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, specified with an international banking sector, in order to explore the effectiveness of alternative monetary police regimes to isolate the domestic economy from global financial cycles. Using an increase 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, macroprudential policy, monetary policy

JEL codes: E32, E37, E44, E520.

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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. The most notable of which has been 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 being 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 entails 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. 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

[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); Miranda-Agrippino and Rey (2020).

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), 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 then explore the role of macroprudential tools and their effects on welfare. I find that with taxes on foreign debt, the SOE is generally able to attenuate the effects of a rise in foreign interest rates. This allows the central bank in the SOE to adjust rates by a smaller amount, contributing to greater domestic monetary policy independence. 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),

[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.

[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 spillover 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.

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 contribution of this paper is that it ties the empirical findings of Rey; Kose et al. (2010); Dedola, Rivolta, and Stracca (2017); Iacoviello and Navarro (2019), with theoretical SOE macroeconomic models equipped with international financial markets. My paper is closely related to Aoki, Benigno, and Kiyotaki (2020) (ABK); Akinci and Queraltó (2019) (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 Gertler and Kiyotaki (2010) and Gertler and Karadi (2011b) 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 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

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.

SOE as a commodity exporter, and competitive 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 explores the role of macroprudential policy – taxes on risky assets and foreign debt – to stabilise macroeconomic quantities; while Section 6 concludes the paper.

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, in line with more thorough studies such as by Dedola, Rivolta, and Stracca (2017); Iacoviello and Navarro (2019). 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 ($\Delta \epsilon_t$),[6] RoK 3-month interbank interest rates (i_t), and spreads of RoK 3-year corporate AA- and government bond yields (μ_t).[7] The matrix of endogenous variables for the VAR to be estimated is then given by

$$\boldsymbol{Y} = \begin{bmatrix} \boldsymbol{i}^* & \boldsymbol{EBP}^* & \Delta \boldsymbol{y}^* & \Delta \boldsymbol{y} & \boldsymbol{\pi} & \boldsymbol{ex} & \boldsymbol{\epsilon} & \boldsymbol{i} & \boldsymbol{\mu} \end{bmatrix}, \tag{1}$$

[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).

[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 B.1.

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

$$\boldsymbol{Y}_t = \boldsymbol{\alpha} + \sum_{j=1}^{p} \boldsymbol{Y}_{t-j}\boldsymbol{\Phi}_j + \boldsymbol{U}_t, \quad \boldsymbol{U}_t \sim \mathrm{IID}(\boldsymbol{0}, \boldsymbol{\Sigma}), \tag{2}$$

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 identification 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 95% 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 the sharp 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

[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 lag orders.

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

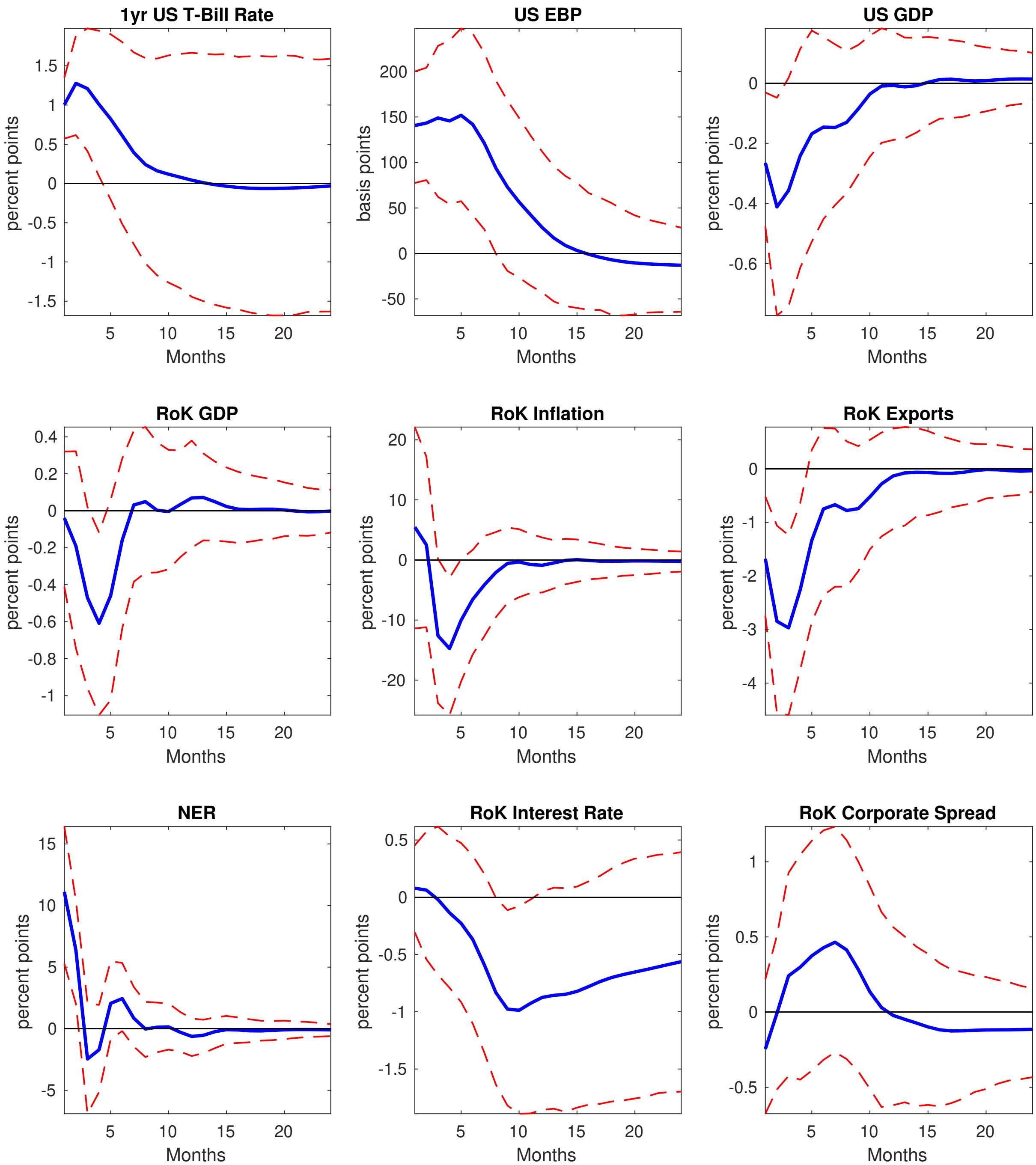


Figure plots impulse responses to a surprise monetary policy contraction of the US 1-year Treasury Bill rate, US external bond premium, US real GDP growth rate, RoK real GDP growth rate, RoK inflation rate, RoK real exports rate, US-RoK nominal exchange rate change (direct quote), RoK nominal short-term 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 dashed red lines are the 95% confidence bands. Responses are scaled so as to get a 1% annual increase in the US short-term nominal interest rate.

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 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); 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 rates – the crux of Rey's Dilemma argument. In the case of Korea here, and the advanced economies in the study of Dedola, Rivolta, and Stracca (2017), contractionary US monetary policy leads to a pronounced decline in 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. 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. The setup is fundamentally based on seminal work in the New Keynesian dynamic stochastic general equilibrium (DSGE) literature such as Clarida, Galí, and Gertler (1999), Christiano, Eichenbaum, and Evans (2005), and Smets and Wouters (2007). 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 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, albeit with foreign exchange risk and some efficiency cost. 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

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

[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.

the influences of financial crises. 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]

3.1. Households

The setup of the representative household is based on Gertler and Kiyotaki (2010) and Gertler and Karadi (2011a). 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, capital/equity holdings in firms, K_t^h, and deposits held at the bank,

[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.
(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. It is noteworthy that both GGN and this paper suggest SOE models that describe sudden stop episodes which are atypical to most of the literature which have occasionally binding constraints (such as in Mendoza (2010)).

D_t,[13] to maximise the present value discounted sum of expected utility[14]

$$\max_{\{C_t, L_t, K_t^h, D_t\}} \mathbb{E}_t \left[\sum_{s=0}^{\infty} \beta^s \exp\left(\xi_{t+s}^h\right) \ln \left(C_{t+s} - \frac{\zeta_0}{1+\zeta} \exp\left(\xi_{t+s}^L\right) L_{t+s}^{1+\zeta} \right) \right],$$

subject to the period budget constraint,

$$C_t + Q_t K_t^h + \chi_t^h + D_t = w_t L_t + \Pi_t^P + (z_t^k + \lambda Q_t) K_{t-1}^h + \frac{R_{t-1}}{\pi_t} D_{t-1} + \tau_t,$$

where Q_t is the equity price in terms of final goods; χ^h are portfolio management costs of the workers in the household; 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; z_t^k is the net rental rate of capital; $R_t = 1 + i_t$ is the gross nominal interest rate; $\pi_t = \frac{P_t}{P_{t-1}}$ is the gross domestic inflation rate, where 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 and ξ_t^L are exogenous household preference and labour shocks, respectively, which follow stationary mean-zero AR(1) processes. The parameters β, ζ_0, ζ, and λ are the household's discount factor, the utility weight on labour supply, the inverse-Frisch elasticity of labour supply, and one minus the depreciation rate of capital, respectively.

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 denote the continuation probability of a

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

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

[14]Greenwood-Hercowitz-Huffman (GHH) preferences remove the income effect from labour supply. They take the form of:

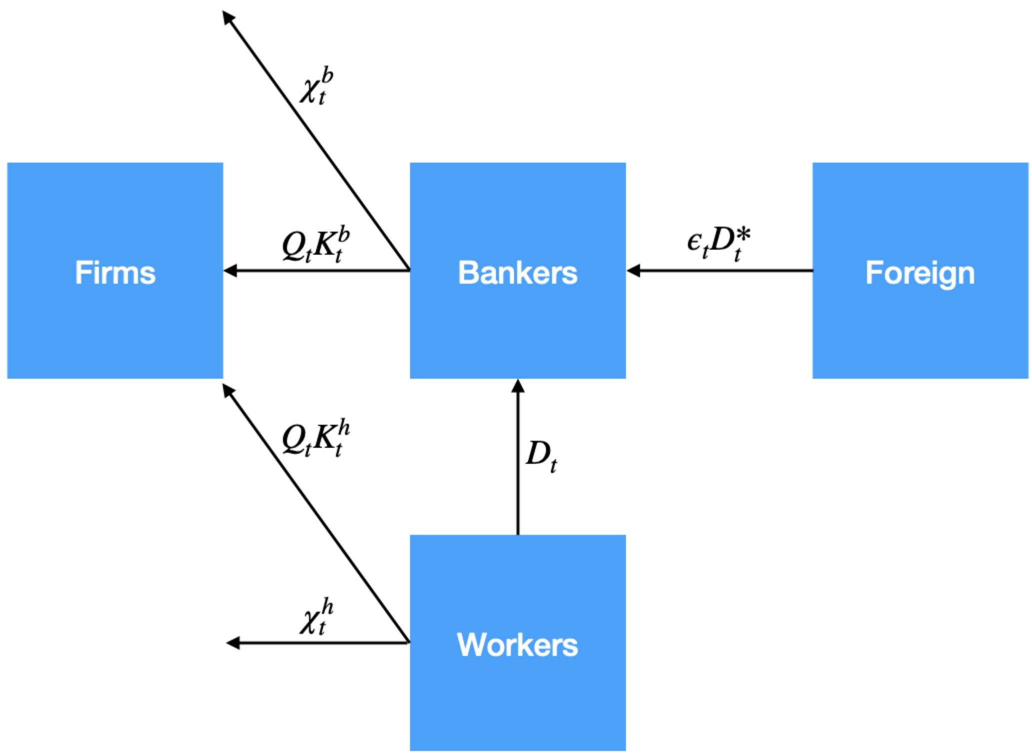
$$u(c, L) = f(c - g(L)).$$

The FOC of $u(c, L)$ with respect to L is:

$$u'(c, L) \left(\frac{dc}{dl} - g'(L) \right) = 0,$$

and since $u'(\cdot) > 0$, this implies that $\frac{dc}{dl} = g'(L)$. Since $\frac{dc}{dl} = w$, we have $w = g'(L)$. In other words, the higher the wage, the more the household chooses to supply labour. This form of utility is often used to capture the procyclicality of employment in formal sectors, essentially capturing a "make hay while the sun shines" effect.

FIGURE 2. Graphical illustration of the model



banker remaining in employment through to the next period, such that they may retire with probability $1-\sigma$ 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. A retiring banker transfers their franchise value – or remaining net worth – as a dividend to the household, and new bankers receive fraction γ of total assets from the household as initial funds.

As mentioned, workers can directly purchase equity in domestic firms, but with an efficiency cost – relative to a banker purchasing equity – given by the following expression:

$$\chi_t^h = \frac{\varkappa^h}{2}\left(\frac{K_t^h}{K_t}\right)^2 K_t,$$

where K_t is the aggregate capital stock and where the parameter $\varkappa^h$ is an efficiency cost of the household's workers financing firms. Workers can also save their earnings in form of bank deposits, which are nominal, short term, and non-contingent, and earn a nominal return of R_t.

Workers cannot access foreign savings directly, and foreign households cannot directly hold domestic capital. All interactions between domestic equity markets and foreign households 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 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 $Q_t k_t^b$, funded by domestic deposits, d_t, foreign deposits, $\epsilon_t d_t^*$, and their own net worth, n_t. However, financial frictions may limit the ability of the banker to raise deposits from households.

To maintain model tractability, in each period, bankers have a fixed probability of moving in and out of the financial sector. Let σ denote the probability that a banker remains as a banker in the following period, with complementary probability $1 - \sigma$ that they retire. This implies an expected franchise life of an individual bank of $\frac{1}{1-\sigma}$. Furthermore, the number of bankers exiting the financial market is matched by the number of new bankers entering.

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, $\mathbb{V}_t^b$, which is the expected present discount value of future dividends:

$$\mathbb{V}_t^b = \mathbb{E}_t \left[\sum_{s=1}^{\infty} \Lambda_{t,t+s} \sigma^{s-1} (1 - \sigma) n_{t+s} \right],$$

by choosing quantities k_t^b, d_t, and d_t^*.

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

$$\epsilon_t = \frac{E_t P_t^*}{P_t},$$

where E_t is the nominal exchange rate defined as the quantity of domestic currency units per one unit of foreign currency.[15] While bankers can invest in domestic firms costlessly – unlike workers – they incur an efficiency cost from taking in deposits from foreign households, defined by the following expression:

$$\chi_t^b = \frac{\varkappa^b}{2} x_t^2 Q_t k_t^b,$$

where $\varkappa^b > 0$ is a foreign borrowing cost parameter.[16] x_t is the fraction of a banker's assets financed by foreign borrowing and is defined as:

$$x_t = \frac{\epsilon_t d_t^*}{Q_t k_t^b}. \tag{3}$$

A financial friction in line with Gertler and Kiyotaki (2010) is used to limit a banker's ability to raise funds, 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 $\theta > 0$ 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 – i.e. it take 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, $\mathbb{V}_t^b$. 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.[17] In other words, the

[15]Thus, an increase (decrease) in ϵ_t and E_t is a domestic currency depreciation (appreciation).

