω.

TABLE 3. Parameter estimation results

Parameter	Description	Prior			Posterior			
		Dist.	Mean	SD	Mean	SD	HPD 5%	95%
χ	GHH+ preference parameter	$\mathcal{B}$	0.660	0.150	0.446	0.143	0.242	0.674
κ_I	Investment adjustment cost	$\mathcal{N}$	1.500	0.500	2.879	0.394	2.223	3.440
η_x	Foreign demand elasticity	$\mathcal{N}$	1.000	0.250	2.580	0.012	2.567	2.590
θ	Bank moral hazard	$\mathcal{N}$	2.580	0.500	2.004	0.536	0.961	2.573
θ_b	Reserve moral hazard	$\mathcal{N}$	2.000	0.500	2.133	0.542	1.554	3.022
κ_b	Foreign debt elasticity	$\mathcal{G}^{-1}$	0.025	Inf	0.004	0.000	0.003	0.004
ϕ_π	Inflation sensitivity	$\mathcal{N}_{>1}$	2.000	0.500	1.250	0.157	1.006	1.472
ϕ_y	Output sensitivity	$\mathcal{N}_{>0}$	0.200	0.100	0.118	0.020	0.083	0.139
ϕ_E	Exchange rate sensitivity	$\mathcal{N}_{>0}$	1.000	0.500	2.127	0.248	1.763	2.516
ρ_R	Taylor rule inertia	$\mathcal{B}$	0.550	0.100	0.845	0.032	0.811	0.894
ρ_A	AR(1) coefficient	$\mathcal{B}$	0.800	0.100	0.811	0.091	0.666	0.931
ρ_h	AR(1) coefficient	$\mathcal{B}$	0.500	0.100	0.499	0.098	0.342	0.640
ρ_I	AR(1) coefficient	$\mathcal{B}$	0.800	0.100	0.965	0.013	0.949	0.987
ρ_K	AR(1) coefficient	$\mathcal{B}$	0.800	0.100	0.718	0.036	0.666	0.777
$\rho_{\mathcal{M}}$	AR(1) coefficient	$\mathcal{B}$	0.800	0.100	0.366	0.077	0.243	0.477
a_{11}	Foreign VAR (y^*, y^*)	$\mathcal{N}$	0.500	0.500	0.978	0.012	0.956	0.993
a_{12}	Foreign VAR (y^*, π^*)	$\mathcal{N}$	0.000	0.500	0.425	0.305	-0.021	0.881
a_{13}	Foreign VAR (y^*, R^*)	$\mathcal{N}$	0.000	0.500	-0.428	0.204	-0.707	-0.085
a_{21}	Foreign VAR (π^*, y^*)	$\mathcal{N}$	0.000	0.500	0.008	0.008	-0.002	0.018
a_{22}	Foreign VAR (π^*, π^*)	$\mathcal{N}$	0.000	0.500	0.407	0.115	0.215	0.576
a_{23}	Foreign VAR (π^*, R^*)	$\mathcal{N}$	0.000	0.500	0.053	0.058	-0.021	0.147
a_{31}	Foreign VAR (R^*, y^*)	$\mathcal{N}$	0.000	0.500	0.014	0.004	0.008	0.021
a_{32}	Foreign VAR (R^*, π^*)	$\mathcal{N}$	0.000	0.500	0.163	0.050	0.073	0.228
a_{33}	Foreign VAR (R^*, R^*)	$\mathcal{N}$	0.500	0.500	0.665	0.027	0.619	0.702
c_{21}	Foreign VAR $(\varepsilon^{\pi^*}, \varepsilon^{y^*})$	$\mathcal{N}$	0.000	0.500	0.044	0.021	0.014	0.078
c_{31}	Foreign VAR $(\varepsilon^{R^*}, \varepsilon^{y^*})$	$\mathcal{N}$	0.000	0.500	0.069	0.014	0.044	0.085
c_{32}	Foreign VAR $(\varepsilon^{R^*}, \varepsilon^{\pi^*})$	$\mathcal{N}$	0.000	0.500	0.005	0.015	-0.020	0.027

Based on a single slice sampling chain with 100 draws, equivalent to 30,000 Metropolis Hastings draws. The first one-fifth of draws are disposed as a burn-in period.

TABLE 4. Estimated standard deviation of shocks

Parameter	Description	Prior			Posterior			
		Dist.	Mean	SD	Mean	SD	HPD 5%	95%
$100\sigma_A$	TFP	$\mathcal{G}^{-1}$	0.500	Inf	0.328	0.177	0.170	0.570
$100\sigma_h$	Household preference	$\mathcal{G}^{-1}$	0.150	Inf	0.112	0.066	0.042	0.202
$100\sigma_I$	MEI shock	$\mathcal{G}^{-1}$	0.100	Inf	5.102	0.475	4.237	5.569
$100\sigma_K$	Capital quality	$\mathcal{G}^{-1}$	0.100	Inf	2.347	0.458	1.663	2.719
$100\sigma_{\mathcal{M}}$	Markups	$\mathcal{G}^{-1}$	0.150	Inf	26.840	3.172	21.990	31.261
$100\sigma_R$	Monetary policy	$\mathcal{G}^{-1}$	0.250	Inf	1.481	0.334	0.931	1.856
$400\sigma_\zeta$	Safe asset preference	$\mathcal{G}^{-1}$	0.192	Inf	0.532	0.041	0.483	0.603
$100\sigma_{y^*}$	Foreign demand	$\mathcal{G}^{-1}$	0.500	Inf	0.617	0.059	0.510	0.687
$100\sigma_{\pi^*}$	Foreign inflation	$\mathcal{G}^{-1}$	0.250	Inf	0.193	0.012	0.179	0.216
$100\sigma_{R^*}$	Foreign interest rate	$\mathcal{G}^{-1}$	0.250	Inf	0.107	0.010	0.092	0.124

Based on a single slice sampling chain with 100 draws, equivalent to 30,000 Metropolis Hastings draws. The first one-fifth of draws are disposed as a burn-in period.

state variables render global solution methods intractable. Conversely, more conventional Newtonian mode-finding methods for linearised DSGE models are not suitable for models with nonlinearities such as occasionally binding constraints as a small change in parameter estimates during mode-finding introduces large jumps or non-monotonicity in the posterior distribution. Nonlinearities also are infeasible for the Kalman filter and smoother. To circumvent these issues, I use the piecewise-linear Kalman filter of Giovanni, Pfeiffer, and Ratto (2021) and the slice sampler of Planas, Ratto, and Rossi (2015) to estimate the model. These two methods combined with the OccBin algorithm of Guerrieri and Iacoviello (2015) enabled the estimation of the model in the Dynare toolkit.[24]

In what follows I describe the calibration and estimation strategy of each of the model's parameters – but most are standard. For example, the inverse-gamma distribution is used for the prior distributions of the shock standard deviation values, as posterior estimates are restricted to $\mathbb{R}^+$. The prior means for these values are mostly based on Christiano, Trabandt, and Walentin (2011), which used Swedish (domestic) and US (foreign) data for their estimation exercise. For the persistence of the AR(1) processes, $\{\rho_A, \rho_h, \rho_I, \rho_K, \rho_{\mathcal{M}}\}$, I adopt

24. These features have recently been integrated into Dynare versions 5 and 6. For further details please see Adjemian et al. (2024).

tight priors with means of 0.80 (except for ρ_h) based on the Beta distribution.

As discussed in Shchapov (2025), GHH+ preferences and higher capital adjustment costs are necessary for models based on the GKK framework to better match data on financial stress episodes. As such, as I set prior means for χ and κ_I to 0.66 and 1.5, respectively, following Shchapov (2025) who calibrates these values to match key business cycle moments in advanced economies.

The prior for the foreign demand elasticity parameter is set 'agnostically' by setting a normal distribution with a mean of 1 and standard deviation of 0.25.

For the banker's moral hazard parameters, θ and θ_b, I assume priors around 2.58 and 2 for foreign deposits and reserves, respectively, based on the calibration in AQ. To avoid the incentive compatibility constraint not binding in steady state, I adopt tight priors for both parameters. Additionally, the prior for the foreign debt elasticity parameter κ_b follows an inverse-gamma distribution to keep the parameter estimate positive, and with a prior mean based on the calibration in Akinci and Queralto (2022).

The parameter governing inertia of the Taylor rule, ρ_R, is set to a prior mean of 0.55 following Guerrieri and Iacoviello (2017). The sensitivity parameter for the central bank's reaction to fluctuations in the nominal exchange rate, ϕ_E, is adjusted depending on the quantitative exercise considered. But for the purposes of estimation, I assume a prior which follows the normal distribution with a mean of 1. The reaction to inflation and the output gap, ϕ_π and ϕ_y, have prior means set at 2 and 0.2, respectively. These values are relatively standard in the New Keynesian literature following the seminal paper by Taylor (1993). For estimation, I assume truncated normal distributions to avoid mode-finding in regions that do not satisfy Blanchard-Kahn conditions.

Finally, prior choices for the foreign VAR parameters are mostly agnostic, where I set priors that follow a normal distribution with a standard deviation of 0.5. The only exceptions are the priors for a_{11} and a_{33}, the AR coefficients for foreign output and the foreign interest rate. These priors are centred at 0.8, and are relatively tight with an assumed standard deviation of 0.15.

Details of the estimation results, such as prior and posterior distributions, are provided in Appendix C.2.

4.3. Quantitative exercises: Global financial cycles, monetary policy, and financial stress

With the model calibrated based on the values in Table 2 and the posterior means in Tables 3 and 4, we return back to the central questions of the paper: How do global financial cycle shocks proxied by fluctuations in foreign interest rates affect the domestic small open economy? What role does monetary policy play, and does the Mundelliam Trilemma persist?

We begin by examining the impact of a global financial cycle shock, proxied by an increase in the nominal interest rate on foreign deposits. Figure 3 plots the impulse responses to a positive realisation of σ_{R^*}, scaled so that the impact on R^* is equivalent to a 1% per-annum increase. The dashed red lines represent responses under the fully linear model, where the banker's incentive compatibility constraint (ICC) in equation (1) does not bind. The solid blue lines represent the piecewise-linear case, where the ICC occasionally binds—occurring when either $\tilde{\mu} > 0$ or $\hat{\phi} = 0$ per the slackness condition in (5). Positive excess returns indicate frictional financial intermediation and an economy in financial stress (Akinci et al., 2023). This nonlinearity generates quantitatively meaningful differences in the responses of real variables—GDP, labour supply, investment, and capital—with financial variables exhibiting even starker divergences.

Although not plotted in Figure 3, the nominal exchange rate (NER) depreciates sharply on impact, consistent with the empirical VAR in Figure 1. The real exchange rate (RER) depreciation initially boosts exports. However, in the empirical VAR, exports declined as weaker foreign demand dominated the expenditure-switching effect. The model, by contrast, features highly elastic exports: they only fall below steady state once the RER depreciation diminishes to approximately 0.2% above steady state, after which they remain depressed due to sluggish foreign demand (since $a_{13} < 0$).