[16]The quadratic adjustment costs, χ_t^h and χ_t^b, can also be thought of as a method to close the model, as explained in Schmitt-Grohé and Uribe (2003).

[17]Consider a simple Gertler and Kiyotaki (2010) 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:

$$\underbrace{R^k(d+n) - Rd}_{\text{Profit from operating honestly}} \quad < \quad \underbrace{\theta R^k(d+n).}_{\text{Absconding payoff}}$$

If the banker wants to abscond, they will set their demand for deposits such that the above inequality bankers face the following incentive constraint:

$$\mathbb{V}_t^b \geq \theta Q_t k_t^b, \tag{4}$$

where I assume that the banker will not abscond in the case of the constraint holding with equality.

3.2.1. Bank balance sheet

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

$$\left(1 + \frac{\varkappa^b}{2} x_t^2\right) Q_t k_t^b = d_t + (1 - \tau_t^{D^*})\epsilon_t d_t^* + (1 + \tau_t^N) n_t, \tag{5}$$

where $\tau_t^{D^*}$ and τ_t^N are macroprudential tools used by the policymaker to tax foreign debt and subsidise bank net worth, respectively.[18] We can write the flow of funds constraint for a banker as

$$n_t = (z_t^k + \lambda Q_t) k_{t-1}^b - \frac{R_{t-1}}{\pi_t} d_{t-1} - \frac{R_{t-1}^*}{\pi_t^*} \epsilon_t d_{t-1}^*, \tag{6}$$

where R_t^* is the foreign gross nominal interest rate and $\pi_t^* = 1 + \pi_t^*$ is foreign gross inflation. 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):

$$n_t = \gamma \left(z_t^k + \lambda Q_t\right) k_{t-1}.$$

Additionally, it is convenient to denote the gross return on equity as

$$R_t^k = \frac{z_t^k + \lambda Q_t}{Q_{t-1}}. \tag{7}$$

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holds, or,

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

[18] For more details of these policy instruments please see Section 3.6.

TABLE 1. Bank balance sheet

Assets	Liabilities + Equity
Loans $Q_t k_t^b$	Deposits d_t
Management costs χ_t^b	Foreign debt $\epsilon_t d_t^*$
	Net worth n_t

3.2.2. Rewriting the banker's problem

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

$$\max_{k_t^b, d_t, d_t^*} \mathbb{V}_t^b = \mathbb{E}_t \Lambda_{t,t+1} \left\{ (1-\sigma) n_{t+1} + \sigma \mathbb{V}_{t+1}^b \right\},$$

subject to the incentive constraint (4) and the balance sheet constraint (5).

Since $\mathbb{V}_t^b$ is the franchise value of the bank, which can be interpreted as a "market value", divide $\mathbb{V}_t^b$ by the bank's net worth to obtain a Tobin's Q ratio for the bank denoted by ψ_t:

$$\psi_t \equiv \frac{\mathbb{V}_t^b}{n_t} = \mathbb{E}_t \Lambda_{t,t+1} (1 - \sigma + \sigma \psi_{t+1}) \frac{n_{t+1}}{n_t}. \tag{8}$$

Define ϕ_t as the maximum feasible asset to net worth ratio, or, rather, the leverage ratio of a bank:

$$\phi_t = \frac{Q_t k_t^b}{n_t}. \tag{9}$$

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_t^* as the cost advantage of foreign debt over home deposits or the deviation from real UIP, and υ_t as the marginal cost of deposits, the banker's problem can then be written as the following:

$$\psi_t = \max_{\phi_t, x_t} \left\{ \mu_t \phi_t + \left(1 + \tau_t^N - \frac{\varkappa^b}{2} x_t^2 \phi_t \right) \upsilon_t + \mu_t^* \phi_t x_t \right\}, \tag{10}$$

subject to

$$\psi_t \geq \theta \phi_t.$$

Solving this problem yields:

$$\psi_t = \theta \phi_t, \tag{11}$$

$$\phi_t = \frac{(1+\tau_t^N)\upsilon_t}{\theta - \mu_t - \frac{(\mu_t^*)^2}{2\varkappa^b \upsilon_t}}, \tag{12}$$

$$x_t = \frac{\mu_t^*}{\varkappa^b \upsilon_t}, \tag{13}$$

where

$$\mu_t = \mathbb{E}_t \Omega_{t,t+1}\left(R_{t+1}^k - \frac{R_t}{\pi_{t+1}}\right), \tag{14}$$

$$\mu_t^* = \mathbb{E}_t \Omega_{t,t+1}\left[(1-\tau_t^{D^*})\frac{R_t}{\pi_{t+1}} - \frac{\epsilon_{t+1}}{\epsilon_t}\frac{R_t^*}{\pi_{t+1}^*}\right], \tag{15}$$

$$\upsilon_t = \mathbb{E}_t \Omega_{t,t+1}\frac{R_t}{\pi_{t+1}}, \tag{16}$$

$$\Omega_{t,t+1} = \Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1}). \tag{17}$$

For further explanation of the banker's problem and a complete solution, please see Appendix A.3.

3.3. Theory of UIP failure

Before proceeding, it is worth exploring the model's theory for the failure of the UIP condition. The banker faces a cost for raising deposit funds from foreigners, and so they have a natural home-bias to raise funds from domestic workers. For $\theta > 0$, the incentive constraint becomes increasingly binding for bankers as they increase funding from domestic deposits – and recall that creditors are assumed to act rationally. But the increased demand, or home-preference, for domestic deposits drives up the interest rate paid out on domestic-currency denominated deposits, R, relative to the foreign interest rate, R^*, leading to a failure of UIP as $R - R^* > 0$, when adjusted for the expected depreciation of the domestic currency. But in this model, the banks – nor foreign creditors – cannot exploit the failure of UIP, as an increase in x_t would lead to an increasingly large rise in foreign borrowing costs for the banker. As such, to account for the failure of UIP, it is assumed that $\mu_t^* > 0$.

Additionally, it is assumed that $\mu_t > 0$. To see why, consider the simple Gertler and Kiyotaki (2010) model with no inflation or foreign savings. The banker chooses deposits, d, to maximise the following:

$$R^k(d+n) - Rd,$$

subject to the no-absconding condition:

$$R^k(d+n) - Rd \geq \theta R^k(d+n).$$

Rearrange this condition to get:

$$d \leq \frac{(1-\theta)R^k}{R-(1-\theta)R^k}n. \tag{18}$$

Suppose that $R = R^k$, then (18) becomes

$$d \leq \frac{1-\theta}{\theta}n,$$

and as the banker makes no profits on deposits, they are indifferent to their choice of d over:

$$0 \leq d \leq \frac{1-\theta}{\theta}n.$$

Now, to motivate the banker's choice of d, it is required that $R < R^k$. Clearly, if this was not the case then $d = 0$. Next, from (18), we require that $R > (1-\theta)R^k$. Thus, we can state:

$$(1-\theta)R^k < R < R^k,$$

and by the banker's objective function, the reader can deduce that the banker will choose d as high as possible subject to the no-absconding constraint. So,

$$d = \frac{(1-\theta)R^k}{R-(1-\theta)R^k}n.$$

3.4. 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 intermediate goods as inputs into production:

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

where $Y_t(i)$, $i \in [0,1]$, 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:

$$Y_t(i) = A_t \left(\frac{K_{t-1}(i)}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_t(i)}{\alpha_M}\right)^{\alpha_M} \left(\frac{A_t^L L_t(i)}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M} - A_t^f c_f(i),$$

where $K_t(i)$, $M_t(i)$, and $L_t(i)$ are capital, imports, and labour inputs into production, respectively, by intermediate good producer i, A_t is a neutral total factor productivity (TFP) process, A_t^L is a labour-augmenting technology, and A_t^f is a fixed cost shock process. The technology shocks are assumed to be stationary AR(1) processes, where unlike Christiano, Trabandt, and Walentin (2011) I abstract from modelling the economy with trend growth. α_K and α_M are input shares for capital and imports, respectively, and are each assumed to be bound between 0 and 1 such that the share of capital, imports, and labour inputs sum to unity. $c_f(i)$ is firm i's fixed costs. More specifically, A_t^f is given by

$$A_t^f = (A_t^I)^{\frac{\alpha_K}{1-\alpha_K}} A_t^L, \tag{19}$$

where A_t^I is an investment-specific technology (IST) shock.

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

$$mc_t = \frac{1}{A_t}(z_t^k)^{\alpha_K} \epsilon_t^{\alpha_M} \left(\frac{w_t}{A_t^L}\right)^{1-\alpha_K-\alpha_M}, \tag{20}$$

and

$$Y_t = A_t \left(\frac{K_{t-1}}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_t}{\alpha_M}\right)^{\alpha_M} \left(\frac{A_t^L L_t}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M} - A_t^f c_f, \tag{21}$$

where

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

is aggregate capital, imports, and labour inputs used in production during period t, respectively. From the FOCs,[19] one also yields the following expenditure shares:

$$\frac{\epsilon_t M_t}{z_t^k K_{t-1}} = \frac{\alpha_M}{\alpha_K}, \tag{22}$$

$$\frac{w_t L_t}{z_t^k K_{t-1}} = \frac{1-\alpha_K-\alpha_M}{\alpha_K}. \tag{23}$$

Inherent to each intermediate firm i's problem – in addition to selecting input quantities to minimise costs – is the choice of $P_t(i)$. Under Rotemberg (1982) pricing, firm i maximises the net present value of profits,

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

where τ^s is a production subsidy funded by lump-sum taxes. Evaluating at the symmetric equilibrium where intermediate firms optimally price their output at $P_t(i) = P_t, \forall i$, gives[20]

$$(\pi_t - 1)\pi_t = \frac{1}{\kappa} \left[1 - \eta + (\eta - 1)(1-\tau^s)\mathcal{M}_t mc_t \right] + \mathbb{E}_t \Lambda_{t,t+1} \frac{Y_{t+1}}{Y_t} (\pi_{t+1} - 1)\pi_{t+1}, \tag{24}$$

where $\mathcal{M}_t$ is the 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:

$$K_t = \lambda K_{t-1} + I_t \exp\left(\xi_t^K\right), \tag{25}$$

where ξ_t^K is a marginal efficiency of investment (MEI) shock (Justiniano, Primiceri, and Tambalotti 2010), and recall that $\lambda = 1 - \delta$ where $\delta \in (0,1)$ is the depreciation rate. Total investment costs are given by:

$$I_t \left[1 + \Phi \left(\frac{I_t}{I} \right) \right],$$

[19] Intermediate firm FOCs are shown in Appendix A.2.

[20] A standard expression for the New Keynesian Phillips Curve (NKPC) can be written by log linearising (24) about the non-inflationary steady state. For details see Appendix A.2.

where $\Phi(\cdot)$ are investment adjustment costs[21] and are defined as:

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

with $\Phi(1) = \Phi'(1) = 0$ and $\Phi''\left(\frac{I_t}{I}\right) > 0$. Thus, the representative investment good firm wishes to maximise its profits:

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

Differentiating with respect to I_t gives the following FOC:

$$Q_t = 1 + \Phi\left(\frac{I_t}{I}\right) - \frac{I_t}{I}\Phi'\left(\frac{I_t}{I_{t-1}}\right). \tag{26}$$

3.5. 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:

$$EX_t = \left(\frac{P_t}{E_t P_t^*}\right)^{-\varphi} Y_t^* = \epsilon_t^{\varphi} Y_t^*, \tag{27}$$

where φ is the price elasticity of foreign demand.

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

$$\ln \epsilon_t - \ln \epsilon_{t-1} = \ln E_t - \ln E_{t-1} + \ln P_t^* - \ln P_{t-1}^* - (\ln P_t - \ln P_{t-1}).$$

This is simplified as:

$$\Delta \ln \epsilon_t = \Delta \ln E_t + \hat{\pi}_t^* - \hat{\pi}_t. \tag{28}$$

A VAR structure – in line with Christiano, Trabandt, and Walentin (2011) – is imposed on the foreign variables, departing from a common modelling assumption that each

[21]Note that these are slightly different to the investment adjustment costs as in Christiano, Eichenbaum, and Evans (2005) which are $\Phi(I_t/I_{t-1})$.

foreign variable follows an independent AR(1) process. First, define foreign output as:

$$\ln Y_t^* = \ln y_t^* + \ln A_t^L + \frac{\alpha_K}{1-\alpha_K} \ln A_t^I, \tag{29}$$

and the system of equations which describe foreign output, inflation, interest rates, and TFP are given as:

$$\begin{bmatrix} \ln\left(\frac{y_t^*}{y^*}\right) \\ \pi_t^* - \pi^* \\ R_t^* - R^* \\ \ln\left(\frac{A_t^L}{A^L}\right) \\ \ln\left(\frac{A_t^I}{A^I}\right) \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} & 0 & 0 \\ a_{21} & a_{22} & a_{23} & a_{24} & \frac{\alpha_K}{1-\alpha_K} a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} & \frac{\alpha_K}{1-\alpha_K} a_{34} \\ 0 & 0 & 0 & \rho_{A^L} & 0 \\ 0 & 0 & 0 & 0 & \rho_{A^I} \end{bmatrix} \begin{bmatrix} \ln\left(\frac{y_{t-1}^*}{y^*}\right) \\ \pi_{t-1}^* - \pi^* \\ R_{t-1}^* - R^* \\ \ln\left(\frac{A_{t-1}^L}{A^L}\right) \\ \ln\left(\frac{A_{t-1}^I}{A^I}\right) \end{bmatrix} + \begin{bmatrix} \sigma_{y^*} & 0 & 0 & 0 & 0 \\ c_{21} & \sigma_{\pi^*} & 0 & c_{24} & \frac{\alpha_K}{1-\alpha_K} c_{24} \\ c_{31} & c_{32} & \sigma_{R^*} & c_{34} & \frac{\alpha_K}{1-\alpha_K} c_{34} \\ 0 & 0 & 0 & \sigma_{A^L} & 0 \\ 0 & 0 & 0 & 0 & \sigma_{A^I} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{y^*} \\ \varepsilon_t^{\pi^*} \\ \varepsilon_t^{R^*} \\ \varepsilon_t^{A^L} \\ \varepsilon_t^{A^I} \end{bmatrix},$$

or, in compact matrix form as:

$$\boldsymbol{X}_t^* = \boldsymbol{A}\boldsymbol{X}_{t-1}^* + \boldsymbol{C}\varepsilon_t. \tag{30}$$

With this setup it is assumed that a foreign demand shock, $\epsilon_t^{y^*}$, affects foreign inflation and interest rates contemporaneously; that a foreign inflationary shock, $\varepsilon_t^{\pi^*}$, affects foreign interest rates contemporaneously; and that foreign monetary policy shocks, $\varepsilon_t^{R^*}$, do not affect foreign inflation or output 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.[22] Also, under these assumptions, the labour augmenting technology shock, $\varepsilon_t^{A^L}$, and the IST shock, $\varepsilon_t^{A^I}$, affects Y_t^* independently of shocks to y_t^*. These technology shocks also affect foreign inflation and interest rates. Thus, the standard assumption made in the DSGE literature that A_t^L and A_t^I are determined by independent stationary AR(1) processes is retained.