Output declines in both cases as the NER depreciation prompts a hike in domestic nominal interest rates, but—importantly—the contraction is more pronounced in the piecewise-linear case. This amplification, a key contribution of this paper, arises because the domestic rate hike causes the ICC to bind, triggering a financial stress episode with the usual financial accelerator dynamics (Kiyotaki and Moore, 1997; Bernanke, Gertler, and

FIGURE 3. IRFs to a positive foreign interest rate shock

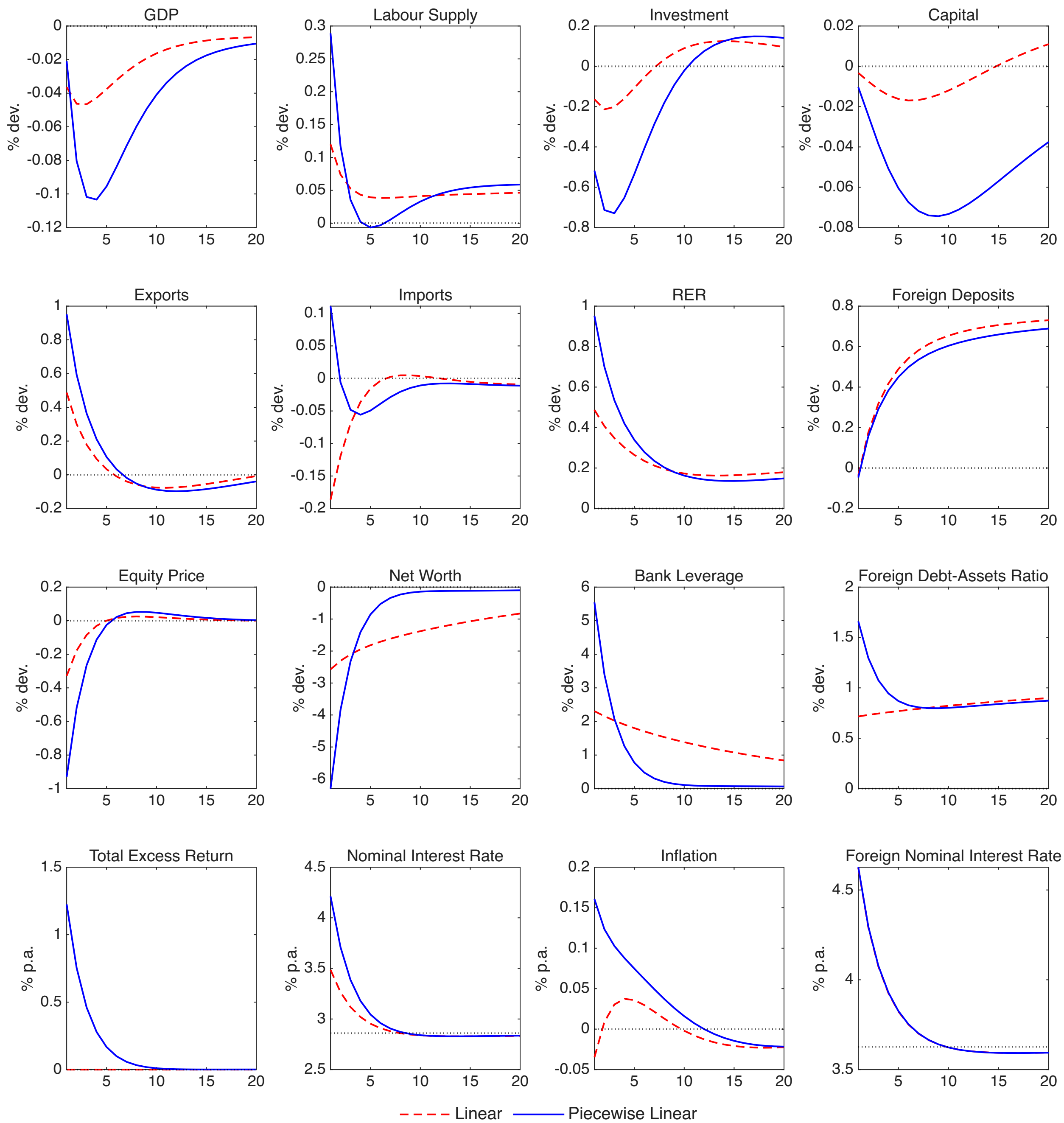


Figure plots impulse responses to a positive realisation of ε_{R^*}. Dashed red lines represent the responses where the model is fully linear (no binding constraint); solid blue lines represent the responses where the model features an occasionally binding constraint, represented as when the bank's total excess return is positive. Thing dootted black lines represent steady state values.

Gilchrist, 1999). Specifically, the increase in the interest rate on foreign deposits is matched by higher rates on domestic deposits RR^d and, crucially, a higher required return on capital z^k. With financial intermediation now frictional, corporate spreads widen as banks curtail lending, depressing investment and capital accumulation. The resulting sharper RER decline raises the cost of imported intermediates (ϵM) and pushes up inflation via higher marginal costs. The central bank responds with tighter monetary policy, reinforcing the financial accelerator. The economy remains in financial stress for approximately ten periods, recovering only once banks recapitalise.[25] In both cases, the economy gradually returns to steady state as banks rebalance their deposit composition from foreign back to domestic sources.

How does the model compare to the empirical evidence in Section 2? The model qualitatively matches most VAR responses: GDP contracts, the NER depreciates sharply, and corporate spreads widen when financial frictions bind. Inflation dynamics depend on whether the economy enters financial stress. Two discrepancies remain. First, the model cannot replicate the decline in exports, an understandable limitation given its parsimonious small open economy structure. Second, it does not capture the easing of domestic nominal interest rates observed in the VAR during periods of economic slack.

Effect of different FX policies. But what of the Mundellian Trilemma—does the exchange rate regime matter when buffering the economy from global financial cycles? The IRFs in Figure 3 are calibrated to the estimated posterior means, including $\phi_E = 2.127$. Figure 4 compares these responses under alternative exchange rate policies: a fully floating regime ($\phi_E = 0$) and a fixed regime ($\phi_E = 100$). Dashed red and dash-dotted green lines represent the linear model; solid blue and dotted magenta lines represent the occasionally binding case. As before, responses are scaled so that the impact on R^* is equivalent to a 1% per-annum increase.

25. See, for example, Gertler, Kiyotaki, and Prestipino (2020).

FIGURE 4. IRFs to a positive foreign interest rate shock with different exchange rate policies

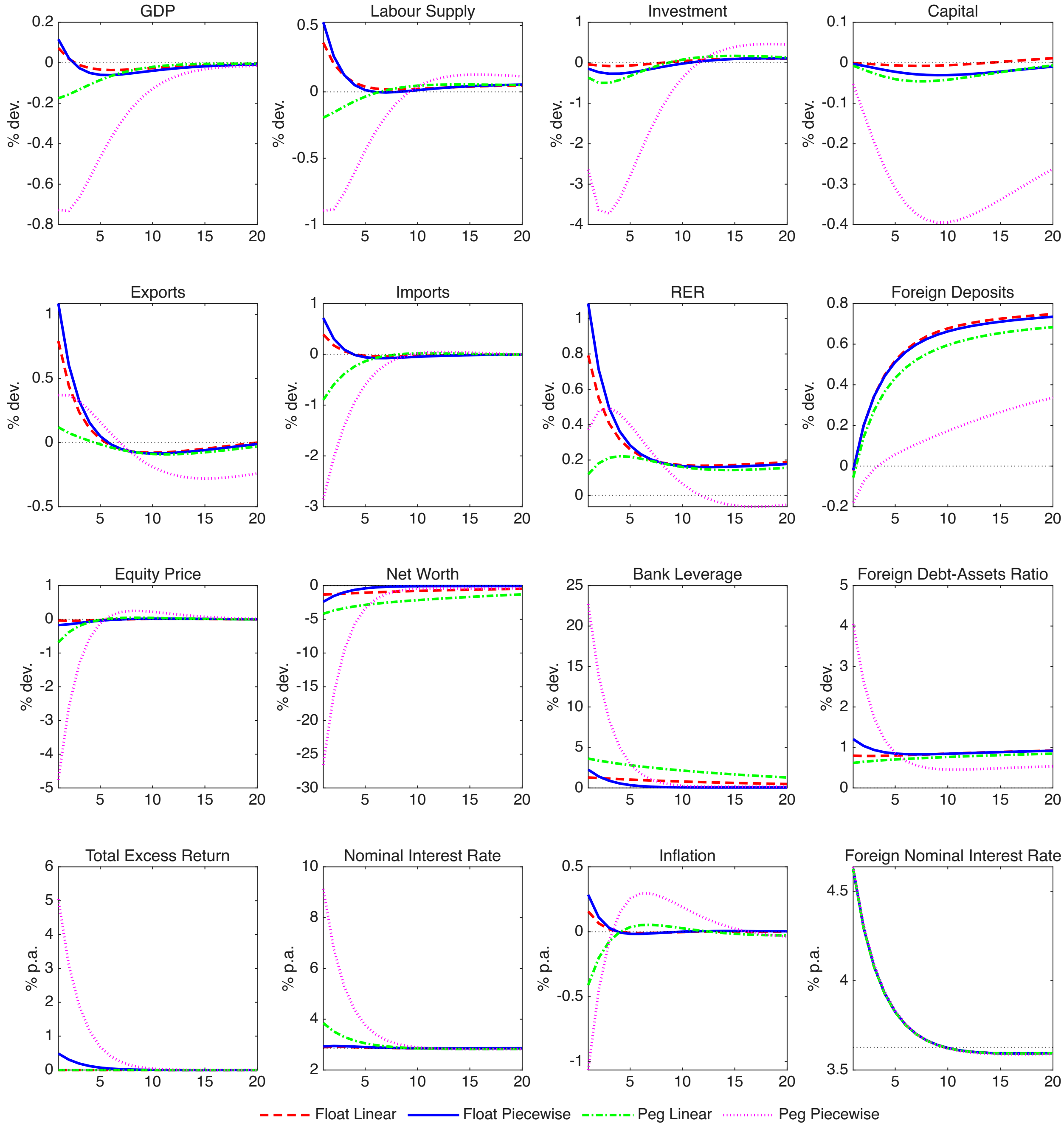


Figure plots impulse responses to a positive realisation of ε^{R^*}. Dashed red and dash-dotted green lines represent the responses where the model is fully linear (no binding constraint); solid blue and dotted magenta lines represent the responses where the model features an occasionally binding constraint, represented as when the bank's total excess return is positive. Solid black lines represent steady state values.

The answer is yes, with some caveats. The floating regime (dashed red and solid blue) exhibits far more stable responses than the peg (dash-dotted green and dotted magenta) across all variables except the RER. Financial stress is almost entirely muted under the float: the banker's excess return reaches only 0.5% p.a. on impact, compared to around 5% p.a. under the peg, and the economy returns to frictionless equilibrium in roughly half the time. Bank net worth is also considerably more stable. The output response is striking: the float generates a mild expansion following the ε^{R^*} shock, whereas the peg induces a sharp contraction. These patterns carry over to inflation and nominal interest rates—conditional on the foreign rate shock, the float demands far fewer monetary policy adjustments. The floating exchange rate acts as a stabilising force, preserving monetary policy independence. This suggests the Mundellian Trilemma remains intact. Under the peg, the economy experiences deflation—matching the empirical VAR in Figure 1—but the nominal interest rate cannot be lowered to provide relief.

A caveat tempers this conclusion. While the float buffers the domestic economy in line with the Mundell-Fleming framework, persistently sluggish foreign output and inflation eventually drag on domestic activity. The exchange rate depreciation and initial export boom are insufficient to prevent an eventual GDP contraction.