3.6. Fiscal and monetary policy

The model assumes that the policymaker operates a balanced by taxing foreign borrowing by bankers and offering a subsidy on banker net worth. Additionally, production subsidies to intermediate firms to ensure an efficient level of output are funded by

[22] Note that this is inconsistent with our assumption of domestic monetary policy shocks, as domestic inflation is not predetermined in the period that a domestic monetary policy shock occurs.

lump-sum taxes levied on households:[23]

$$\tau_t^N N_t + \tau^s Y_t = \tau_t^{D^*} \epsilon_t D_t^* + \tau_t, \tag{31}$$

where N_t and D_t^* denote aggregate net worth and foreign debt holdings of the entire banking sector.

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. Then, for ease of exposition, the monetary policy rule can be written as:

$$\hat{i}_t = \rho_R \hat{i}_{t-1} + (1 - \rho_R) \left[\phi_\pi \hat{\pi}_t + \phi_y \hat{y}_t + \phi_E \hat{e}_t\right] + \varepsilon_t^R, \tag{32}$$

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, (32) eases the trade-off between inflation and exchange rate stabilisation.[24] Note that the central bank operates a standard feedback rule (Taylor 1993) as $\phi_E \to 0$, and an exchange rate peg as $\phi_E \to \infty$.

3.7. Market equilibrium

The aggregate resource constraint of the domestic economy is

$$Y_t = C_t + \left[1 + \Phi\left(\frac{I_t}{I_{t-1}}\right)\right] I_t + EX_t + \frac{\kappa}{2}(\pi_t - 1)^2 Y_t + \chi_t^h + \chi_t^b, \tag{33}$$

which states that output must be consumed, invested, exported, and used to pay for adjustments.[25]

[23]An additional revenue condition ensures that lump-sum taxes only fund the production subsidy.

[24]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.

[25]Note that GDP is given as:

$$Y_t^{GDP} = Y_t - \epsilon_t M_t.$$

Aggregate capital is the sum of capital (equity) owned by households and bankers:

$$K_t = K_t^h + K_t^b. \tag{34}$$

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

$$D_t^* = \frac{R_{t-1}^*}{\pi_t^*} D_{t-1}^* + M_t - \frac{1}{\epsilon_t} EX_t, \tag{35}$$

the aggregate net worth of the bankers is:

$$N_t = \sigma \left[(z_t^k + \lambda Q_t) K_{t-1}^b - \frac{R_{t-1}}{\pi_t} D_{t-1} - \epsilon_t \frac{R_{t-1}^*}{\pi_t^*} D_{t-1}^* \right] + \gamma (z_t^k + \lambda Q_t) K_{t-1}, \tag{36}$$

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

$$Q_t K_t^b \left(1 + \frac{\varkappa^b}{2} x_t^2 \right) = D_t + (1 - \tau_t^{D^*}) \epsilon_t D_t^* + (1 + \tau_t^N) N_t, \tag{37}$$

$$\phi_t = \frac{Q_t K_t^b}{N_t}, \tag{38}$$

$$x_t = \frac{\epsilon_t D_t^*}{Q_t K_t^b}. \tag{39}$$

Upon inspection, (37) is an aggregate version of the balance sheet identity (5), and (38) is an identity based on (9). Meanwhile, as all banks are identical, (39) is the corresponding aggregate version of (3).

A competitive equilibrium is a set of nine prices, $\{ E_t, mc_t, Q_t, R_t, w_t, z_t^k, R_t^k, \epsilon_t, \pi_t \}$; 13 quantity variables, $\{ C_t, D_t, D_t^*, EX_t, I_t, K_t, K_t^b, K_t^h, L_t, M_t, N_t, Y_t, \tau_t \}$; six bank variables, $\{ x_t, \psi_t, \phi_t, \upsilon_t, \mu_t, \mu_t^* \}$; four foreign variables, $\{ y_t^*, Y_t^*, R_t^*, \pi_t^* \}$; two policy instruments, $\{ \tau_t^{D^*}, \tau_t^N \}$; and seven exogenous variables, $\{ \xi_t^h, \xi_t^L, \xi_t^K, \mathcal{M}_t, A_t, A_t^L, A_t^I \}$, which satisfy 41 equations which include additional macroprudential rules (to be specified in Section 5) and processes for the stationary AR(1) shocks.

4. Estimation and Simulation

I estimate the model using Bayesian methods outlined in An and Schorfheide (2007) and Del Negro (2012), which are featured in notable contributions to the literature on open economy New Keynesian models such as: Christiano, Trabandt, and Walentin (2011),

TABLE 2. Calibrated parameter values

Parameter	Value	Description
β	0.9922	Discount rate
ζ	1/3	Inverse-Frisch elasticity
ζ_0	7.883	Labour disutility
$\varkappa^h$	0.0197	Cost parameter of direct finance
σ	0.94	Bank survival probability
γ	0.0046	Fraction of total assets inherited by new banks
$\varkappa^b$	0.0219	Management cost for foreign borrowing
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	9	Elasticity of demand
κ	$\frac{\omega(\eta-1)}{(1-\omega)(1-\beta\omega)}$	NKPC slope parameter
c_f	0.497	Production fixed cost
τ^s	0	Rate of subsidy

Iacoviello (2015), and Justiniano, Primiceri, and Tambalotti (2010). This section provides a description of the parameters which have been either calibrated or estimated, as well as the data used for model estimation.

4.1. Calibration and prior selection

I calibrate and estimate the model using Korean data between 1999 and 2019. The model frequency is quarterly. Table 2 shows calibrated parameter values; whilst Tables 3 and 4 show estimated parameters, including information about their prior and posterior distributions. I estimate eight structural parameters, 16 VAR parameters for the foreign economy, seven AR(1) coefficients, and 11 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.

In what follows I describe the calibration and estimation strategy of each of the model's parameters – 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 $\mathbb{R}^+$. For the persistence of the AR(1) processes, $\{\rho_A, \rho_{A^L}, \rho_{A^I}, \rho_K, \rho_{\mathcal{M}}, \rho_h, \rho_L\}$, I adopt tight priors with means of 0.80 based on the Beta distribution.

The domestic discount factor is chosen to match the average annual nominal interest rate in Korea of 3.15%. The foreign gross nominal interest is selected to approximately match the average yield on US 1-year Treasury Bills of 2.03% for the period. The parameters which pertain to production and labour 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. Meanwhile, the investment adjustment cost, κ_I, is set to a prior mean of 0.66 in line with empirical evidence from Eberly (1997). The foreign demand elasticity, φ, is set to a prior mean of 1 following a Gaussian distribution, and is truncated to values above 0.1.

The inverse-Frisch elasticity and the disutility weight of labour supply parameters, ζ and ζ_0, respectively, are set to 1/3 and 7.883, respectively, as in ABK. These values are sufficient given the simple setup of the labour market in the model, and to assist estimation, are calibrated and not estimated.

The fraction of firms which do not adjust their prices each period, ω, 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).[26] Given that the data used for estimation is from Korea, I choose a Beta distribution prior with a mean value of of 0.75.

The parameter governing inertia of the Taylor rule, ρ_R, is set to a prior mean of 0.55 as in Guerrieri and Iacoviello (2015). 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 inverse-Gamma distribution with a mean of 0.1. The reaction to inflation and the output gap, ϕ_π and ϕ_y, have prior means set at 1.5 and 0.2, respectively. These values are standard in the New Keynesian literature (see, for example, Guerrieri and Iacoviello (2015)). For estimation, I assume Gamma distributions with standard deviations of 0.1 and 0.05 for ϕ_π and ϕ_y, respectively.

Most bank parameters are calibrated using baseline values from ABK and AQ. As

[26]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.

an example, the severity of the banker's moral hazard, management costs of foreign borrowing, and the fraction of household assets brought on by new bankers – θ, $\varkappa^b$, and γ, respectively – are selected so that: i) the bank leverage multiple, ϕ, is roughly equal to 4 in steady state; ii) the spread between the rate of return on bank assets and deposits is approximately 2%; and, iii) the fraction of foreign borrowing by bankers, x, is approximately 15% in steady state. The banker's continuation probability, σ, is set so that the annualised dividend payout of the banker is equal to $4(1 - \sigma) = 24\%$ of the bank's net worth in steady state. The start up fraction of funds for new bankers is set at $\gamma = 0.0046$. The cost of foreign borrowing parameter, $\varkappa^b$, is set so that the fraction of capital financed by banks is roughly 3/4. Of the bank parameters, I estimate θ using a tight Beta distribution prior as $\theta \in (0, 1)$.

In the baseline calibration of the model, and for the estimation exercise, I disable the tax instruments. However, Section 5 explores the welfare effects of applying macroprudential rules on equity and foreign debt.

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 exception to this choice 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 0.5, and are relatively tight with an assumed standard deviation of 0.25. This choice was made based on the prior choices of Christiano, Trabandt, and Walentin (2011), as well as the calibration of ABK and literature such as Mendoza (2010) and Avdjiev et al. (2017). Additionally, a_{13} and a_{23}, the responses of foreign output and inflation to the foreign interest rate, respectively, are set to –0.5 with a standard deviation of 0.1, in line with the broad macroeconomic literature (see, for example, Uhlig (2005)).

4.2. Data

I estimate the model using Korean and US data between 1999Q1 and 2019Q4. I use 10 observable time series. A plot of the time series can be seen in Figure A11, and data sources can be found in Appendix B.1. The following time series are in levels and percent annualised form: Korean CPI inflation, Korean short-term nominal interest rates, US inflation, and US 1-year Treasury Bill (TBill) interest rates. For the following time series I take logs and first differences: Korean real equity prices, Korean GDP, Korean real exports, US GDP, and the Dollar-Won real exchange rate. The real quantities are in per capita terms. Lastly, Korean corporate spreads are expressed as percentage point differences. It important to note that the Korean and US interest rates are centred

Table 3. Parameter estimation results

Parameter	Description	Prior			Posterior			
		Dist.	Mean	SD	Mode	SD	HPD 5%	95%
ω	Calvo parameter	$\mathcal{B}$	0.750	0.050	0.837	0.020	0.812	0.878
κ_I	Investment adjustment cost	$\mathcal{G}$	0.666	0.050	0.711	0.040	0.735	0.859
φ	Foreign demand elasticity	$\mathcal{N}_{\geq 0.1}$	1.000	0.250	0.100	0.011	0.100	0.122
θ	Bank moral hazard	$\mathcal{B}$	0.399	0.100	0.316	0.051	0.205	0.371
ϕ_π	Inflation sensitivity	$\mathcal{G}$	1.500	0.100	1.540	0.087	1.346	1.623
ϕ_y	Output sensitivity	$\mathcal{G}$	0.200	0.050	0.131	0.037	0.118	0.240
ϕ_E	Exchange rate sensitivity	$\mathcal{G}^{-1}$	0.100	Inf	0.053	0.012	0.049	0.089
ρ_R	Taylor rule inertia	$\mathcal{B}$	0.550	0.075	0.843	0.027	0.784	0.872
ρ_A	AR(1) coefficient	$\mathcal{B}$	0.800	0.050	0.722	0.028	0.726	0.822
ρ_{A^L}	AR(1) coefficient	$\mathcal{B}$	0.800	0.050	0.833	0.030	0.737	0.835
ρ_{A^I}	AR(1) coefficient	$\mathcal{B}$	0.800	0.050	0.926	0.018	0.895	0.953
ρ_k	AR(1) coefficient	$\mathcal{B}$	0.800	0.050	0.728	0.027	0.759	0.848
$\rho_{\mathcal{M}}$	AR(1) coefficient	$\mathcal{B}$	0.800	0.050	0.787	0.031	0.741	0.843
ρ_H	AR(1) coefficient	$\mathcal{B}$	0.800	0.050	0.845	0.045	0.707	0.851
ρ_L	AR(1) coefficient	$\mathcal{B}$	0.800	0.050	0.855	0.023	0.705	0.782
a_{11}	Foreign VAR (y^*, y^*)	$\mathcal{B}$	0.500	0.250	0.973	0.019	0.934	0.994
a_{12}	Foreign VAR (y^*, π^*)	$\mathcal{N}$	0.000	0.500	0.255	0.239	0.146	0.926
a_{13}	Foreign VAR (y^*, R^*)	$\mathcal{N}$	-0.500	0.100	-0.207	0.046	-0.410	-0.259
a_{21}	Foreign VAR (π^*, y^*)	$\mathcal{N}$	0.000	0.500	0.043	0.017	0.013	0.070
a_{22}	Foreign VAR (π^*, π^*)	$\mathcal{N}$	0.000	0.250	0.251	0.112	0.180	0.545
a_{23}	Foreign VAR (π^*, R^*)	$\mathcal{N}$	-0.500	0.100	-0.364	0.067	-0.515	-0.291
a_{24}	Foreign VAR (π^*, A^L)	$\mathcal{N}$	0.000	0.500	0.305	0.130	0.096	0.515
a_{31}	Foreign VAR (R^*, y^*)	$\mathcal{N}$	0.000	0.500	-0.007	0.005	-0.016	0.001
a_{32}	Foreign VAR (R^*, π^*)	$\mathcal{N}$	0.000	0.500	0.152	0.048	0.099	0.257
a_{33}	Foreign VAR (R^*, R^*)	$\mathcal{B}$	0.500	0.250	0.975	0.026	0.920	0.998
a_{34}	Foreign VAR (R^*, A^L)	$\mathcal{N}$	0.000	0.500	-0.134	0.066	-0.261	-0.056
c_{21}	Foreign VAR (ε^{π^*}, ε^{y^*})	$\mathcal{N}$	0.000	0.500	0.034	0.046	-0.026	0.126
c_{24}	Foreign VAR (ε^{π^*}, ε^{A^L})	$\mathcal{N}$	0.000	0.500	0.452	0.266	0.129	0.966
c_{31}	Foreign VAR (ε^{R^*}, ε^{y^*})	$\mathcal{N}$	0.000	0.500	0.063	0.021	0.030	0.098
c_{32}	Foreign VAR (ε^{R^*}, ε^{π^*})	$\mathcal{N}$	0.000	0.500	0.040	0.052	-0.035	0.137
c_{34}	Foreign VAR (ε^{R^*}, ε^{A^L})	$\mathcal{N}$	0.000	0.500	0.372	0.146	0.181	0.632

Based on a single Metropolis Hastings chain with 1,000,000 draws. The first one-third of draws are disposed as a burn-in period.

TABLE 4. Estimated standard deviation of shocks

Parameter	Description	Prior			Posterior			
		Dist.	Mean	SD	Mode	SD	HPD 5%	95%
ε^{A}	TFP	$\mathcal{G}^{-1}$	0.500	Inf	0.537	0.081	0.444	0.666
ε^{A^L}	Labour technology	$\mathcal{G}^{-1}$	0.150	Inf	0.064	0.028	0.038	0.117
ε^{A^I}	IST	$\mathcal{G}^{-1}$	0.150	Inf	0.364	0.185	0.139	0.661
ε^{K}	MEI	$\mathcal{G}^{-1}$	0.150	Inf	0.070	0.133	0.035	0.270
$\varepsilon^{\mathcal{M}}$	Markups	$\mathcal{G}^{-1}$	0.500	Inf	2.171	0.420	1.554	2.870
ε^{h}	Household preference	$\mathcal{G}^{-1}$	0.050	Inf	0.024	0.040	0.011	0.089
ε^{L}	Labour supply	$\mathcal{G}^{-1}$	0.150	Inf	0.070	0.254	0.032	0.441
ε^{R}	Monetary policy	$\mathcal{G}^{-1}$	0.250	Inf	0.082	0.008	0.069	0.095
ε^{y^*}	Foreign demand	$\mathcal{G}^{-1}$	0.500	Inf	0.538	0.052	0.472	0.644
ε^{π^*}	Foreign inflation	$\mathcal{G}^{-1}$	0.250	Inf	0.178	0.018	0.158	0.215
ε^{R^*}	Foreign interest rate	$\mathcal{G}^{-1}$	0.250	Inf	0.063	0.008	0.055	0.080

Based on a single Metropolis Hastings chain with 1,000,000 draws. The first one-third of draws are disposed as a burn-in period.

when the model is taken to the data,[27] and the differenced series are demeaned, as the underlying model is stationary.