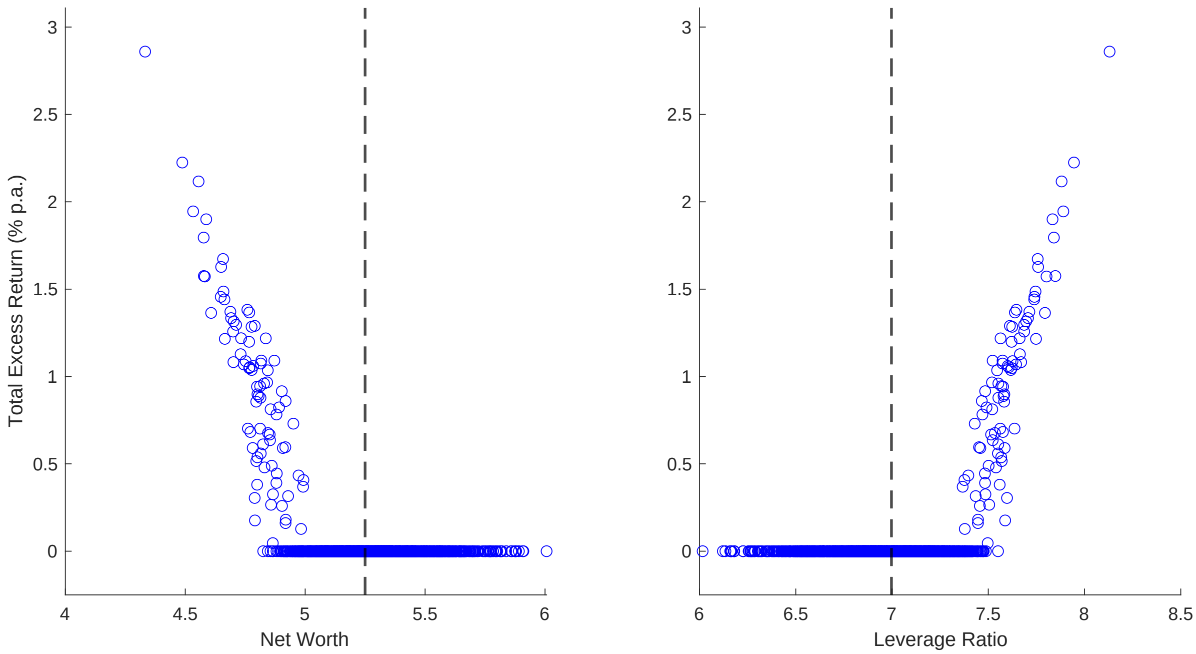
Two open questions remain. First, how well does exchange rate policy stabilise the economy against other structural shocks? Second, can a float or peg reduce the frequency of financial stress episodes? I turn to the latter question in the next section.

5. Global Financial Cycles, FX Policies and Financial Crises Frequency

Leveraging the model which allows for occasional financial crisis or stress episodes, I now turn to the interaction between the foreign exchange rate position of the central bank and frequency of financial stress. To begin, I use the model calibrated in line with the parameter values in Table 2 and the posterior means in Tables 3 and 4. However, as my focus is on global financial cycles, I shut down all shocks except for shocks to the interest rate paid on foreign deposits ε_{R^*}.[26] I then simulate the model for 2,000 periods and plot the domestic bank's total excess return expressed in annual percentage points against two key financial

26. I also scale σ_{R^*} so that the standard deviation of the foreign interest rate is approximately 1% per annum.

FIGURE 5. Frequency of financial crises: Total Excess Returns, Net Worth and Leverage



Vertical axes are bank total excess returns expressed in annual percentage points. Horizontal axes are bank net worth (left) and the leverage ratio (right). Dashed vertical lines represent non-stochastic steady state values.

variables, bank net worth and the leverage ratio, in the two panels of Figure 5.

Intuitively, periods of financial stress or crisis correspond to periods of low bank net worth and when banks are highly leveraged. The frequency of a financial crisis occurring conditional on the economy only being subject to markup and foreign interest rate shocks in the baseline estimation exercise is approximately 4.20%. That is, $\tilde{\mu}_t > 0$ or $\hat{\phi}_t = 0$ in approximately 85 periods of the 2000 period simulation. Re-running the simulation with different exchange rate policies, I find that a floating exchange rate policy reduces the frequency of financial crises to approximately 1.75%, while a fixed exchange rate policy increases it to approximately 10.55%.

However, a few caveats are in order before introducing another contribution of this paper. As mentioned in Section 4.2, thus far the model solution has been computed using the OccBin toolkit, which uses an extended perfect foresight path (EPFP) method to compute

FIGURE 6. Leverage distribution (OccBin)

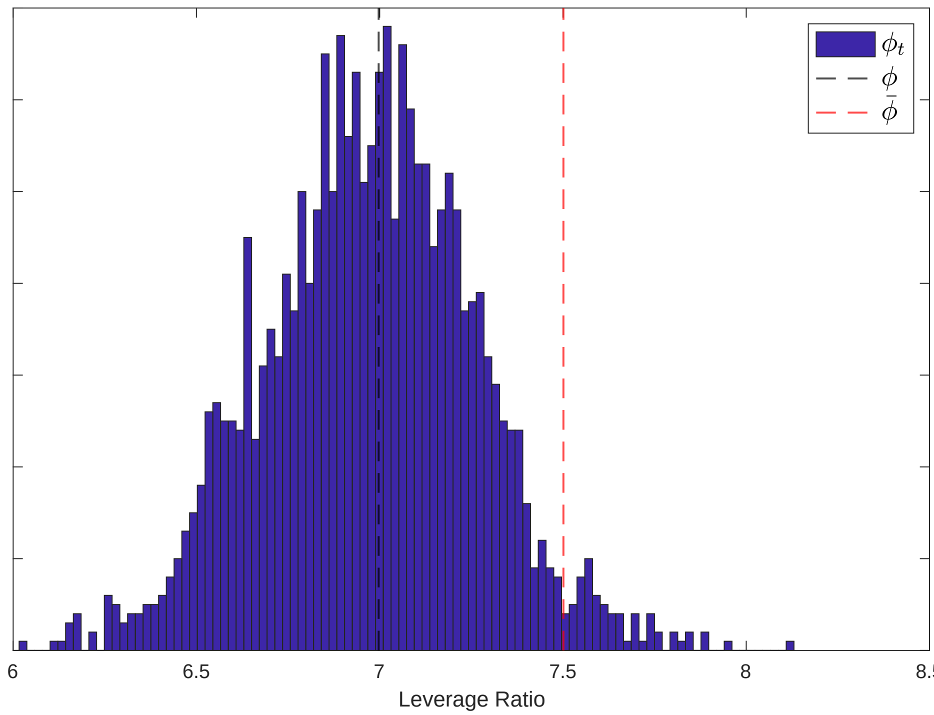


Figure plots the distribution of leverage from a baseline simulation (using the estimated value of $\phi_E = 2.127$) with 2000 periods.

deviations from a 'slack regime' and a return back to it from a 'binding regime'. OccBin is not unique in this regard, Eggertsson and Woodford (2003), Christiano, Eichenbaum, and Trabandt (2015), Kulish, Morley, and Robinson (2017), and Holden (2019) are also based on the EPFP methodology. But there are many shortcomings with this approach, as described in Faria and Neves (2020) and Aruoba et al. (2021) in the context of DSGE model estimation. Arguably, the biggest criticism levelled against OccBin and other similar algorithms is its inability to capture precautionary savings behaviour of agents in the economy.[27]

27. There are other criticisms of OccBin and EPFP methods. For example, Harrison (2020) notes that OccBin is ill-suited for optimal policy analysis and implementation in large-scale DSGE models; Swarbrick (2021) raises concerns over speed and accuracy of OccBin and highlights the advantages of news-shock or time-iteration filters; Böhl (2022) also raises concerns about OccBin's performance for large and frequently-binding

FIGURE 7. Leverage distribution with Cubature (precautionary savings)

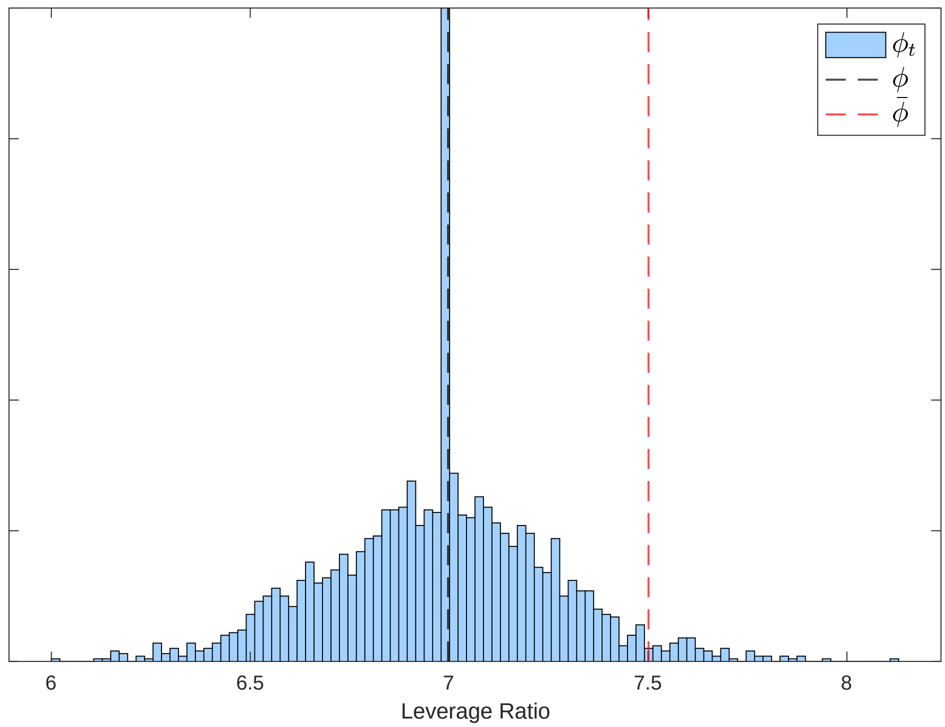


Figure plots the distribution of leverage from a baseline simulation (using the estimated value of $\phi_E = 2.127$) with 2000 periods.

Figure 6 plots the distribution of leverage from the baseline simulation. The sample has a mean of 6.97, slightly below the steady state value of 7 and a steady state value of the leverage upper bound of $\bar{\phi} = 7.5$ shown by the vertical dashed black and red lines, respectively. A test for normality shows that we cannot reject the hypothesis that the distribution is normal. Simply put, agents in the model currently do not show any precautionary behaviour.

To address this shortcoming, I re-run these simulations but this time by implementing the "news shocks approach" in the DynareOBC toolkit by Holden (2019). This approach employs a local approximation method but introduces news shocks that activate whenever a constraint is violated, pushing relevant variables back to satisfy the constraint. The

constraints; and Ascari and Mavroeidis (2022) and Böhl and Strobel (2023) highlight issues of solution multiplicity. These are all valid concerns, but are not the focus of this paper.

TABLE 5. Frequency of financial crises under alternative exchange rate regimes

		Frequency of crisis (%)	
Regime	ϕ_E	OccBin (No Prec. Savings)	DynareOBC (Prec. Savings)
Baseline	2.127	4.2	3.82
Float	0	1.75	1.68
Fixed	100	10.55	7.23

core innovation lies in how these "shadow shocks" are constructed to be consistent with rational expectations, effectively treating them as if they were anticipated by agents along a perfect-foresight path. At each point in time, the algorithm solves a mixed-integer linear complementarity problem (LCP) to determine whether constraints are binding, the magnitude of the news shocks required to enforce the constraint, and the associated shadow values.

Crucially, DynareOBC can capture precautionary savings through its 'Cubature' option. While first-order solutions typically ignore the risk of future constraints binding, the cubature method integrates over future uncertainty using numerical integration methods. Instead of assuming agents are surprised by the bounds, this method essentially computes conditional perfect foresight paths for each possible realisation of shocks. Agents thus form expectations knowing that future bounds might bind depending on future shocks and optimal policy responses. When combined with approximations around the risky steady state (rather than the deterministic steady state) and higher-order perturbations, this allows the model to generate precautionary behaviour where agents accumulate buffers against the risk of hitting constraints. While this remains an approximation compared to fully global solution methods, it offers a computational advantage while still qualitatively capturing the key precautionary motives absent in the standard OccBin implementations.