Throughout the rest of this paper, I interchangeably refer to the Korean economy as the “domestic” or “home” economy, and the US economy as the “foreign” economy.

4.3. Simulating the global financial cycle – trilemma or dilemma?

Before proceeding to the results of model estimation, I first explore the behaviour of the theoretical model to an orthogonalised shock to the foreign interest rate. This innovation to the foreign interest rate can be thought of as a proxy to the global financial cycle – whereby the interest rate at which the domestic economy borrows from foreigners increases due to changes in foreign monetary policy (for example, the taper tantrum) and/or the risk premium demanded by foreign creditors (Miranda-Agrippino and Rey 2020). Note that for the simulations in this section, the model is parameterised according to the values in Table 2 and the prior mean values in Table 3.

Figure 3 displays the impulse response functions (IRFs) to an innovation in the foreign nominal interest by 1% (annualised) for three different nominal exchange rate regimes of the domestic central bank: the red lines are a float ($\phi_E = 0$), the green is a managed or dirty float ($\phi_E = 1$), and the blue is an exchange rate peg ($\phi_E = 100$). These IRFs are computed by taking a first-order approximation of the policy rules about the deterministic steady state (Adjemian et al. 2022). Furthermore, the IRFs represent quarterly percent deviations from the deterministic steady state – with the exception of inflation and interest rates which are in annualised percent rates.

The 1% increase in the foreign interest rate, has starkly different effects depending on how the central bank responds to fluctuations in the nominal exchange rate. The pressure on the domestic currency to depreciate leads the central bank to increase domestic interest rates in a bid to attract foreign capital flows – reminiscent of the policy recommendations set out by the IMF to many South East Asian economies during the 1997 Asian Financial Crisis. This, of course, directly speaks to the trilemma vs dilemma hypothesis. Depending on the calibration of the model – particularly ζ, ζ_0, φ, and θ – the model is able to account for either the trilemma or dilemma narratives. These key structural parameters motivate the estimation exercise (to be discussed below).

Let us focus on the response of the financial variables to the foreign interest rate increase. Under a Mundell-Fleming-Dornbusch framework, the exchange rate would

[27] As in Gourinchas (2018). This is a way of avoiding potential estimation concerns related to the zero lower bound on interest rates in the post-Global Financial Crisis period.

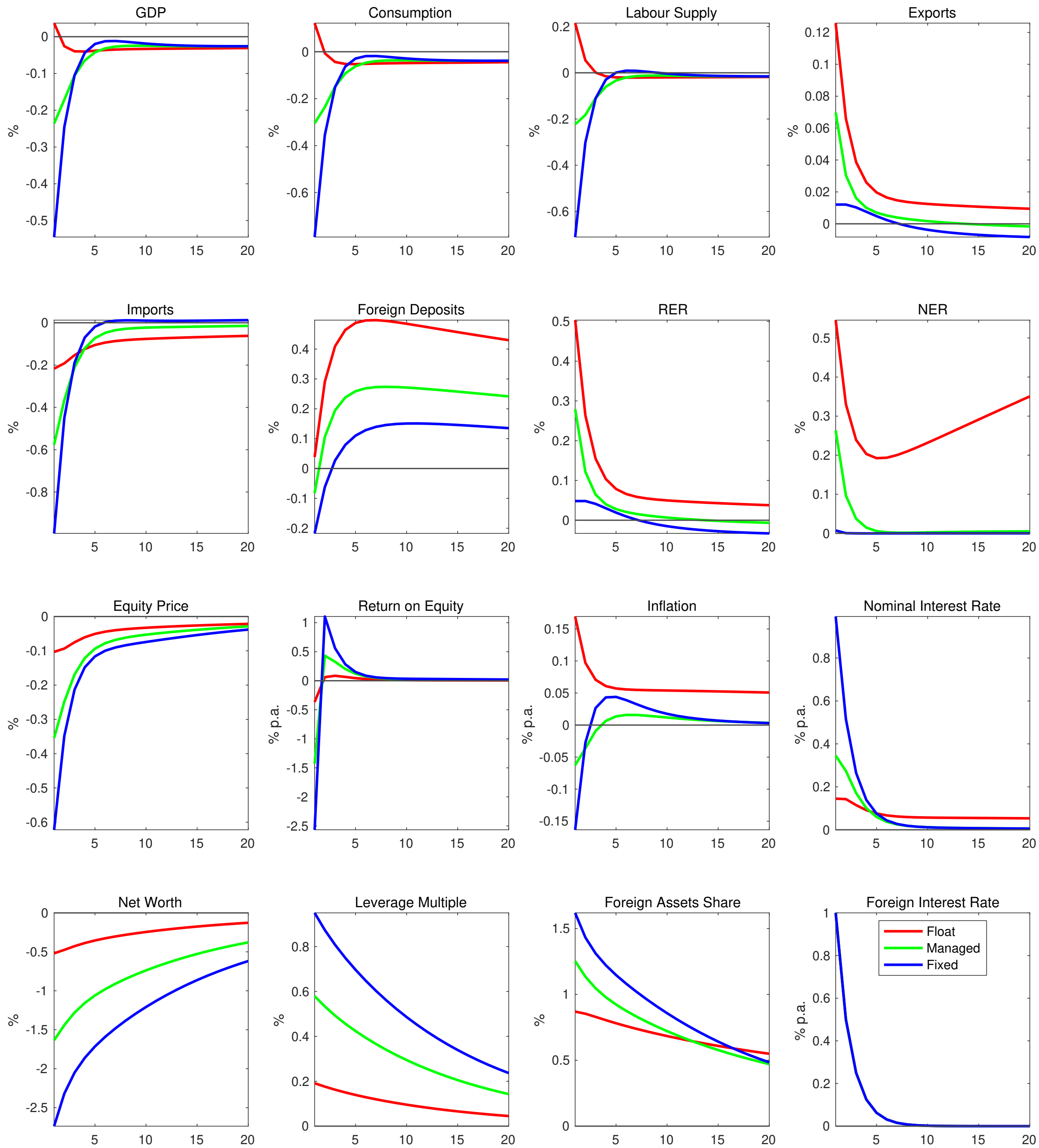

FIGURE 3. IRFs to an annualised 1% shock to the Foreign Interest Rate

Variables are expressed in percent changes from their non-stochastic steady state values. Model parameters are calibrated to prior means. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

absorb the entire effect of capital outflows from the domestic economy, as investors pursue higher yields overseas, keeping up aggregate demand and preventing a domestic recession. This is because under UIP, the domestic nominal interest rate cannot rise as much as the foreign nominal interest (due to the presence of a Taylor-type interest rate rule), which implies that the exchange rate needs to significantly depreciate through a Dornbusch mechanism. This sees the domestic small open economy undergo an export led-boom, with aggregate demand being raised sufficiently enough to stave off recession. But in this model this does not happen. As Equation (15) stipulates, μ_t^*, the real cost advantage of foreign currency debt over home deposits (the deviation from real UIP term in the model), rises and thus removes pressure on the exchange rate depreciation.[28] The depreciation of the real exchange rate is insufficient for the domestic small open economy to undergo export led growth, and so aggregate demand falls, particularly when the central bank operates a managed float and peg.

The exchange rate depreciation and rise in μ_t^* leads to an increase in the banker's leverage ratio, ϕ_t, and increases the ratio of the banker's foreign debt commitments, x_t. The increase in x_t leads to a fall in capital prices, Q_t, since the banker will be balance sheet constrained (Equations (38) and (37)), and this drop in Q_t will lead to a substantial fall in bank net worth, N_t. In general equilibrium, both the drop in Q_t and the exchange rate depreciation, which causes a rise in the foreign debt burden, contribute to the sharp decline in N_t. The mechanism for this is the financial accelerator through asset prices, as in Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1999), and Gertler and Kiyotaki (2015). Furthermore, the banking sector sees a decline in the Tobin Q ratio, ψ_t, as the fall in net worth implies a proportionally steeper decline in the franchise/market value of the bank, $\mathbb{V}_t^b$, as shown in Equations (8) and (A7).

The deterioration of domestic financial conditions then spills over to the real economy, as the decline in N_t hampers the ability of the banker to fund investments in domestic firms. This sees output and consumption consequently fall. Compounding this under a managed float or exchange rate peg are recessionary pressures stemming from the insufficient depreciation of the nominal exchange rate and the response of the central bank in increasing R_t.[29]

In this simple exercise, the model results are mixed between the arguments of

[28]One thing to note is that the expression for μ_t^* denotes deviations from real UIP, since I make the crucial assumption of decoupling nominal interest rates and inflation. If we simply assumed that net inflation always be zero, then the experiment of an increase to R_t^* would lead to a decline in μ_t^*.

[29]This, broadly, captures the experiences of many EMEs during the taper tantrum. See Blanchard (2017) for further discussion.

Obstfeld and Rey: One could make argument for either the trilemma or dilemma, as flexible exchange rates are merely a sufficient condition for independent monetary policy. Given this model's calibration, the effects of an increase in the foreign interest rate are attenuated by the exchange rate when the domestic central bank leans towards the stabilisation of inflation and output rather than exchange rates. But the model still shows that there is a slight contractionary effect of the foreign rate hike, departing from standard results if we were operating with Mundell-Fleming-Dornbusch assumptions with the UIP condition and efficient international financial markets. Real variables such as output and investment still decline, as the domestic economy cannot rely on a simple export-led recovery. This is due to the dynamics of the financial markets and the effects of the financial accelerator described earlier.

Perhaps an illuminating result: a central bank which leans towards an exchange rate peg bares a stronger brunt from the global financial cycle. Under the Taylor rule specification when $\phi_E = 100$, a drop in equity prices of approximately 0.6% leads to a drop in banker net worth of around 2.75% and a decline in net foreign debt to a low of nearly 0.2%. These significant disruptions to the domestic financial sector see a decline in output of over 0.55% and consumption also falls by nearly 0.8%. The explanation for this is that while the nominal exchange rate sees little movement thanks to the peg by the central bank, minimising the obligation of domestic bankers to foreign creditors, the cost of defending the peg is a sharp hike in the domestic nominal interest rate. This domestic nominal interest rate channel leads to a suppression of domestic aggregate demand and thus results in deflationary pressure. This leads to a deviation from real UIP, as explained above, only this time the collapse in aggregate demand results in higher bank leverage, and steeper falls in equity prices, foreign deposits, and bank net worth. Furthermore, because of the nominal exchange rate peg and rise in domestic interest rates, there is no export-growth path or buffer.

Thus, one could argue that that there is indeed a trade-off for the domestic central bank when it considers the risks of the global financial cycle and its exchange rate policy: it must balance the effects of an exchange rate depreciation leading to higher debt obligations to foreign creditors against the costs of maintaining a peg and causing a drop in aggregate demand.

Though I omit the discussion here, readers interested in the non-estimated model's dynamic characteristics to other shocks can find additional IRFs in Appendix A.6.

4.4. Estimation results: Accounting for the dilemma

Posterior parameter values. I now outline the model estimation strategy and results. First, a note about shocks and measurement errors. The model features 11 structural shocks:

$$\varepsilon_t^A, \varepsilon_t^{A^L}, \varepsilon_t^{A^I}, \varepsilon_t^h, \varepsilon_t^L, \varepsilon_t^K, \varepsilon_t^{\mathcal{M}}, \varepsilon_t^R, \varepsilon_t^{y^*}, \varepsilon_t^{\pi^*}, \varepsilon_t^{R^*}, \tag{40}$$

of which, seven belong to independent AR(1) stationary processes. I also include the following six measurement error terms:

$$\varepsilon_t^{EX,obs}, \varepsilon_t^{Q,obs}, \varepsilon_t^{\epsilon,obs}, \varepsilon_t^{\mu,obs}, \varepsilon^{Y,obs}, \varepsilon_t^{\pi,obs}. \tag{41}$$

Note that I assume no measurement errors for the domestic nominal interest rate, foreign nominal interest rate, foreign inflation rate, and foreign output. This is because it is assumed that the US variables are measured with a high degree of accuracy. As mentioned earlier, the variance of the measurement errors are scaled so that they correspond to 10% of the variance of each observed time series, with the exception of the inflation series, which are scaled by 25% to account for additional high frequency noise.

Estimation was conducted by using a random walk Metropolis-Hasting (MH) chain with 1,000,000 draws, including a burn-in run of 333,333 draws. The acceptance ratio was tuned to be approximately 0.2-0.3, in line with most of the Bayesian macroeconometrics literature. Prior-posterior plots and other diagnostic results are available in the Appendix B.

Before discussing the estimated model's performance, I will outline a few estimation results presented in Tables 3 and 4. These tables show the posterior mode of the estimated parameters – which are used for model calibration – as well as the posterior standard deviations, and 90% highest probability density (HPD) intervals of the parameter estimates.

The estimated Calvo parameter implies that prices adjust slowly in Korea, with an estimated mode of 0.837 that is above the prior value of 0.75. Investment adjustments costs roughly match the empirical evidence of 2/3 in Eberly (1997), coming in at 0.71. I defer the discussion of the estimation results of θ and φ below. The Taylor rule coefficients have prior modes at $\{\phi_\pi, \phi_y, \phi_E, \rho_R\} = \{1.54, 0.131, 0.053, 0.843\}$. These results are generally promising for the estimation exercise, given the Bank of Korea's commitment to price stability and a flexible exchange rate.[30] However, I will note that the estimate for ρ_R is slightly higher than what would be expected for other advanced economies.

As for the Foreign VAR parameters, most are in line with economic theory and the estimation results of Christiano, Trabandt, and Walentin (2011). For example, the response of the foreign output process, y^*, to past values of inflation, a_{12}, and interest rates, a_{13}, are of the correct sign. The response of π^* to R^*,a_{23}, is also negative. The coefficients which map the response of R^* to y^*, a_{31}, and π^*, a_{32}, are mixed: $a_{31} < 0$ at the posterior mode, but is not well identified looking at HPD. However, $a_{32} > 0$, albeit with quite a large credibility band – a curiosity perhaps due to the Fed's decision to keep rates low well after the 2008 Global Financial Crisis. Persistence of US output, a_{11}, and interest rates, a_{33}, are quite high. For the elements of $\boldsymbol{C}$, the coefficient matrix of the foreign shock vector, with the exception of c_{31}, the estimation exercise suggests that the shocks are uncorrelated like in Christiano, Trabandt, and Walentin (2011).