With DynareOBC and cubature, I again plot the distribution of leverage in Figure 7. Upon visual inspection, we can see that the disitrbution is much more concentrated about the mean and steady state of the leverage ratio. Indeed, running a test for this normality, this we can reject the hypothesis that the distribution is normally distributed. For the baseline foreign exchange rate policy based on the estimated value of $\phi_E = 2.127$, the frequency of financial crises decreases from 4.2% to 3.82% for the same 2,000 period simulation: a clear sign of precautionary savings behaviour. Adjusting the central bank's exchange rate policy parameter, I find that with precautionary savings the frequency of financial crises decreases to 1.68% for a floating exchange rate policy and to 7.23% for a fixed exchange rate policy. These results are summarised in Table 5.

6. Conclusion

This paper explored the debate on the Mundellian Trilemma versus the Dilemma, put forward most notably by Rey and Obstfeld, using a small open economy New Keynesian model estimated to Korean and US data. The research addressed three main questions: How do global financial cycles originating from the US affect a small open economy like Korea? How effective is monetary policy in a financially integrated world? And to what extent can exchange rate regimes buffer the domestic economy from foreign financial shocks?

To answer these questions, I first provided empirical evidence showing that the Korean economy is significantly affected by the global financial cycle emanating from US monetary policy shocks. An increase in US interest rates leads to a contraction in Korean GDP despite a sharp depreciation of the Korean Won, suggesting that the export channel—a key stabiliser in the conventional Mundellian framework—is insufficient to fully offset the shock.

To explain this mechanism, I developed a DSGE model featuring a banking sector that intermediates equity investment funded by both domestic and foreign deposits. The model captures the transmission of global financial shocks through bank balance sheets and asset prices. Taking the model to the data, I found that it successfully replicates the empirical spillover effects, highlighting the role of US monetary policy in driving Korean macroeconomic conditions.

Using the estimated model, I conducted counterfactual policy exercises. A key finding is that the Mundellian Trilemma remains relevant: floating exchange rates outperform fixed exchange rates in buffering the economy from foreign shocks. Under a float, the initial financial impact of a foreign rate hike is significantly muted, and the economy returns to equilibrium faster than under a peg. Furthermore, by analysing the frequency of financial crises, I showed that a floating exchange rate reduces the probability of crisis episodes compared to a fixed regime. Importantly, accounting for agents' precautionary savings behaviour via the "news shock approach" reveals that the actual risk of crises is lower than what standard linear approximations might suggest.

These findings suggest that while EME policymakers should still prefer floating exchange rates, they may need to complement this choice with macroprudential tools to more fully insulate their economies from global financial shocks.

Several avenues for future research remain. First, while I addressed the non-linearity of occasionally binding constraints, I did not incorporate the effective lower bound on interest rates. Second, the model abstracts from unconventional monetary policy and foreign exchange interventions, which Blanchard et al. (2016) suggest could preserve the Trilemma without the need for capital controls. Finally, future work could explicitly analyse the welfare implications of macroprudential tools, such as taxes on foreign debt, to see if they can further restore monetary policy independence in a financially integrated world.

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A. Model equations and solutions

A.1. Household optimisation problem

With GHH+ preferences from Auclert, Bardóczy, and Rognlie (2023), define $\Gamma_t \equiv C_t - \frac{\chi\varphi_0}{1+\varphi} L_t^{1+\varphi}$ as the argument of the utility function. The FOCs for labour and deposits which emerge from the representative household problem are:

$$
\begin{aligned}
w_t &= \chi\varphi_0 L_t^{\varphi} + (1-\chi)\varphi_0 L_t^{\varphi}\Gamma_t^{\sigma}, \qquad \text{(A.1)}\\
RR_{t+1}^{d} &= \frac{1}{\Lambda_{t,t+1}},
\end{aligned}
$$

where $\Lambda_{t,t+1}$ is the stochastic discount factor of the household and is defined as

$$
\Lambda_{t,t+1} = \beta\,\mathbb{E}_t\left[\frac{\xi_{t+1}^{h}}{\xi_t^{h}}\left(\frac{\Gamma_t}{\Gamma_{t+1}}\right)^{\sigma}\right].
$$

A.2. Firms and production

Final good firms' problem. The problem of a final good firm is:

$$
\max_{Y_{i,t}} P_t Y_t - \int_0^1 P_t Y_{i,t}\, di.
$$

Thus, as in Blanchard and Kiyotaki (1987), following the FOC of the final good firm problem, intermediate good producers face a downward sloping demand curve for their products:

$$
Y_{i,t} = \left[\frac{P_{i,t}}{P_t}\right]^{-\eta} Y_t,
$$

where $P_{i,t}$ is the price for good i, and P_t is the price index for the aggregate economy and is defined as:

$$
P_t = \left(\int_0^1 P_{i,t}^{1-\eta}\, di\right)^{\frac{1}{1-\eta}}.
$$

Intermediate good firms' problem. The cost minimisation problem for each intermediate good producer is:

$$\min_{K_{i,t-1},M_{i,t},L_{i,t}} z_t^k K_{i,t-1} + \mathcal{E}_t M_{i,t} + w_t L_{i,t},$$

subject to:

$$A_t \left(\frac{K_{i,t-1}}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_{i,t}}{\alpha_M}\right)^{\alpha_M} \left(\frac{\xi_t^L L_{i,t}}{\alpha_L}\right)^{\alpha_L} \geq Y_{i,t} = \left(\frac{P_{i,t}}{P_t}\right)^{-\eta} Y_t.$$

The Lagrangian for intermediate firm i's problem is:

$$\mathcal{L} = z_t^k K_{i,t-1} + \mathcal{E}_t M_{i,t} + w_t L_{i,t} - MC_{i,t}\left[Y_{i,t} - \left(\frac{P_{i,t}}{P_t}\right)^{-\eta} Y_t\right]$$

The FOCs to this problem are:

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial K_{i,t-1}} : z_t^k &= MC_{i,t} A_t \left(\frac{K_{i,t-1}}{\alpha_K}\right)^{\alpha_K - 1} \left(\frac{M_{i,t}}{\alpha_M}\right)^{\alpha_M} \left(\frac{\xi_t^L L_{i,t}}{\alpha_L}\right)^{\alpha_L}, \\
\frac{\partial \mathcal{L}}{\partial M_{i,t}} : \mathcal{E}_t &= MC_{i,t} A_t \left(\frac{K_{i,t-1}}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_{i,t}}{\alpha_M}\right)^{\alpha_M - 1} \left(\frac{\xi_t^L L_{i,t}}{\alpha_L}\right)^{\alpha_L}, \\
\frac{\partial \mathcal{L}}{\partial L_{i,t}} : w_t &= MC_{i,t} \xi_t^L A_t \left(\frac{K_{i,t-1}}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_{i,t}}{\alpha_M}\right)^{\alpha_M} \left(\frac{\xi_t^L L_{i,t}}{\alpha_L}\right)^{-\alpha_K - \alpha_M}.
\end{aligned}$$

Following Rotemberg (1982) pricing, intermediate firms also face the following profit maximisation problem:

$$\max_{P_{i,t}} \mathbb{V}_{i,t}^I = \mathbb{E}_t \sum_{s=0}^{\infty} \Lambda_{t,t+s} \left[\left(\frac{P_{i,t+s}}{P_{t+s}} - MC_{t+s}\right) Y_{i,t+s} - \frac{\kappa}{2}\left(\frac{P_{i,t+s}}{P_{i,t-1+s}} - 1\right)^2 Y_{t+s}\right],$$

by optimally choosing $P_{i,t}$. Differentiating $\mathbb{V}_t^I$ with respect to $P_{i,t}$ yields the following FOC:

$$\frac{\mathbb{V}_{i,t}^I}{\partial P_{i,t}} : \kappa \left(\frac{P_{i,t}}{P_{i,t-1}} - 1\right) \frac{Y_t}{P_{i,t-1}} = \frac{1}{P_t}\left(\frac{P_{i,t}}{P_t}\right)^{-\eta} - \eta \left(\frac{P_{i,t}}{P_t} - MC_t\right)\left(\frac{P_{i,t}}{P_t}\right)^{-\eta - 1} \frac{Y_t}{P_t}$$

$$+\kappa\,\mathbb{E}_t\left[\Lambda_{t,t+1}\left(\frac{P_{i,t+1}}{P_{i,t}}-1\right)Y_{t+1}\frac{P_{i,t+1}}{P_{i,t}^2}\right].$$

As all firms engage in identical pricing, this gives Equation (10) in the text.

The New Keynesian Phillips Curve. If we log linearise (10) about the non-inflationary steady state, one can yield the standard NKPC. To show this, totally differentiate (10):

$$(2\pi-1)d\pi_t=\frac{\eta-1}{\kappa}dMC_t+\frac{(\eta-1)MC}{\kappa}d\mathcal{M}_t+\beta(2\pi-1)\,\mathbb{E}_t\,d\pi_{t+1},$$

multiply and divide by the relevant quantities using their steady state properties to yield

$$\hat{\pi}_t=\frac{\eta-1}{\kappa}\hat{MC}_t+\beta\,\mathbb{E}_t\,\hat{\pi}_{t+1}+u_t,$$

where $u_t=\frac{\eta-1}{\kappa}\hat{\mathcal{M}}_t$ is a cost-push shock. This representation of the NKPC is identical to the NKPC following pricing à la Calvo (1983) if

$$\kappa=\frac{(\eta-1)\omega}{(1-\omega)(1-\beta\omega)}.$$

κ is calibrated by selecting ω, where $1-\omega$ represents the probability that an intermediate firm is able to adjust its price during a certain period.

A.3. Rewriting and solving the banker's problem

Start with a banker's balance sheet

$$Q_tK_{j,t}+B_{j,t}=D_{j,t}+\mathcal{E}_tD^*_{j,t}+N_{j,t}, \tag{A.2}$$

and the flow of funds constraint

$$N_{j,t}=R^k_tQ_{t-1}K_{j,t-1}+RR_tB_{j,t-1}-RR^d_tD_{j,t-1}-\mathcal{E}_tRR^*_tD^*_{j,t-1}. \tag{A.3}$$

With the constraints of the banker established, one can proceed to write the banker's problem as:

$$\mathbb{V}^b_{j,t} = \max_{\left\{K_{j,t}, B_{j,t}, D_{j,t}, D^*_{j,t}\right\}} \left\{\mathbb{E}_t\, \Lambda_{t,t+1} \left[(1-\sigma_b)N_{j,t+1} + \sigma_b \mathbb{V}^b_{j,t+1}\right] + \zeta_t B_{j,t}\right\}, \tag{A.4}$$

subject to the incentive constraint and the balance sheet constraint. But since the objective, balance sheet, and incentive compatibility constraint are all constant returns to scale, (A.4) can be written as

$$\mathbb{V}^b_{j,t} = \mathbb{E}_t \sum_{s=0}^{\infty} \sigma_b^s \left[\Lambda_{t,t+1+s}(1-\sigma_b)N_{j,t+1+s} + \Lambda_{t,t+s}\zeta_{t+s}B_{j,t+s}\right],$$

which can also be interpreted as a bank's market value. If we divide $\mathbb{V}^b_{j,t}$ by the bank's net worth we obtain a Tobin's Q ratio for the bank denoted by $\psi_{j,t}$:

$$\psi_{j,t} \equiv \frac{\mathbb{V}^b_{j,t}}{N_{j,t}} = \mathbb{E}_t\, \Lambda_{t,t+1}\left(1-\sigma_b+\sigma_b\psi_{j,t+1}\right)\frac{N_{j,t+1}}{N_{j,t}} + \zeta_t \frac{B_{j,t}}{N_{j,t}}. \tag{A.5}$$

Iterate (A.3) forward by one period and then divide through by $N_{j,t}$:

$$\frac{N_{j,t+1}}{N_{j,t}} = R^k_{t+1}\frac{Q_t K_{j,t}}{N_{j,t}} + RR_{t+1}\frac{B_{j,t}}{N_{j,t}} - RR^d_{t+1}\frac{D_{j,t}}{N_{j,t}} - RR^*_{t+1}\mathcal{E}_{t+1}\frac{D^*_{j,t}}{N_{j,t}}.$$

Then, divide the balance sheet (A.2) by $N_{j,t}$ and substitute it into the above expression to get:

$$\frac{N_{j,t+1}}{N_{j,t}} = \frac{R^k_{t+1}Q_t K_{j,t} + RR_{t+1}B_{j,t}}{N_{j,t}} - RR^d_{t+1}\left[(1-x_{j,t})\phi_{j,t}-1\right] - RR^*_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}x_{j,t}\phi_{j,t},$$

using the definitions of $\phi_{j,t}$ and $x_{j,t}$. Then do some manipulation to the first term on the

RHS:

$$\begin{aligned}
\frac{R^k_{t+1} Q_t K_{j,t} + RR_{t+1} B_{j,t}}{N_{j,t}} &= \frac{R^k_{t+1} Q_t K_{j,t} + RR_{t+1} B_{j,t} + RR_{t+1} Q_t K_{j,t} - RR_{t+1} Q_t K_{j,t}}{N_{j,t}} \\
&= RR_{t+1}\phi_{j,t} + \frac{R^k_{t+1} Q_t K_{j,t} - RR_{t+1} Q_t K_{j,t}}{N_{j,t}} \\
&= RR_{t+1}\phi_{j,t} + \left(R^k_{t+1} - RR_{t+1}\right)\frac{Q_t K_{j,t}}{N_{j,t}} \\
&= RR_{t+1}\phi_{j,t} + \left(R^k_{t+1} - RR_{t+1}\right)\frac{(Q_t K_{j,t} + B_{j,t} - B_{j,t})}{N_{j,t}} \\
&= RR_{t+1}\phi_{j,t} + \left(R^k_{t+1} - RR_{t+1}\right)\phi_{j,t} - \left(R^k_{t+1} - RR_{t+1}\right)\frac{B_{j,t}}{N_{j,t}}, \\
&= R^k_{t+1}\phi_{j,t} - \left(R^k_{t+1} - RR_{t+1}\right)x^b_{j,t}\phi_{j,t},
\end{aligned}$$

where in the last line we used the definition of $x^b_{j,t}$. So, $N_{j,t+1}/N_{j,t}$ can be written as:

$$\begin{aligned}
\frac{N_{j,t+1}}{N_{j,t}} = R^k_{t+1}\phi_{j,t} + RR^d_{t+1} - RR^d_{t+1}\left(1 - x_{j,t}\right)\phi_{j,t} \\
- \left(R^k_{t+1} - RR_{t+1}\right)x^b_{j,t}\phi_{j,t} - RR^*_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}x_{j,t}\phi_{j,t}.
\end{aligned}$$

To keep the notation compact, we can drop bank-specific notation since all banks behave identically, then substitute N_{t+1}/N_t into (A.5) and use $\Omega_{t,t+1} = \Lambda_{t,t+1}(1 - \sigma_b + \sigma_b\psi_{t+1})$ to write:

$$\psi_t = \mathbb{E}_t\,\Omega_{t,t+1}\begin{bmatrix} R^k_{t+1}\phi_t + RR^d_{t+1} - RR^d_{t+1}\left(1 - x_t\right)\phi_t \\ -\left(R^k_{t+1} - RR_{t+1}\right)x^b_t\phi_t - RR^*_{t+1}\frac{\mathcal{E}_{t+1}}{\mathcal{E}_t}x_t\phi_t \end{bmatrix} + \zeta_t x^b_t\phi_t.$$

Add and subtract $RR^d_{t+1}x^b_t\phi_t$ in the square brackets of the above expression, and then use the definitions of μ_t, μ^b, μ^*_t, and υ_t to write the banker's problem as:

$$\psi_t = \max_{\phi_t, x_t, x^b_t}\left[\mu_t\left(1 - x^b_t\right) + \left(\mu^b_t + \zeta_t\right)x^b_t + \mu^*_t x_t\right]\phi_t + \upsilon_t,$$

subject to

$$\psi_t \geq \Theta(x_t, x_t^b)\phi_t,$$

which is (3) and (4) in the text.

We can write the Lagrangian for a bank's problem as:

$$\mathcal{L} = (1 + \lambda_t)\psi_t - \lambda_t \Theta(x_t, x_t^b)\phi_t,$$

where λ_t is the Lagrangian multiplier, and we have the complementary slackness condition:

$$\lambda_t \left[\psi_t - \Theta(x_t, x_t^b)\phi_t\right] = 0.$$

Differentiating the Lagrangian with respect to λ_t yields

$$\frac{\partial \mathcal{L}}{\partial \lambda_t} = \psi_t - \Theta(x_t, x_t^b)\phi_t \geq 0,$$

and substituting this back into the banker's objective function yields the banker's maximum leverage ratio

$$\bar{\phi}_t = \frac{v_t}{\Theta(x_t, x_t^b) - \left[\mu_t \left(1 - x_t^b\right) + \left(\mu_t^b + \zeta_t\right) x_t^b + \mu_t^* x_t\right]}.$$

Taking the FOC of the Lagrangian with respect to ϕ_t gives

$$\frac{\lambda_t}{1 + \lambda_t}\Theta(x_t, x_t^b) = \mu_t \left(1 - x_t^b\right) + \left(\mu_t^b + \zeta_t\right) x_t^b + \mu_t^* x_t \equiv \tilde{\mu}_t. \tag{A.6}$$

The FOC with respect to x_t is:

$$\mu_t^* = \frac{\lambda_t}{1 + \lambda_t}\Theta'_{x,t}, \tag{A.7}$$

and the FOC with respect to x_t^b is:

$$\begin{aligned} \mu_t^b - \mu_t &= \frac{\lambda_t}{1+\lambda_t}\Theta'_{x^b,t} - \zeta_t \\ \Leftrightarrow \mathbb{E}_t\, \Omega_{t,t+1}\left(RR_{t+1} - R_{t+1}^k\right) &= \frac{\lambda_t}{1+\lambda_t}\Theta'_{x^b,t} - \zeta_t \\ \Leftrightarrow \mathbb{E}_t\, \Omega_{t,t+1}\left(R_{t+1}^k - RR_{t+1}\right) &= \zeta_t - \frac{\lambda_t}{1+\lambda_t}\Theta'_{x^b,t}. \end{aligned} \tag{A.8}$$

With the functional form for $\Theta(\cdot)$, we have: $\Theta'_{x,t} = \theta_0\theta x_t$ and $\Theta'_{x^b,t} = -\theta_0\theta_b x_t^b$. Dividing the two FOCs, (A.6) and (A.7), yields

$$\tilde{\mu}_t = \frac{\Theta(x_t, x_t^b)}{\theta_0\theta x_t}\mu_t^*.$$

Then dividing (A.6) with (A.8) gives:

$$\tilde{\mu}_t = \frac{\Theta(x_t, x_t^b)}{\theta_0\theta_b x_t^b}\left[\mathbb{E}_t\, \Omega_{t,t+1}\left(R_{t+1}^k - RR_{t+1}\right) - \zeta_t\right].$$

B. Steady state

This appendix outlines the non-stochastic steady state of the baseline model economy in which (4) does not bind. As the model abstracts from trend inflation, we can write:

$$\pi = 1 = \pi^*,$$
$$RR^d = \frac{1}{\Lambda} \Rightarrow R^d = \frac{1}{\Lambda},$$
$$\Lambda = \beta,$$

and

$$E = 1,$$
$$\mathcal{E} = 1.$$

Then, from (11) when $I_t = I_{t-1} = I$ we have:

$$Q = 1.$$

As stated in the next, when the ICC is slack, financial intermediation is frictionless and bankers do not extract any excess returns. Thus:

$$\mu = 0,$$
$$\mu^* = 0,$$
$$\mu^b = -\zeta,$$
$$\tilde{\mu} = 0,$$

and by implication,

$$\psi = Q = 1 = \upsilon,$$
$$\Omega = \beta.$$

Since total excess returns are zero in the steady state, we have the standard condition for the return on capital:

$$z^k = \frac{1}{\beta} - (1 - \delta) \Rightarrow R^k = 1/\beta,$$

and so we can write

$$RR = R = R^k - \frac{\zeta}{\beta},$$

along with

$$i = \rho,$$
$$R^* = R^d.$$

Then use (6), (7), (8), and (9) to write:

$$MC = 1 - \frac{1}{\eta} = \frac{r^k}{\alpha_K}\frac{K}{Y},$$

or

$$\frac{K}{Y} = \left(1 - \frac{1}{\eta}\right)\frac{\alpha_K}{r^k}. \tag{B.1}$$

With GHH+ preferences, the labour supply condition (A.1) in steady state is:

$$W = \chi\varphi_0 L^{\varphi} + (1 - \chi)\varphi_0 L^{\varphi}\Gamma^{\sigma}, \tag{B.2}$$

where φ_0 is a labour disutility scale parameter and $\Gamma = C - \frac{\chi\varphi_0}{1+\varphi}L^{1+\varphi}$. Since the labour supply condition depends on C, which itself depends on Y through the resource constraint, we cannot obtain a closed-form solution for output as in the pure GHH case.[28] Instead, we solve for Y numerically using the following procedure.

From (9), we can write:

$$M = \frac{\alpha_M}{\alpha_K}\frac{z^k K}{\mathcal{E}}. \tag{B.3}$$

28. With pure Greenwood, Hercowitz, and Huffman (1988) preferences ($\chi = 1$), the labour supply condition reduces to $W = \varphi_0 L^{\varphi}$, for which a closed-form solution exists. With standard CRRA preferences, the labour supply condition would be $C^{-\sigma} = L^{\varphi}/W$, which also requires numerical methods.

Given a candidate value for Y, compute K from (B.1), then $I = [1 - (1 - \delta)]K$ and M from (B.3). Next, compute L by inverting the production function (7):

$$L = \alpha_L \left[\frac{Y}{A \left(\frac{K}{\alpha_K} \right)^{\alpha_K} \left(\frac{M}{\alpha_M} \right)^{\alpha_M}} \right]^{1/\alpha_L}.$$

Consumption follows from the resource constraint (15) after computing exports and foreign output from the trade balance. The wage can be computed from the capital-labour expenditure ratio (8):

$$W^{\text{factor}} = \frac{\alpha_L}{\alpha_K} \frac{z^k K}{L},$$

and also from the labour supply condition (B.2):

$$W^{\text{FOC}} = \chi \varphi_0 L^{\varphi} + (1 - \chi) \varphi_0 L^{\varphi} \Gamma^{\sigma}.$$

The steady state value of Y is then determined by finding the root of the residual $W^{\text{factor}} - W^{\text{FOC}} = 0$ using Newton's method. This yields Y, and hence K, I, M, L, and W.