Estimation challenges. As previously mentioned, the inverse-Frisch elasticity and labour disutility parameter, ζ and ζ_0, as well as the bank moral hazard severity parameter, θ, and the foreign demand elasticity, φ, determine the model's capability to account for either the trilemma or dilemma hypothesis. Higher values of ζ_0 and the Frisch elasticity parameter (lower ζ), θ, and φ push the model towards befitting the Mundellian trilemma. This is because these parameters amplify the financial intermediation and export channels of the domestic economy. For instance, as θ increases, then the bank incentive compatibility constraint, (4), binds less severely. Recall that in equilibrium, no bank actually absconds with depositors' funds, and the incentive compatibility constraint is always binding. Thus, a higher value of θ corresponds to improved financial intermediation. The intuition for this is that, ceteris parabus, an increase in the foreign interest rate reduces bank profitability through a compression of the spread, μ^*, pushing the model towards a case with competitive financial markets. Additionally, φ, affects the strength and responsiveness of exports to real exchange rate depreciations, strengthening export-led growth.

However, jointly estimating these parameters presents a challenge precisely because of collapsing spreads along the potential parameter space. Consider the deterministic steady state. As alluded to in Section 3.3, for there to be a unique equilibrium to exist,

[30]The Bank of Korea moved to an inflation targeting regime aiming for an annual inflation rate of 2% since 1998.

there must exist a discounted spread between returns on equity and deposits,

$$s = \beta R^k - 1,$$

and a discounted spread between domestic and foreign deposits,

$$s^* = 1 - \beta R^*.$$

$s^* > 0$ is considered to be exogenous as US TBill rates are higher than Korean short-term interest rates (R^* and β are calibrated to US and Korean interest rates, respectively). However, s can numerically collapse to zero as R^k is an endogenous object,[31] and is particularly sensitive to ζ and ζ_0. To address this problem, I choose to calibrate ζ and ζ_0 to the baseline values in ABK, as this ensures that $s > 0$. Furthermore, I apply a lower bound on the distribution of φ from below 0.1 to prevent explosive quantities in the deterministic steady state.

Bayesian IRFs of a global financial cycle shock. Figure 4 shows the Bayesian IRFs to a 1% (annualised) innovation to the US 1-year TBill rate. The IRFs in blue are the mean impulse responses, while the dashed red lines are the 90% HPD intervals. Since this simulation is based on the estimated set of parameters, while most of the dynamics described in Section 4.3 hold here, a foreign interest rate increase now has pass through effects to foreign output and foreign inflation through the foreign VAR system. The results presented are broadly in line with the empirical findings of Kose et al. (2010); Rey (2015, 2016); Dedola, Rivolta, and Stracca (2017); Iacoviello and Navarro (2019); Miranda-Agrippino and Rey (2020), and the empirical evidence presented in Section 2 of US monetary policy tightening leading to economic slowdowns abroad.

Restricting the discussion to the mean impulse response, now the shock to the US interest rate leads to an initial 4% depreciation in the nominal and real exchange rates. As the price elasticity of export demand estimate is at its lower bound at the mode, the depreciation of the exchange rate does not lead to a proportional increase in real exports. Imports also initially decline by just over 3.5%, reducing the quantity of inputs into firm production. Thus, the domestic economy's output initially declines. As before, in Section 4.3, the exchange rate depreciation leads to an increase in domestic inflation; albeit quite mild despite the strong depreciation of the real exchange rate. With the estimated model, there is also no initial current account improvement, as evidenced by

[31] For details, see the derivation of the deterministic steady state in Appendix A.5.

comparing the IRFs of Foreign Deposits (net foreign debt) in Figures 3 and 4.

But the primary finding of the estimation exercise is that the US monetary tightening has significant effects on financial intermediation domestically. As before, banker leverage increases (by about 5% here) as the banker's foreign debt commitments increase. Balance sheet constraints – stemming from higher debt obligations to US investors and a tightening of Korean monetary policy – then cause Korean equity prices to fall by about 1.75%, which leads to a significant decline in Korean bank net worth of approximately 12%. Though not shown in Figure 4, the deterioration in bank balance sheets leads to an aggregate decline in equity or capital, further constraining the productive capacity of the Korean economy. Furthermore, the composition of capital shifts away from being funded by efficient bankers towards households, which undertake equity acquisitions with a cost.

Unsurprisingly, the Bayesian estimation exercise suggests that the central bank leans quite heavily toward stabilising inflation rather than the output gap or exchange rate. The increase in Korean inflation and exchange rate depreciation leads to a domestic monetary policy tightening by approximately 0.2% (annualised). Thus, although higher domestic inflation eases the obligation of Korean banks to Korean depositors[32], the deteriorating bank balance sheets and the decline in equity prices based on the financial accelerator or credit cycles mechanism (Kiyotaki and Moore 1997; Gertler and Kiyotaki 2015) leads to a decline in real economic activity.

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[32] $\frac{R_{t-1}}{\pi_t \uparrow} D_{t-1}$ in the evolution of bank net worth, Equation (36).

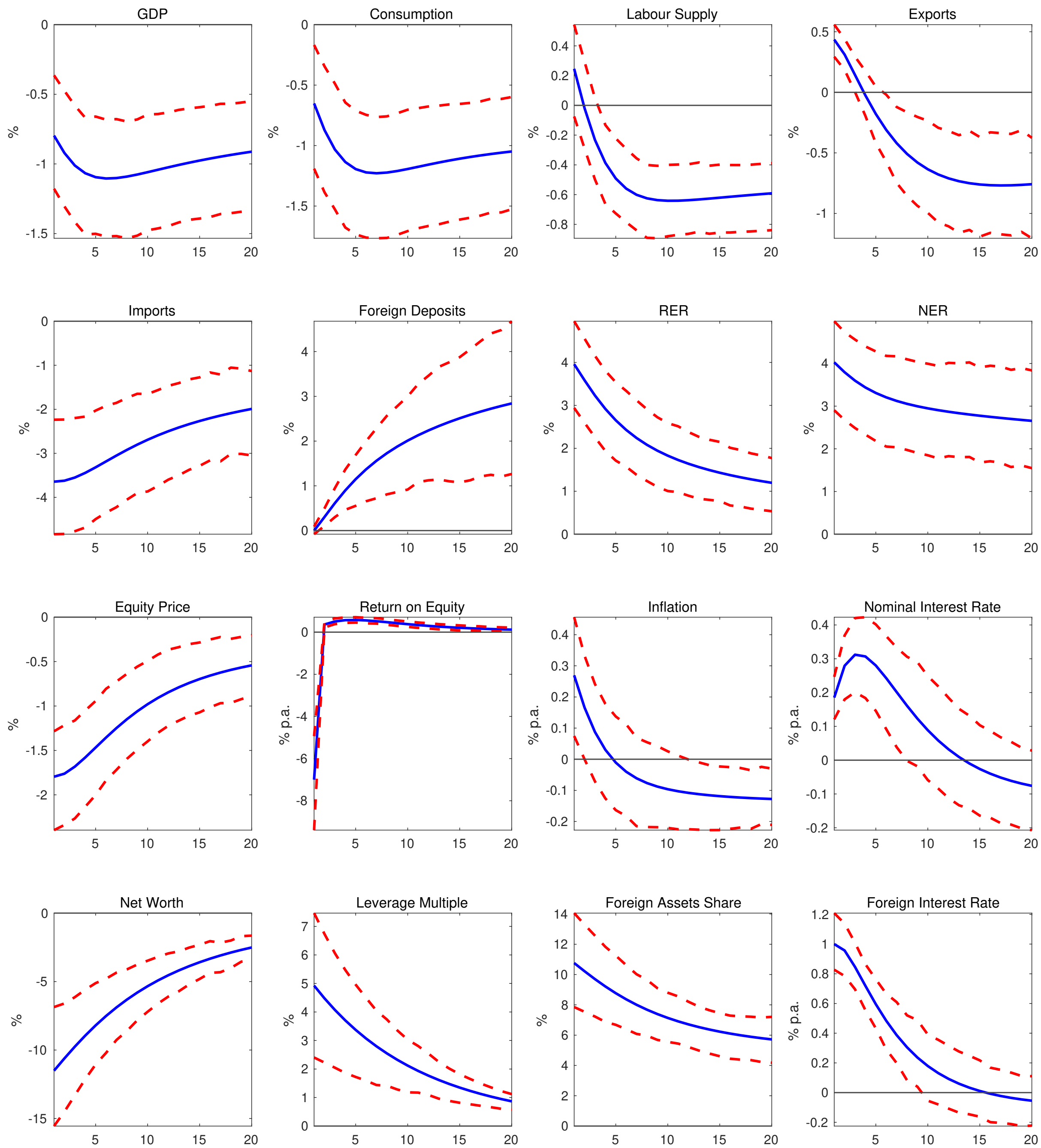

FIGURE 4. Bayesian IRFs to a 1% annualised innovation to the US 1-year Treasury Bill rate

Variables are expressed in percent deviations from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Solid line: posterior mean IRF; dashed lines: 5th and 95th HPD percentiles.

4.5. Counterfactuals with the estimated model

No bankers. The first counterfactual I run with the model parameterised to the posterior mode is one in which I eliminate the banker from the model. Domestic households (now all workers) can now invest in domestic equity costlessly, and are able to borrow from savers abroad with some efficiency cost. Their period budget constraint of the representative domestic household is now

$$C_t + B_t + Q_t K_t + \chi_t^{h,*} + \epsilon_t D_t^* = w_t L_t + \Pi_t^P + \frac{R_{t-1}}{\pi_t} B_{t-1} + (z_t^k + \lambda Q_t) K_t + \frac{R_{t-1}^*}{\pi_t^*} \epsilon_t D_{t-1}^* + \tau_t,$$

where B_t are one-period zero-coupon bonds that are in zero net supply, and $\chi_t^{h,*}$ are foreign debt borrowing costs:

$$\chi_t^{h,*} = \frac{\varkappa^{h,*}}{2} \frac{(\epsilon_t D_t^*)^2}{Q_t K_t}.$$

Figure 5 plots key IRFs to a 1% unanticipated increase in US interest rates, highlighting the role of financial frictions in this model. The model in both the baseline (blue lines) and no financial frictions (red lines) configuration are calibrated to the values in Table 2 and posterior mode estimates with the exception of $\varkappa^{h,*} = 2.19$.

The US interest rate hike now produces slightly muted contractions in Korean GDP, consumption, and import quantities. Exports are not significantly affected, and the current account balance now improves after the initial period. As for prices, the return on equity, inflation, and Korean nominal interest rate are approximately 0.05-0.1% below the baseline responses. Eliminating the banker also implies that model no longer has an endogenous term for the deviation from the real UIP condition, μ_t^*. Thus, the depreciation of the real and nominal exchange rates are attenuated, contributing to lower inflation and a softer response by the central bank.

Qualitatively, these results for GDP and inflation match those of Cesa-Bianchi, Ferrero, and Li (2023) who also inspect the amplification of financial frictions on macroeconomic performance. However, the extent to which the models produce comparable results is limited, given other differences in the model setups.

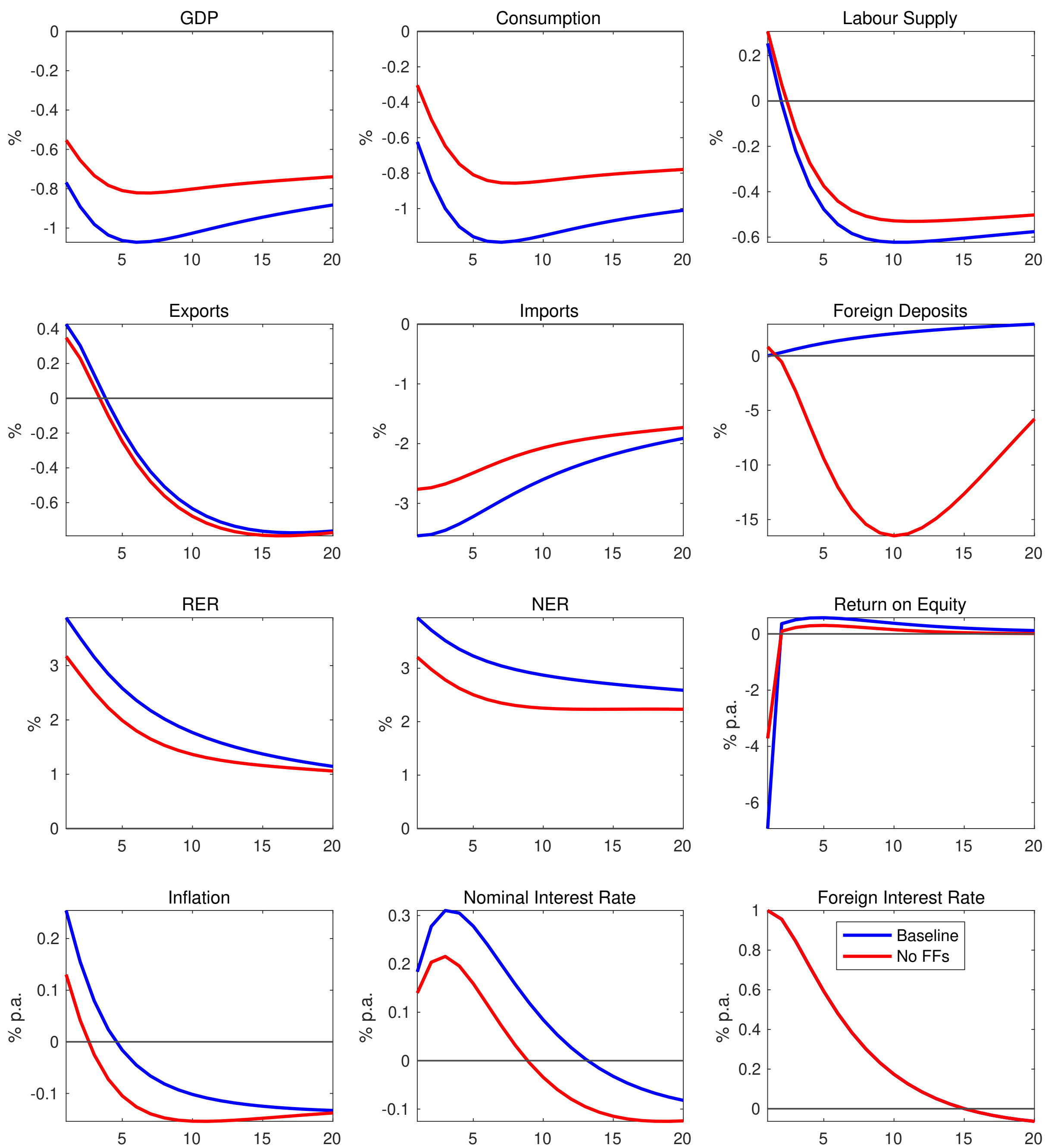

FIGURE 5. No bankers: IRFs to an annualised 1% shock to the US 1-year Treasury Bill rate

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Model is calibrated at estimated posterior mode. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Model is calibrated at estimated posterior mode. Red responses depict a model with no bankers; blue is the baseline model.