From (2), since the steady state value of x^b is calibrated we have:

$$B = \frac{x^b}{1 - x^b} K.$$

Then from (13):

$$\tau = B(R - 1).$$

After dividing through by Y and multiplying by $\mathcal{E}$, we can write the current account relationship (16) in steady state as:

$$\frac{\mathcal{E} D^*}{Y} = \frac{R^* D^*}{Y} + \frac{\mathcal{E} M}{Y} - \frac{EX}{Y}.$$

But from (12) we can write $EX = \mathcal{E}^{\eta_x} Y^*$, from (B.1) and (B.3)

$$\frac{\mathcal{E}M}{Y} = \alpha_M \left(1 - \frac{1}{\eta}\right),$$

and from (17)

$$\frac{\mathcal{E}D^*}{Y} = \frac{x(K+B)}{Y},$$

but recall that $Q = \mathcal{E} = 1$, so we can write:

$$\frac{Y^*}{Y} = \alpha_M \left(1 - \frac{1}{\eta}\right) + (R^* - 1)x\frac{(K+B)}{Y}.$$

This yields Y^*, EX, and D^*. Then, manipulate the aggregate resource constraint (15) in steady state to get C:

$$\begin{aligned} Y &= C + I + EX \\ \Rightarrow C &= Y - [1 - (1-\delta)]K - \mathcal{E}^{\eta_x} Y^*. \end{aligned}$$

Finally, aggregate bank net worth is:

$$N = \frac{1}{1 - \sigma_b R^d} \left\{ \sigma_b \left[R^k K + R \times B - R^d (K + B - D^*) - R^* D^* \right] + \gamma R^k K \right\},$$

and thus aggregate deposits are

$$D = K + B - N - D^*,$$

and leverage is

$$\phi = \frac{K+B}{N}.$$

C. Computational appendix

C.1. Data sources

VAR data sources. Monthly data for VAR model estimation are sourced from:

- US monetary policy shocks: From Jarociński and Karadi (2020).[29]
- US excess bond premium: From Gilchrist and Zakrajšek (2012) and Favara et al. (2016).[30]
- US real GDP. Quarterly data interpolated to monthly data following Miranda-Agrippino and Rey (2020). See DSGE model data sources below.
- US 1-year Treasury Bill rate: Market Yield on U.S. Treasury Securities at 1-Year Constant Maturity, Quoted on an Investment Basis, FRED.
- Korea real GDP. Quarterly data interpolated to monthly data following Miranda-Agrippino and Rey (2020). See DSGE model data sources below.
- Korea inflation: GDP deflator, The Bank of Korea.
- Korea real exports. Quarterly data interpolated to monthly data following Miranda-Agrippino and Rey (2020). See DSGE model data sources below.
- US-Korea nominal exchange rate: Korean Won to U.S. Dollar Spot Exchange Rate (direct quote), retrieved from FRED.
- Korea short-term interest rate: 3-Month or 90-Day Rates and Yields Total for Korea, retrieved from FRED; The Bank of Korea.
- Korea corporate spreads: 3-year bond spread (AA- corporate and government), The Bank of Korea.

DSGE model data sources. Quarterly data for DSGE model estimation are sourced from:

- Domestic Nominal Interest Rate: 90-day yield on deposits, FRED, The Bank of Korea.
- Domestic Inflation: GDP deflator, National Accounts, The Bank of Korea.
- Foreign Inflation: US Gross Domestic Product, Implicit Price Deflator, FRED.
- Foreign Nominal Interest Rate: 12-month Treasury Bill rate, FRED.

29. An updated series of Fed surprise monetary policy shocks is available for download from Marek Jarocinski's website: `https://marekjarocinski.github.io`.

30. An updated series of the US excess bond premium is available for download from the FEDS Note website: `FEDS Note`.

- Domestic GDP: Gross Domestic Product, National Accounts, The Bank of Korea.
- Exports: Exports of goods and services, National Accounts, The Bank of Korea.
- Nominal Exchange Rate: FRED, Statistics Korea.
- Corporate Interest Rate Spread: 3-year spread (AA- corporate and treasury), The Bank of Korea.
- Foreign GDP: US Gross Domestic Product, FRED.

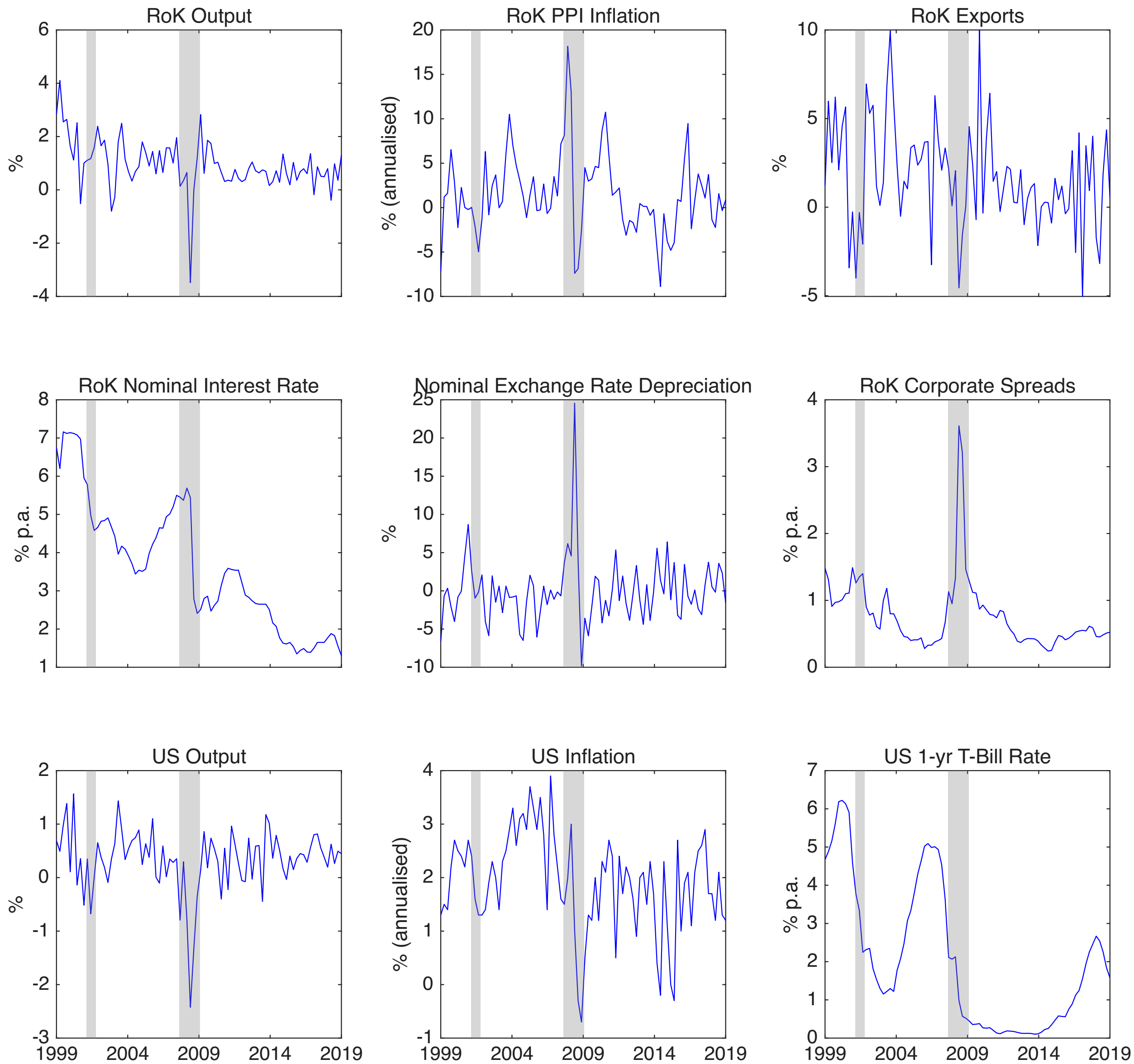

FIGURE 8. Plot of Korean and US time series data used for DSGE estimation (1999Q1-2019Q4)

C.2. Additional estimation results

C.2.1. Prior and posterior distributions

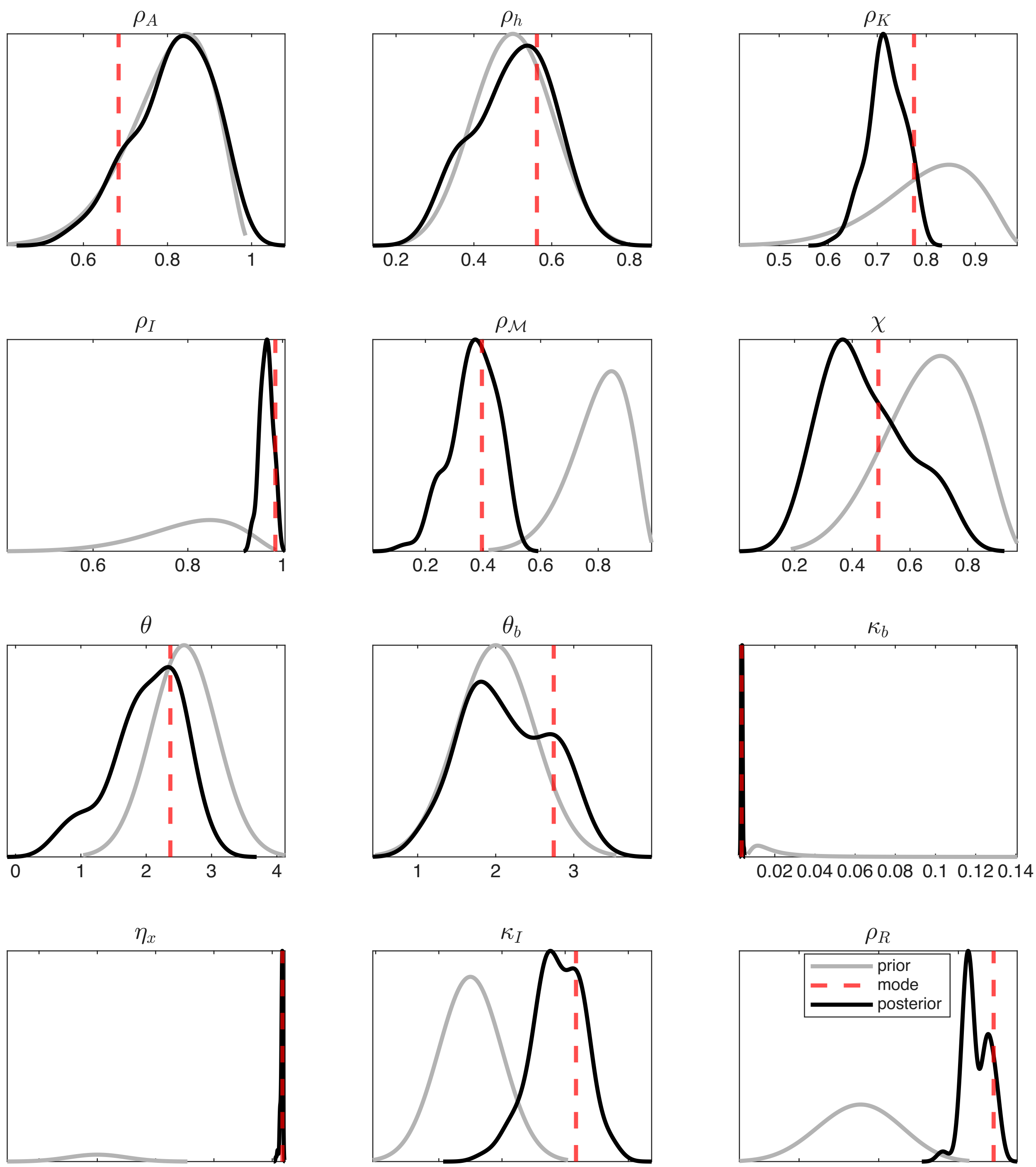

FIGURE 9. Prior and posterior distributions of estimated parameters (1/3)