The role of floating exchange rates. The next counterfactual is to test the estimated model for three different exchange regimes on the part of the domestic central bank, essentially repeating the exercise of Section 4.3: To highlight the importance of the exchange rate, Figure 7 shows the IRFs of the estimated model calibrated to the posterior mode but for three different configurations of ϕ_E. Figure 6 plots impulse responses for equities and deposits under the floating exchange rate regime.

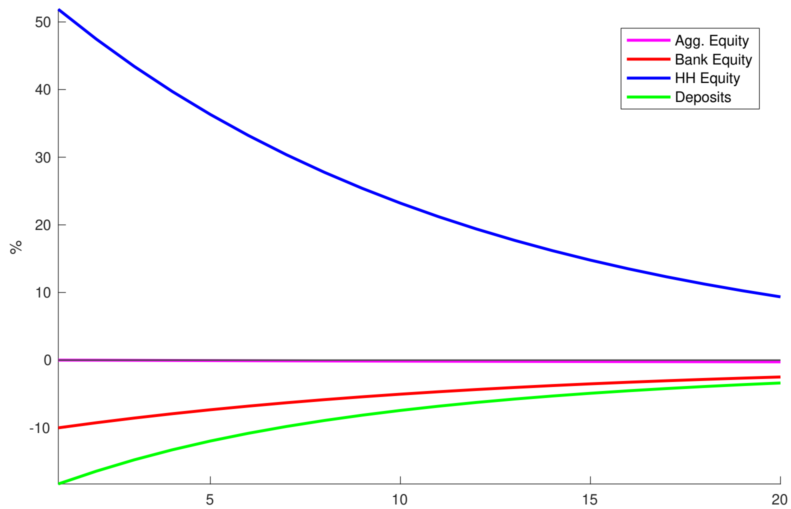

FIGURE 6. Equity and Deposits IRFs ($\phi_E = 0$)

Impulse responses to an orthgonalised 1% (annualised) shock to US 1-yr Treasury Bill rates of aggregate equity, K_t, bank equity, K_t^b, household equity, K_t^h, and domestic deposits, D_t. Variables are expressed in percent changes from their non-stochastic steady state values.

The results of this exercise are consistent with the argument of Obstfeld (2015) and the findings of Obstfeld, Ostry, and Qureshi (2019) and Cesa-Bianchi, Ferrero, and Li (2023). A fully floating exchange rate – while not perfectly buffering against the effects of a US monetary policy contraction – vastly outperforms alternative exchange rate regimes in terms of macroeconomic stability. The mechanism for this are the export growth channel (in the short run) and the financial intermediation channel. The strong exchange rate depreciation leads to an initial increase in inflation of 2.5% p.a., causing a fall in the real interest rate. Households then undertake more consumption and switch away from deposits to undertaking investments in equity (see Figure 6). This switch on the part of households prevents a sharp drop in equity prices, alleviating pressure on the banker who is balance sheet constrained due to the sharp real exchange rate depreciation. As equity prices are mostly buoyed, the decline in bank net worth is less than 1% per quarter within the first year after the US monetary contraction.

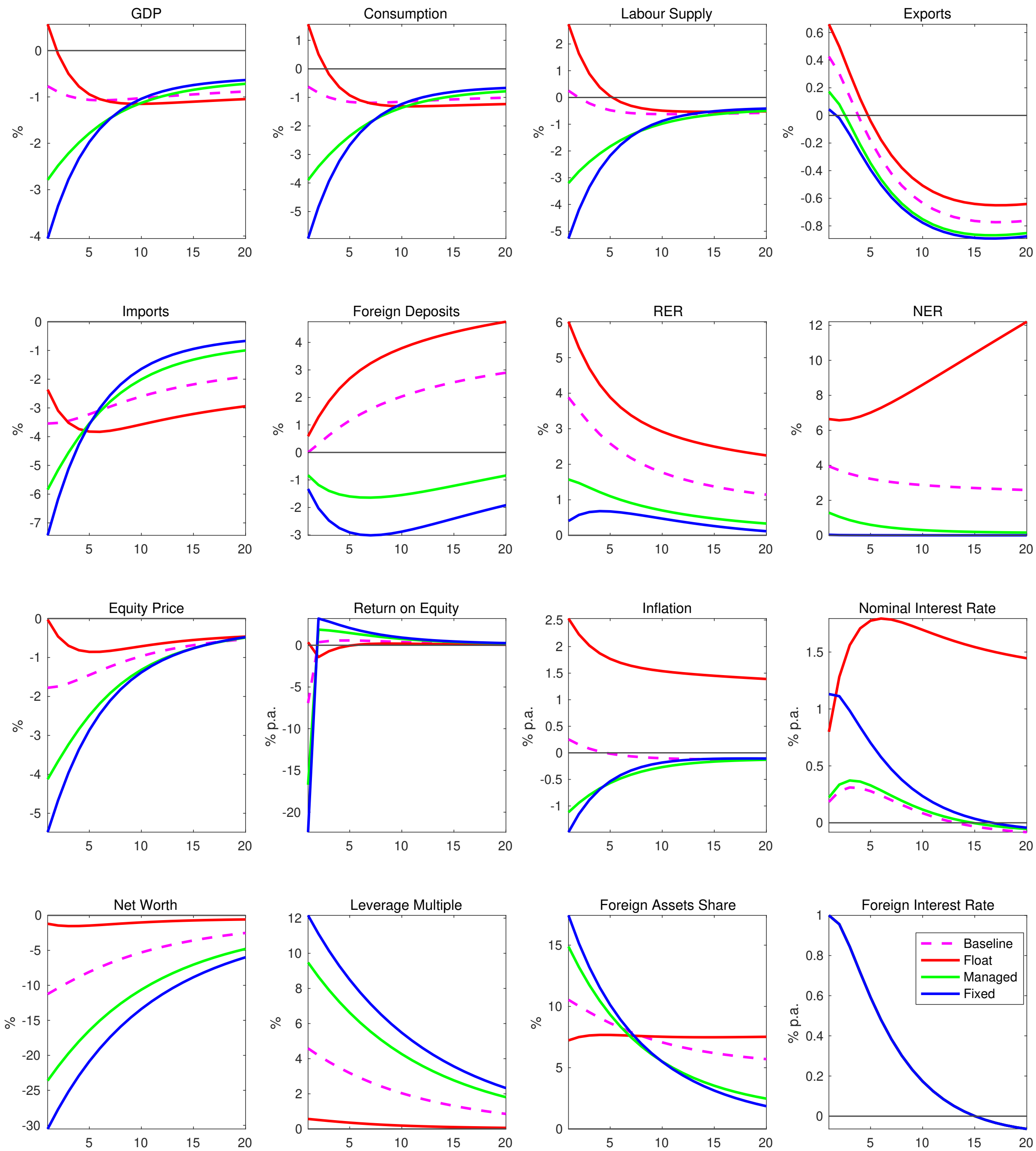

FIGURE 7. Exchange rate regimes: IRFs to an annualised 1% shock to the US 1-year Treasury Bill rate

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Model is calibrated at estimated posterior mode. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Dashed magenta lines correspond to the baseline estimated model. The three alternative exchange rate regimes are: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

4.6. Historical shock decomposition

To inspect the driving forces of key economic variables, Figures 8-10 present the historical shock decomposition of Korean GDP of the theoretical model, log differenced observed Korean GDP, and observed Korean short-term interest rates. Here, "technology shocks" are a composition of A_t, A_t^L, and A_t^I; "preference shocks" are a composition of ξ_t^h and ξ_t^L; and the "observed data shocks" are the six measurement error terms in (41). Shaded regions in the figures denote NBER US recession periods.

Starting with the GDP of the theoretical model, there are three main observations. The first is that financial frictions in the model amplify the magnitude of foreign monetary policy shocks, which is typically understated in small open economy New Keynesian models (Justiniano and Preston 2010). Second, structural shocks originating from the US increase in their significance, relative to domestic shocks, for the latter half of the sample period. Third, in the post global financial crisis period, the two main forces on the model's domestic GDP are expansionary US monetary policy shocks and negative demand shocks. Turning to the observed Korean GDP series, while the effects are less discernible, there is upward pressure on Korean GDP growth stemming US monetary policy shocks between 2010 and 2016. These patterns also continue in the historical shock decomposition of observed Korean interest rates. Through the lens of the model, weak demand from the US and expansionary monetary policy shocks on the part of the Fed – as part of its Quantitative Easing and Large Scale Asset Purchase programs – placed significant pressure on the Bank of Korea to ease its monetary policy. Then, as the Fed began to taper these programs in early 2017, we see that the model attributes upward pressure on Korean interest rates to US monetary policy shocks. This continues up until the end of the sample period before the COVID-19 pandemic.

This corroborates the mechanism outlined in ABK, AQ, and Gourinchas (2018), as well as the empirical evidence on global financial cycles and the Dilemma: expansionary (contractionary) US monetary policy places upward (downward) pressure on the output of other economies and expansionary (contractionary) non-US monetary policy regimes.

Though not discussed here, readers interested in the historical shock decomposition of observed Korean CPI inflation, model excess return of capital, observed Korean corporate spreads, model real exchange rate, the observed real exchange rate, and cost advantage of foreign debt over domestic deposits can refer to Appendix B.2.

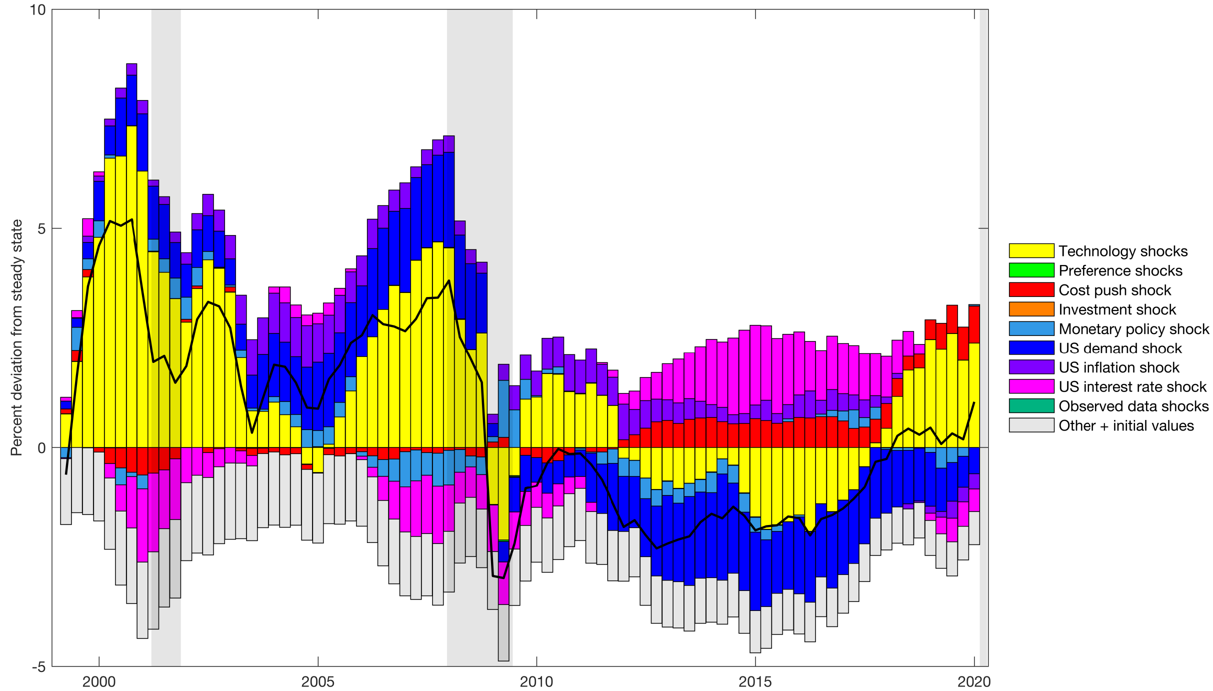

FIGURE 8. Historical shock decomposition of model GDP (Y_t^{GDP})

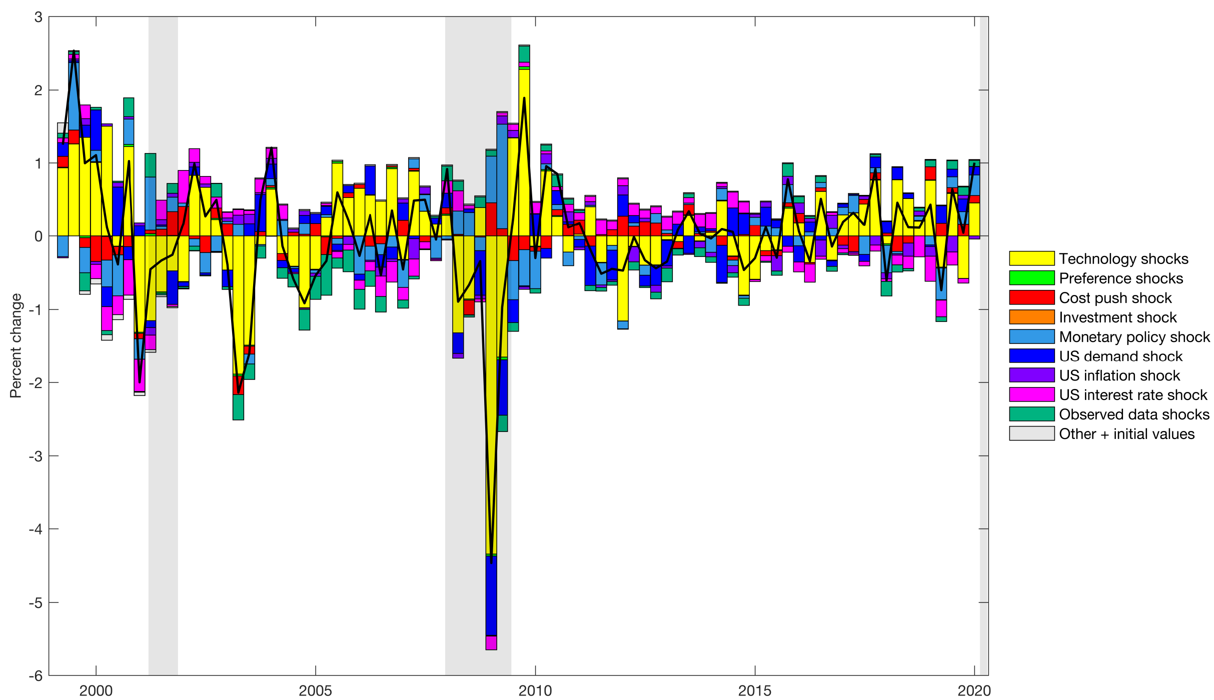

FIGURE 9. Historical shock decomposition of observed Korean GDP ($100 \times \Delta \ln Y_t^{GDP,obs}$)