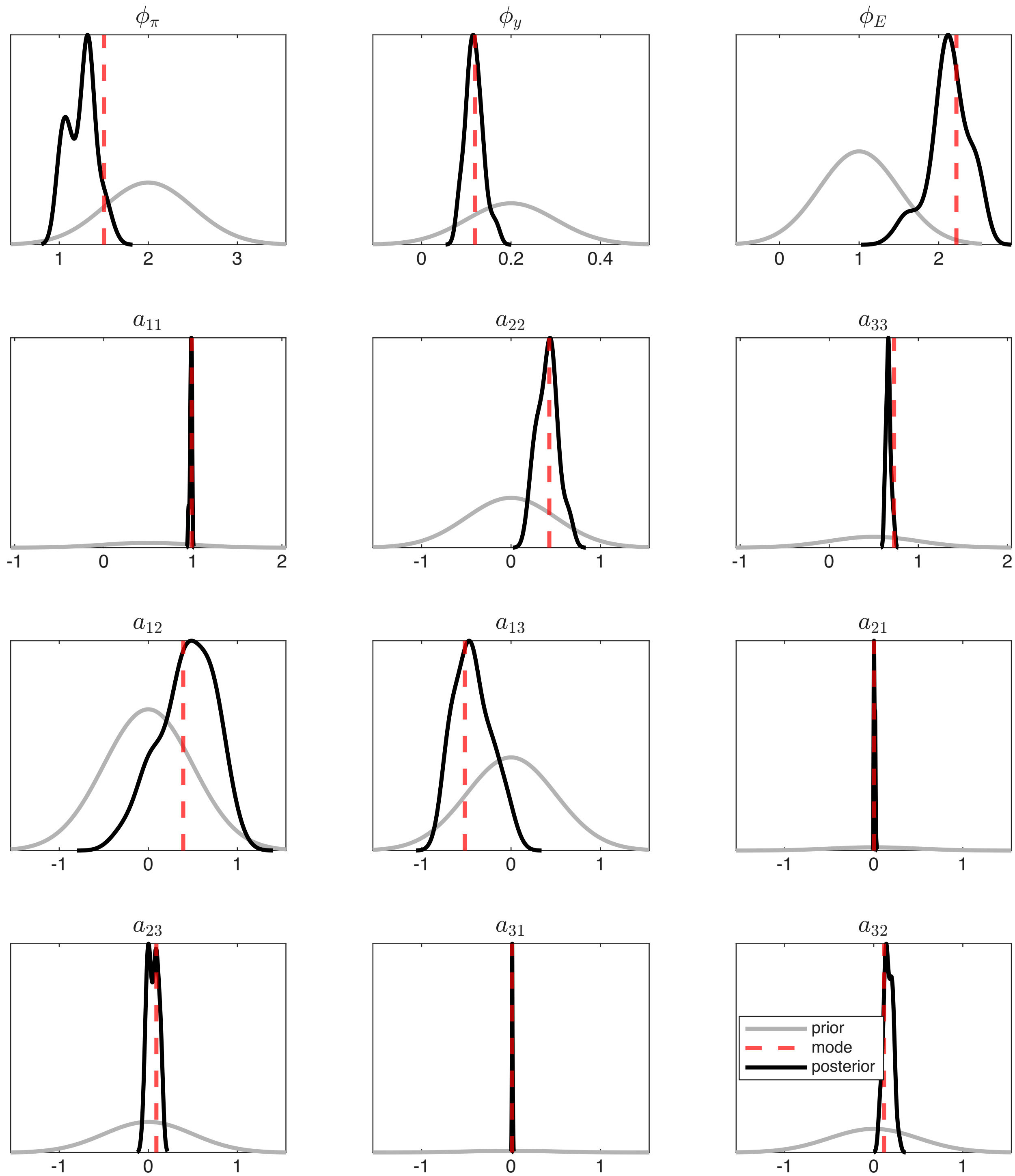

FIGURE 10. Prior and posterior distributions of estimated parameters (2/3)

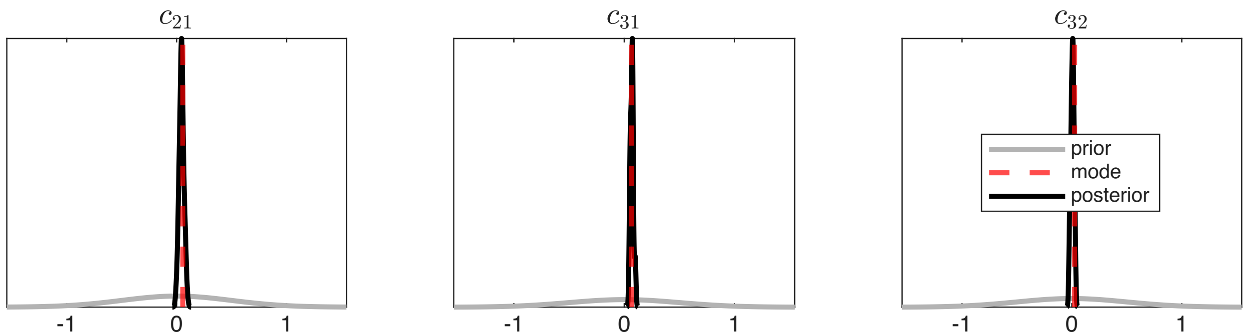

FIGURE 11. Prior and posterior distributions of estimated parameters (3/3)