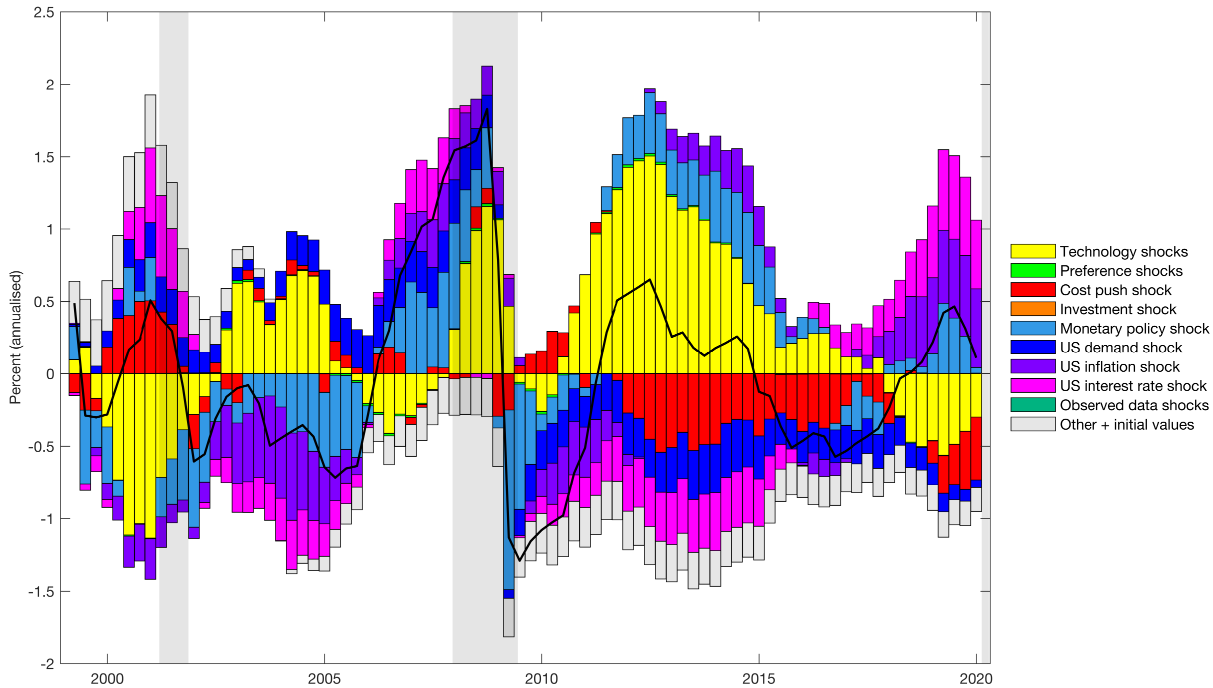

FIGURE 10. Historical shock decomposition of observed Korean interest rate ($100 \times \ln R_t^{obs}$)

Plot shows percentage point deviations from an average interest rate of 3.15% p.a..

5. Macroprudential Policy

Given the financial accelerator mechanism amplifying the effects of global financial cycles on real economic variables, a natural question to ask is what potential roles can macroprudential policies play in buffering a small open economy to foreign shocks. In particular, through the lens of the model, the domestic bank's position on foreign borrowing left it exposed to foreign financial shocks. Borrowing in foreign currency is referred to as "original sin", a term coined by Eichengreen, Hausmann, and Panizza (2007), and it is a topic of focus particularly in the context of EMEs. In this section, I look at policy tools to potentially limit original sin and financial instability arising from the global financial cycle. As described in Section 3, the model features two macroprudential instruments at the disposal of the domestic policymaker: taxes on foreign borrowing ($\tau_t^{D^*}$) and subsidies on bank net worth (τ_t^N).

The basic setup of these macroprudential tools is that the domestic policymaker can use a rule to set $\tau_t^{D^*}$, rebating domestic banks by allowing τ_t^N to adjust such that the government budget (Equation (31)) remains in balance.

5.1. Permanent tax policy

Table 5 presents results for taxes on foreign borrowing, showing the deterministic steady state quantities for a selection of key variables indicated by the first two columns, as well as stochastic steady state values.[33] The baseline regime is one where $\tau_t^{D*} = 0$; quantities and prices are just evaluated at the deterministic steady state following the parameter values in Tables 2-4. The tax regimes are when taxes on foreign borrowing are set at $\tau_t^{D^*} = 0.0025$ (0.25%) permanently. The figures in the brackets denote the unconditional standard deviation of the variables, when the model is subject to the shocks outlined in Table 4 at the estimated posterior mode. These values are attained by simulating the model by a second-order approximation about the deterministic steady state in order to capture the effects of uncertainty on household welfare.[34]

[33]The stochastic steady state is also commonly referred to as the "ergodic mean" or unconditional theoretical mean. In a stochastic steady state, agents anticipate recurrent arrivals of various shocks and choose the quantities as the function of the state variables; and when aggregate shocks never materialise, the economy settles in the stochastic steady state. There is a contradiction in the stochastic steady state: Even though agents anticipate aggregate shocks to arrive, the shocks never materialise (Aoki, Benigno, and Kiyotaki 2020).

[34]Though not discussed here, IRFs to a US interest rate shock for the estimated model with and without permanent taxes are available in the Appendix (Figure A20).

TABLE 5. Permanent tax on foreign borrowing

Variable	Steady state		Stochastic steady state	
	Baseline	Tax	Baseline	Tax
Y^{GDP}	3.726	3.691	3.746	3.708
			(6.619)	(5.018)
C	2.823	2.825	2.829	2.829
			(7.902)	(5.622)
L	0.405	0.402	0.406	0.403
			(4.603)	(3.734)
K	42.911	42.330	43.151	42.468
			(4.070)	(3.001)
I	0.858	0.847	0.863	0.849
			(6.620)	(5.128)
EX	0.840	0.812	0.840	0.812
			(4.448)	(4.618)
N	6.310	6.197	6.187	6.156
			(23.826)	(15.581)
Q	1.000	1.000	1.010	1.006
			(5.255)	(4.077)
D^*	4.350	0.406	3.353	-0.143
			(28.449)	(512.119)
ε	1.000	1.000	1.004	0.998
			(9.706)	(7.765)
R^k	1.012	1.012	1.012	1.012
			(1.426)	(1.125)
R	1.008	1.008	1.008	1.008
			(0.326)	(0.333)
π	1.000	1.000	1.000	1.000
			(0.437)	(0.440)

Values in parentheses are standard deviations of variables as a percentage of stochastic steady state quantities in absolute value.

At the deterministic steady state, there is no uncertainty and so prices are almost identical between the no-tax and tax regimes. As for the quantities with taxes, output is slightly lower due to lower investment and capital, as is bank net worth. However, the household consumes slightly more and supplies less labour. A key takeaway is that even a slight increase in the tax rate leads to a stark decline in the amount of foreign borrowing undertaken by domestic banks in the deterministic steady state. This is because even a small increase in $\tau_t^{D^*}$ is enough to close the gap between domestic and foreign interest rates. In the stochastic steady state, the emergence of uncertainty and shocks causes pronounced difference in the price of equity and the real exchange rate between the tax and no tax regimes: With no taxes, equity prices are 1% higher than in deterministic steady state, and domestic goods and service are depreciated relative to foreign bundles. Following this, the position of domestic banks' net foreign asset position flips. GDP with taxes are lower, however volatility in significantly lower – as are volatilities of most prices and quantities. The exceptions being net foreign debt, a product of the small unconditional mean value of D^*, and slightly higher volatility in inflation and interest rates.

To compare the welfare gains or losses from applying the tax on foreign debt, I compute the consumption equivalence factor, λ^{ce}, by making use of the GHH log preferences of the household and the recursive expression for welfare,

$$\mathbb{E}_t \mathbb{V}_t = u(C_t, L_t, \lambda^{ce}) + \beta \mathbb{E}_t \mathbb{V}_{t+1},$$

which defines a fixed point for welfare. Specifically, I find the value for λ^{ce} which equates the two quantities at the stochastic steady state:[35]

$$\mathbb{V}(C, L, \lambda^{ce})\big|_{no-tax} = \mathbb{V}(C, L)\big|_{tax}.$$

The consumption equivalence factor needed to make households indifferent pre and post application of the permanent foreign debt text is approximately:

$$\lambda^{ce} = -0.0063 = -0.63\%.$$

That is, households would require an additional 0.63% consumption in the no-tax stochastic steady state to be just as well off in a regime with the permanent tax on foreign debt. The takeaway is that despite the slightly higher volatility in inflation with the tax (0.003% higher standard deviation), the substantially lower volatility in primarily consumption and labour supply, lead to welfare gains for the household.

However, the tax can be harmful to household welfare if set too high. Repeating the above consumption equivalence exercise and setting $\tau_t^{D*} = 0.01$ leads to a consumption equivalence factor of $\lambda^{ce} = 0.026 = 2.63\%$. That is, households would be willing to give up 2.63% of their stochastic steady state (no tax) consumption to be just as well off had

[35]To be clear:

$$\begin{aligned} &\mathbb{V}(C, L, \lambda^{ce}) = \ln\left(C(1-\lambda^{ce}) - \frac{\zeta_0}{1+\zeta} L^{1+\zeta}\right) + \beta \mathbb{V}(C, L, \lambda^{ce}) \\ \implies &\mathbb{V}(C, L, \lambda^{ce}) = \frac{1}{1-\beta} u(C, L, \lambda^{ce}). \end{aligned}$$

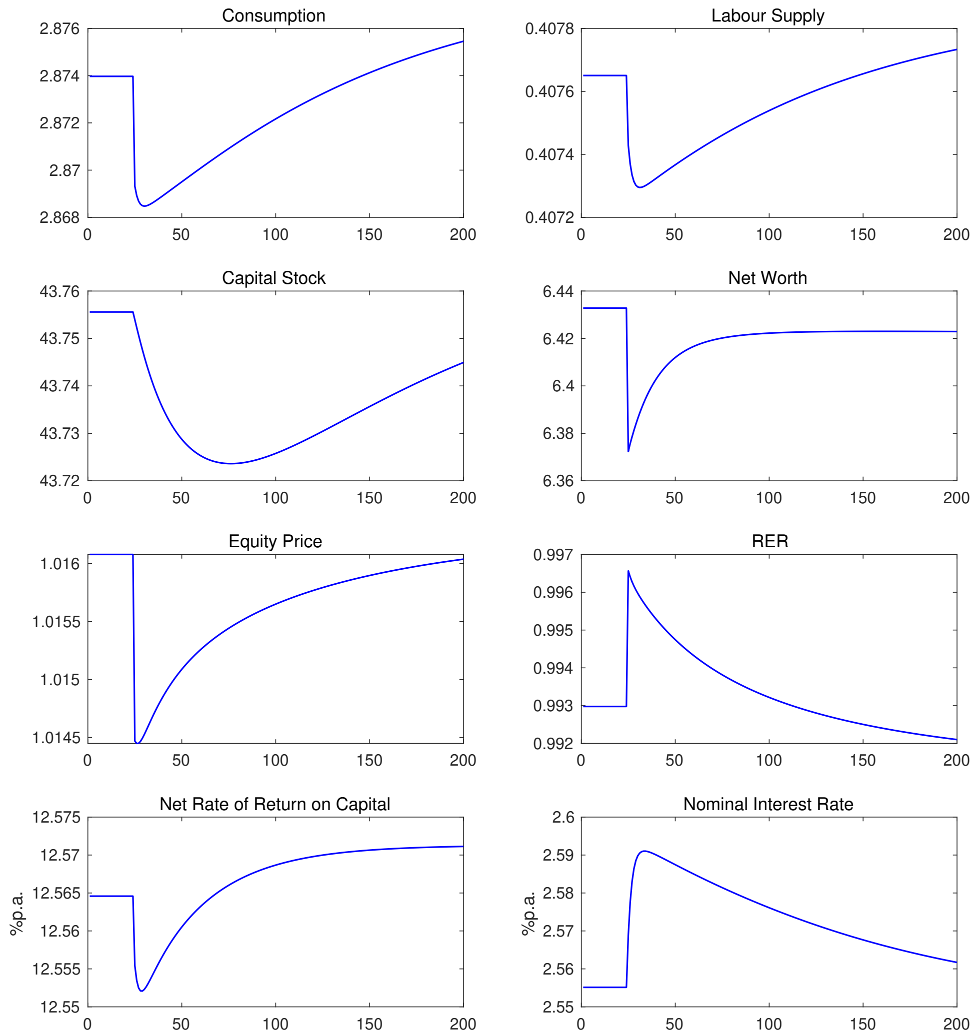

FIGURE 11. Stochastic steady state transition (permanent tax increase on foreign borrowings, $\tau_t^{D^*}$)

the tax been applied. Put another way, households would be willing to give up a small proportion of their consumption to avoid the implementation of the tax. This is because while the tax on foreign debt reduces volatility in the economy, it inhibits bankers in the model to borrow from abroad to provide equity finance to firms.

Next, to illustrate the transition path of key variables once taxes have been implemented, I plot the time path of key model variables in Figure 11. To do this, I first initialise the economy as starting in the baseline stochastic steady state. Then in period 25 an unexpected permanent increase of $\tau^{D^*} = 0.01\%$ is announced.[36] The economy then transitions to the new stochastic steady state.

[36]For computational accuracy, I restrict the size of the shock for the stochastic steady state analysis.

As the transition plots show, although agents are better off in the long run, the tax policy comes at a short term cost: consumption and labour initially decline before settling at a higher long term value. Additionally, macroeconomic prices fall quite sharply upon impact of the tax police change.

Although the welfare analysis in this section is quite simple, the potential benefits of macroprudential policies for the small open economy are quite evident. A tax on foreign borrowing – or to curb original sin for the case of an EME – can provide a sufficient buffer to the global financial cycle by reducing the potential exposure of domestic banks.

5.2. Cyclical tax policy

As an extension of simple macroprudential policies available to the small open economy, suppose that the tax on foreign borrowing, $\tau_t^{D^*}$, follows the following rule:

$$\tau_t^{D^*} = \omega_{D^*} \left(\ln K_t^b - \ln K^b \right) . \tag{42}$$

As stated in ABK, using this rule, taxes on foreign debt are an increasing function of the percent deviation of bank equity away from its deterministic steady state level. The intuition is that when bankers extend their investments in a credit boom, the policymaker raises the tax rate on bank foreign debt specifically. The reverse also holds true when bank equity undershoots its deterministic steady state level; whereby the tax becomes a subsidy on bank foreign debt positions.

Figure 12 shows model IRFs for a 1% annualised innovation to the foreign nominal interest rate for the model with and without a cyclical tax on foreign debt. Model parameters are again set following the estimation results. In the case of a cyclical tax on foreign debt, I set $\omega_{D^*} = 0.05$ following ABK.