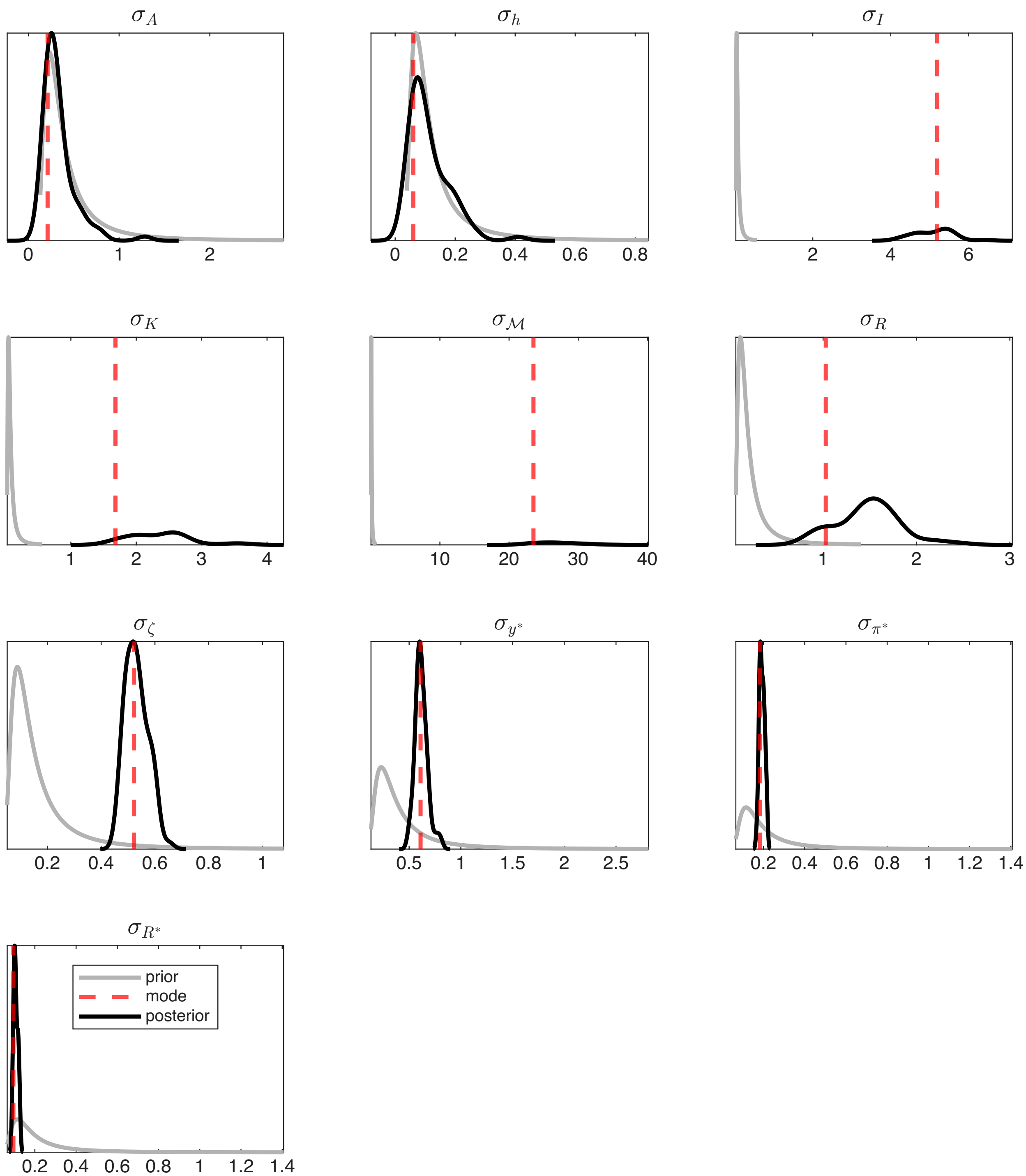

FIGURE 12. Prior and posterior distributions of shock standard deviations

C.2.2. Shock decompositions

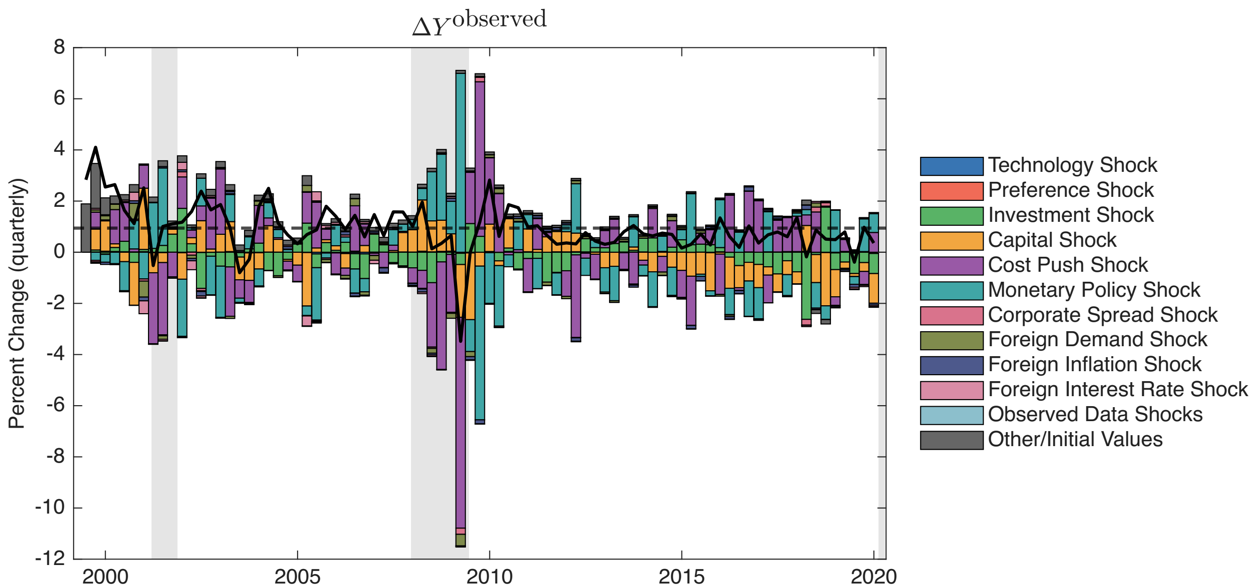

FIGURE 13. Shock decomposition: Korean output growth

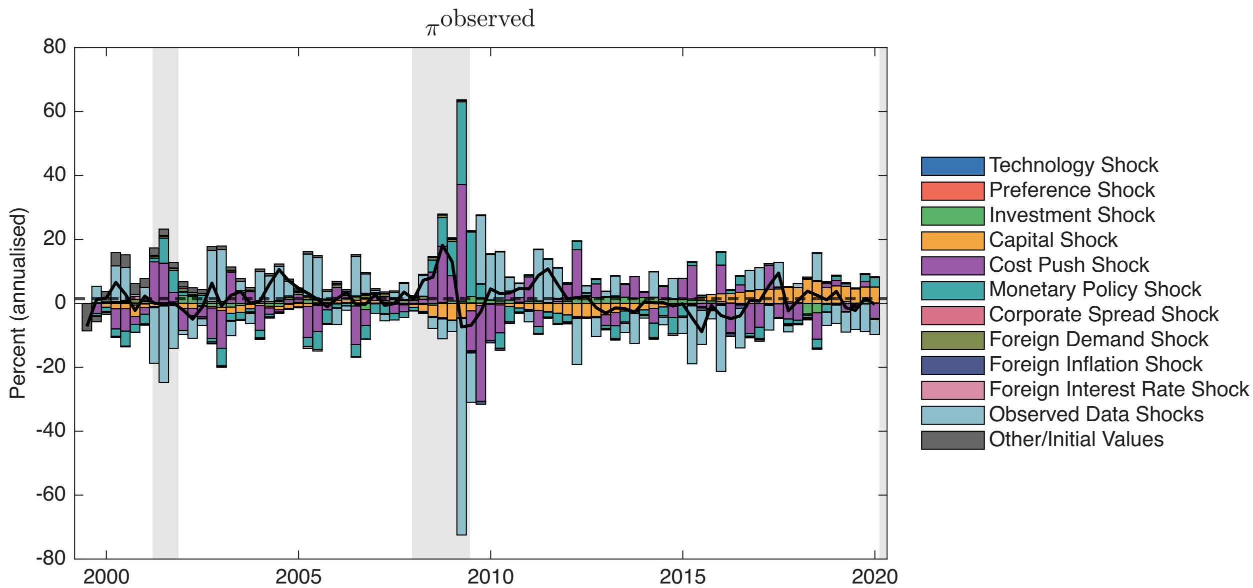

FIGURE 14. Shock decomposition: Korean PPI inflation

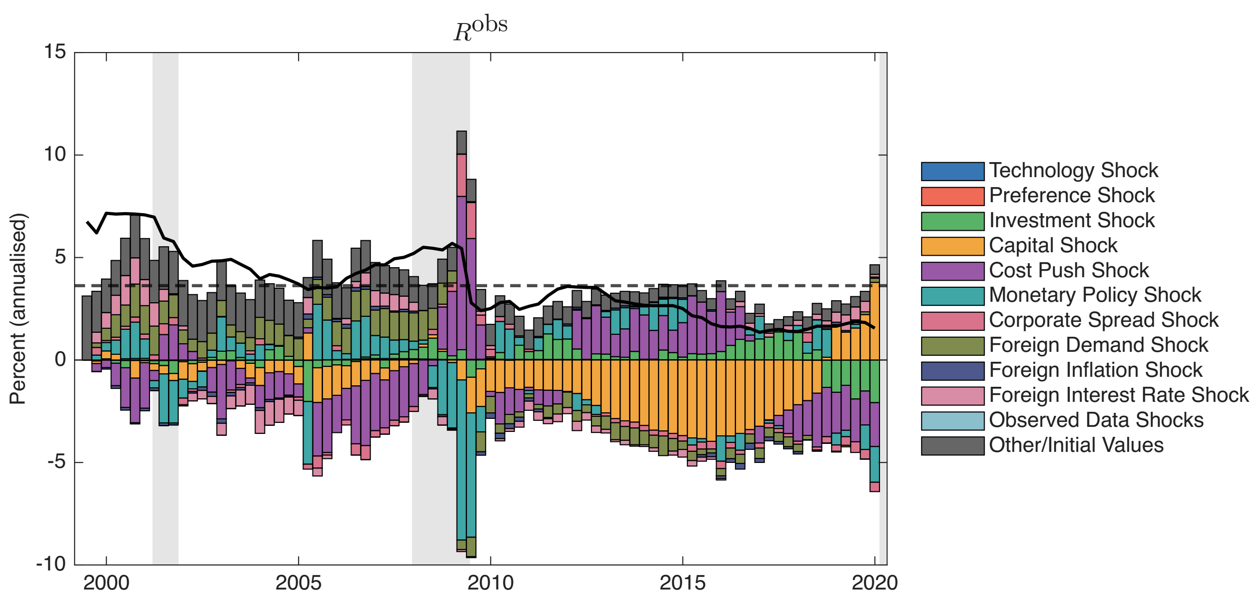

FIGURE 15. Shock decomposition: Korean nominal interest rate

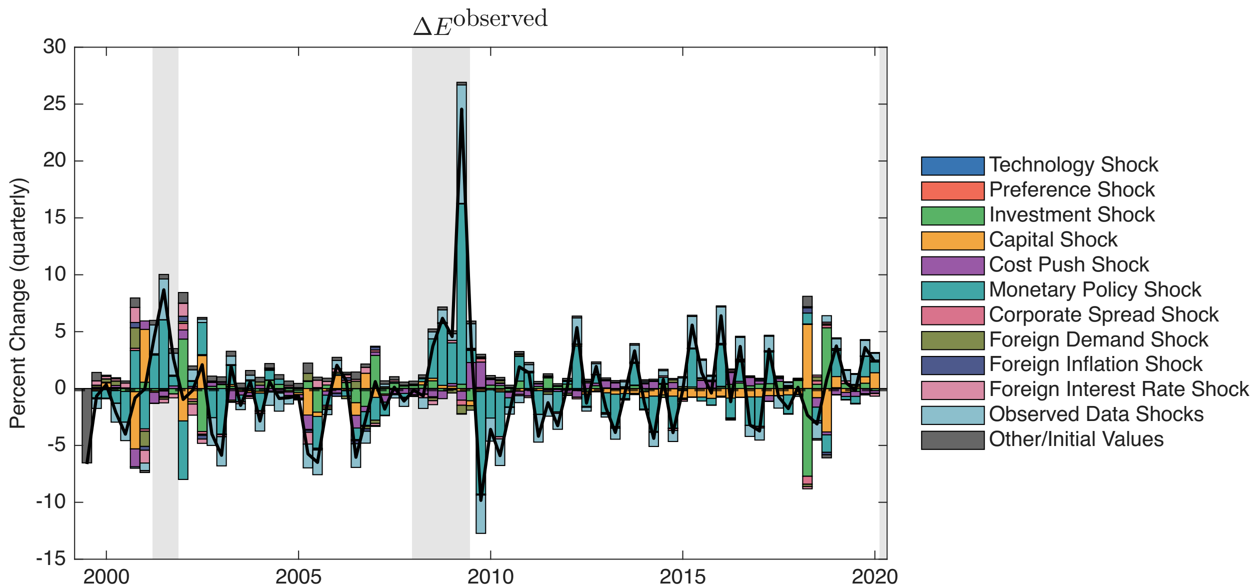

FIGURE 16. Shock decomposition: Nominal exchange rate change

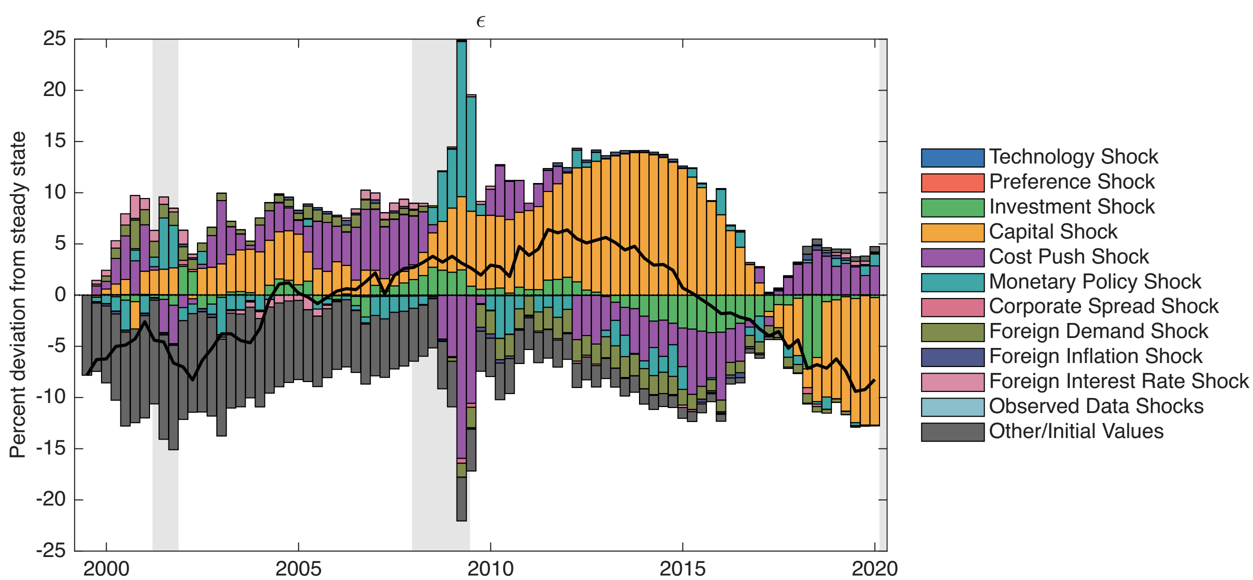

FIGURE 17. Shock decomposition: Real exchange rate

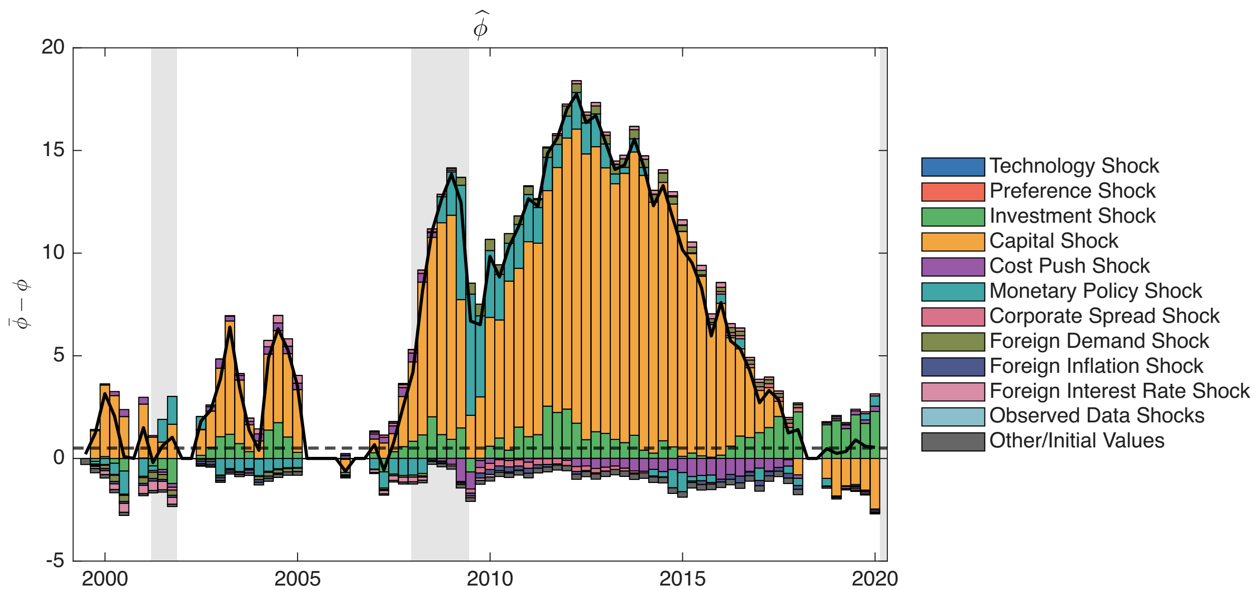

FIGURE 18. Historical shock decomposition: Bank leverage gap ($\hat{\phi} = \bar{\phi} - \phi$)