With the cyclical tax in place, the domestic economy is generally able to attenuate the effects of a rise in US interest rates. The domestic central bank, arguably, is able to regain much of its monetary policy independence as after five quarters it lowers interest rates below steady state level in order to respond to the deflationary pressures in the domestic economy. The implementation of the cyclical tax leads to milder depreciations of both the nominal and real exchange rates – the depreciation is approximately half as small on impact with the tax. This places less pressure on the balance sheet constraint of the bank, with smaller increases in leverage and share of foreign assets. This results in a smaller decline in equity prices from banks lowering equity, and thus a smaller

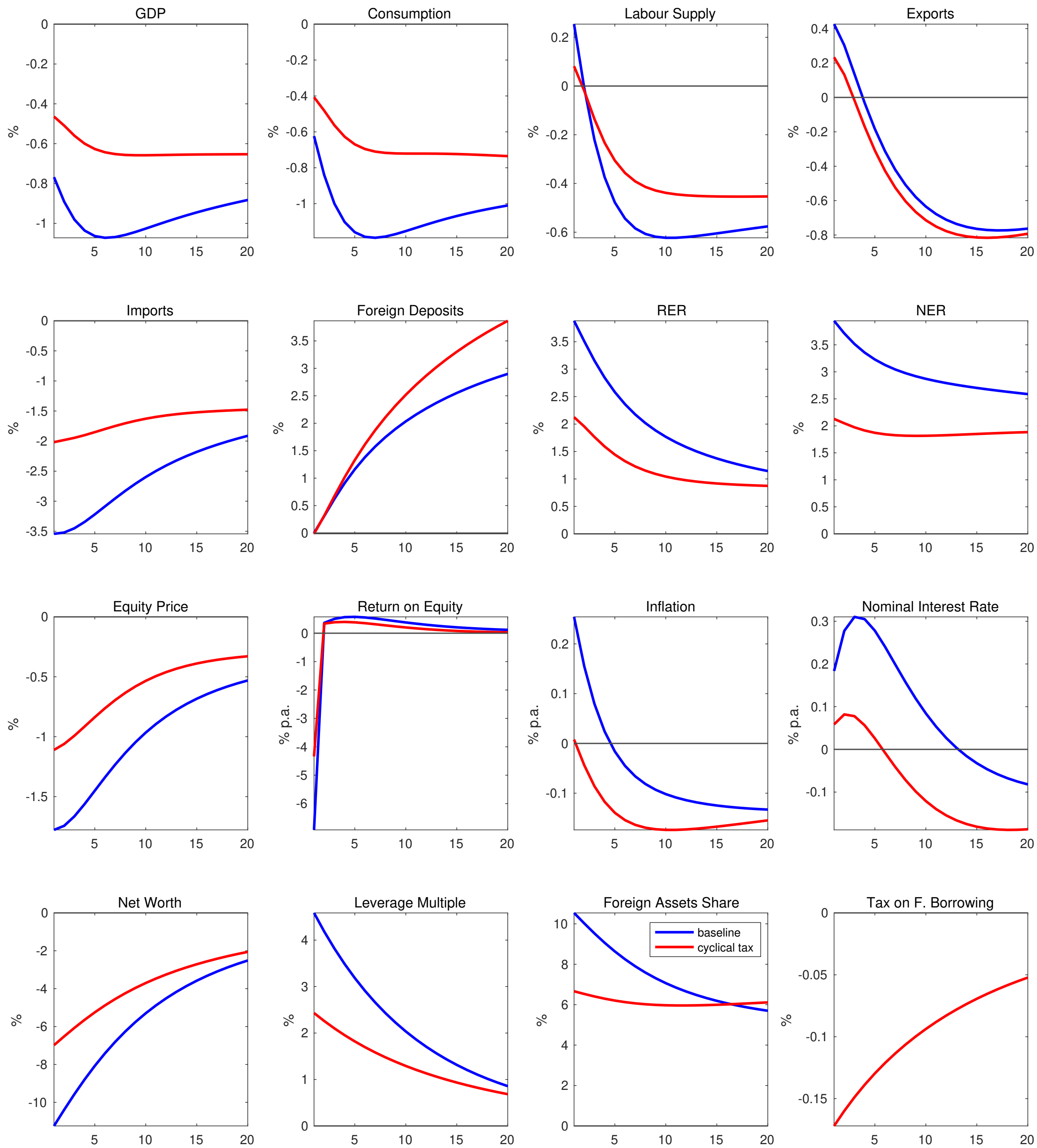

FIGURE 12. IRFs to an annualised 1% shock to the Foreign Interest Rate with and without cyclical tax policy

Variables are expressed in percent deviations from their non-stochastic steady state values. Model is calibrated at estimated posterior mode. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Blue line denotes baseline (no tax) model responses; red line denotes cyclical tax model responses.

decline in bank net worth. Note that the tax acts as a subsidy on foreign debt obligations of the domestic bank, as banks actually increase their liabilities to foreign depositors over the baseline no-tax case.

TABLE 6. Volatility and cyclical tax policy

Variable	Stochastic steady state	
	Baseline	Cyclical tax
Y^{GDP}	3.746	3.711
	(6.619)	(5.8922)
C	2.829	2.791
	(7.902)	(7.442)
L	0.406	0.404
	(4.603)	(4.378)
K	43.151	42.753
	(4.070)	(3.326)
EX	0.840	0.841
	(4.448)	(4.451)
N	6.187	6.207
	(23.826)	(16.164)
Q	1.010	1.000
	(5.255)	(3.770)
D^*	3.353	4.613
	(28.449)	(45.402)
ϵ	1.004	1.006
	(9.706)	(7.583)
R^k	1.012	1.012
	(1.426)	(0.904)
R	1.008	1.008
	(0.326)	(0.333)
π	1.000	1.000
	(0.437)	(0.419)

Values in parentheses are standard deviations of variables as a percentage of stochastic steady state quantities in absolute value.

To consider the other structural shocks and implications for welfare, Table 6 shows the stochastic steady state values and standard deviations (in percent) of key model variables with and without the cyclical tax policy. As before, a second-order approximation about the deterministic steady state and the unconditional means of the model were used to construct these values. GDP and consumption are slightly lower compared to the baseline model at the stochastic steady state. Volatility of GDP, consumption, labour, capital, and net worth is reduced; but this comes at the expensive of higher volatility in net foreign debt and the domestic interest rate. As before, to calculate whether or not the tax policy is welfare improve, I compute the consumption equivalence factor for

TABLE 7. Welfare costs of shocks (λ^{ce})

Shock	Baseline (%)	Cyclical tax (%)
ε^{A}	-6.037	-5.807
ε^{A^L}	-23.658	-21.740
ε^{A^I}	-65.121	-59.867
ε^{K}	-0.549	-0.547
$\varepsilon^{\mathcal{M}}$	-1.677	-1.659
ε^{h}	0.019	0.203
ε^{L}	2.200	2.113
ε^{R}	-1.456	-2.218
ε^{y^*}	-12.424	-11.950
ε^{π^*}	5.395	4.995
ε^{R^*}	31.373	28.918

Values denote percentage points of non-stochastic steady state consumption agents pay in order to maintain consumption equivalent welfare before a one standard deviation realisation of a structural shock.

the model with and without the tax. I find that consumption equivalence ratio to be:

$$\lambda^{ce} = 0.0082 = 0.82\%.$$

That is, households are worse off with the cyclical tax, and would be willing to pay up to 0.82% of their unconditional mean consumption to not have the cyclical tax regime.

To understand the sources of this welfare loss, Table 7 lists the consumption equivalence ratios for various structural shocks for the non-stochastic steady state. In other words, it is the fraction of steady state consumption agents would need to forfeit to avoid a realisation of a structural shock. The cyclical tax restricts the benefit of a positive realisation of the TFP, labour technology, IST, MEI, and foreign demand shocks. However, it does lessen the welfare cost of the labour preference, foreign inflation, and the US interest rate shock. So while it succeeds in limiting the exposure of the domestic financial sector to foreign financial shocks, it inhibits the economy to grow and households to smooth consumption for technology shock realisations.

6. Conclusion

This paper explored the Mundellian Trilemma vs Dilemma argument put forward most notably by Rey and Obstfeld, using a small open economy New Keynesian model estimated to Korean and US data. Underpinning the research were the following three questions: How do global financial cycles originating from the US affect a small open economy such as Korea? How effective is monetary policy in a financially integrated world, and can domestic monetary policy design shield the economy from global financial cycle shocks? What is the role of macroprudential or financial policies in buffering the domestic economy from these foreign financial shocks?

To begin answering these questions, the first finding of the paper is that the Korean economy is subject to the global financial cycle emanating from US monetary policy shocks. Empirical evidence suggests that an increase in US interest rates lead to a contraction in South Korean GDP. Despite a sharp depreciation of the Korean Won, the export channel – a prominent feature of the conventional Mundellian framework – does not lead to a recovery in domestic economic performance. This is a common feature of small open economies in the literature focusing on international spillover effects of US monetary policy shocks (Dedola, Rivolta, and Stracca 2017; Iacoviello and Navarro 2019; Miranda-Agrippino and Rey 2020). I also find mild empirical evidence suggesting that Korean credit spreads increase following the US monetary contraction and exchange rate depreciation – consistent with the global financial cycle narrative.

To explain the mechanism of international spillovers of US monetary policy shocks, the DSGE model in this paper features a banking sector that intermediates equity investment to firms funded by both domestic and foreign deposits. The model is able to account for both the Dilemma and conventional Trilemma hypotheses depending on parameters governing the export channel, the severity of financial frictions in the economy, and household labour supply. Taking the model to the data, it replicates the empirical findings and finds that US monetary policy shocks play a significant role in Korean macroeconomic conditions. For example, monetary easing by the Fed in the post-Global Financial Crisis period placed expansionary pressure on Korean monetary policy. Subsequently, the Fed's tapering of its Quantitative Easing and Large Scale Asset Purchase programs in early 2017 coincides with upward pressure on the Korean interest rate up until the COVID-19 pandemic.

Using the estimated models I then conduct a number of policy counterfactuals. Despite the emergence of the global financial cycle reducing the independence or effectiveness of domestic monetary policy, a key merit of the Mundellian Trilemma remains: Floating exchange rates outperform fixed exchange rates in terms of buffering the domestic economy from foreign monetary policy shocks, as argued by Obstfeld. Additionally, I find that macroprudential or financial policies levelled on the balance sheets of the domestic banking sector can help restore monetary policy independence from the global financial cycle. However, these policies bring with them a raft of other trade-offs. For example, a fixed tax on foreign debt which is set too high, or a cyclical tax that scales with the quantity of risky assets held by banks, may actually be welfare reducing. This is because while these policies address adverse effects of foreign interest rate shocks, they constrain the economy from adjusting productive capital and ultimately inhibit the consumption smoothing of domestic households.

But potential research questions and challenges remain. First, the model solution and estimation techniques I employed are all linear; yet there are two significant sources of non-linearities that I have not addressed: the effective lower bound on US interest rates and the assumption that the banker's incentive compatibility constraint is always binding in equilibrium. While the issue of the effective lower bound is well documented, research on the latter is on-going and active with potentially significant policy implications (see, for example, Bocola (2016); Akinci and Queralto (2022); Akinci et al. (2023)). Next is the omission of unconventional monetary policy and sophisticated fiscal policy in the model. This was a conscientious choice as model tractability was a priority. In a similar vein, the setup of the firm is kept simple and there is no consideration for dominant currency pricing (Gopinath et al. 2020). Labour supply and household preferences are also modelled simply, with the advantages being straightforward analytical derivations. However, moving to a more general additive-separate specification of household utility (such as constant relative risk aversion with habits) and including unemployment would allow the model to account for more realistic dynamics. Modelling such labour markets in tandem with accounting for occasionally binding constraints would allow for a potentially more robust estimation as labour supply is a key variable for equity returns.

Finally, I do not consider foreign exchange interventions as part of the domestic central bank's toolkit. Blanchard et al. (2016) show that monetary policy and foreign exchange interventions can circumvent the need for capital controls and macroprudential policy, preserving the Trilemma. These shortcomings and limitations are left to future research.

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Appendix A. Model equations and solutions

A.1. Household optimisation problem

The FOCs for labour, savings in equity, and deposits which emerge from the representative household problem are:

$$w_t = \zeta_0 L_t^{\zeta} \exp\left(\xi_t^L\right), \tag{A1}$$

$$1 = \Lambda_{t,t+1} \frac{z_{t+1}^k + \lambda Q_{t+1}}{Q_t + \varkappa^h \frac{K_t^h}{K_t}}, \tag{A2}$$

$$1 = \Lambda_{t,t+1} \frac{R_t}{\pi_{t+1}}, \tag{A3}$$

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

$$\Lambda_{t,t+1} = \beta \mathbb{E}_t \left[\frac{\exp\left(\xi_{t+1}^h\right)}{\exp\left(\xi_t^h\right)} \left(\frac{C_t - \frac{\zeta_0}{1+\zeta} \exp\left\{\xi_t^L\right\} L_t^{1+\zeta}}{C_{t+1} - \frac{\zeta_0}{1+\zeta} \exp\left(\xi_{t+1}^L\right) L_{t+1}^{1+\zeta}} \right) \right]. \tag{A4}$$

A.2. Firms and production

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

$$\max_{Y_t(i)} P_t Y_t - \int_0^1 P_t Y_t(i) di.$$

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:

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\eta} Y_t,$$

where $P_t(i)$ is the price for good i, and P_t is the price index for the aggregate economy and is defined as:

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

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

$$\min_{K_{t-1}(i),M_t(i),L_t(i)} z_t^k K_{t-1}(i) + \epsilon_t M_t(i) + w_t L_t(i),$$

subject to:

$$A_t \left(\frac{K_{t-1}(i)}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_t(i)}{\alpha_M}\right)^{\alpha_M} \left(\frac{A_t^L L_t(i)}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M} - A_t^f c_f(i) \geq Y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\eta} Y_t.$$

The Lagrangian for intermediate firm i's problem is:

$$\mathcal{L} = z_t^k K_{t-1}(i) + \epsilon_t M_t(i) + w_t L_t(i) - mc_t(i)\left[Y_t(i) - \left(\frac{P_t(i)}{P_t}\right)^{-\eta} Y_t\right]$$

The FOCs to this problem are:

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial K_{t-1}(i)} &: z_t^k = mc_t(i) A_t \left(\frac{K_{t-1}(i)}{\alpha_K}\right)^{\alpha_K - 1} \left(\frac{M_t(i)}{\alpha_M}\right)^{\alpha_M} \left(\frac{A_t^L L_t(i)}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M}, \\
\frac{\partial \mathcal{L}}{\partial M_t(i)} &: \epsilon_t = mc_t(i) A_t \left(\frac{K_{t-1}(i)}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_t(i)}{\alpha_M}\right)^{\alpha_M - 1} \left(\frac{A_t^L L_t(i)}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M}, \\
\frac{\partial \mathcal{L}}{\partial L_t(i)} &: w_t = mc_t(i) A_t^L A_t \left(\frac{K_{t-1}(i)}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_t(i)}{\alpha_M}\right)^{\alpha_M} \left(\frac{A_t^L L_t(i)}{1-\alpha_K-\alpha_M}\right)^{-\alpha_K-\alpha_M}.
\end{aligned}$$

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

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

by optimally choosing $P_t(i)$. Differentiating $\mathbb{V}_t^I$ with respect to $P_t(i)$ yields the following FOC:

$$\begin{aligned}
\frac{\mathbb{V}_t^I}{\partial P_t(i)} : \kappa \left(\frac{P_t(i)}{P_{t-1}(i)} - 1\right) \frac{Y_t}{P_{t-1}(i)} &= \frac{1}{P_t}\left(\frac{P_t(i)}{P_t}\right)^{-\eta} - \eta \left(\frac{P_t(i)}{P_t} - (1-\tau^s) mc_t\right) \left(\frac{P_t(i)}{P_t}\right)^{-\eta-1} \frac{Y_t}{P_t} \\
&\quad + \kappa \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{P_{t+1}(i)}{P_t(i)} - 1\right) Y_{t+1} \frac{P_{t+1}(i)}{P_t(i)^2}\right].
\end{aligned}$$

As all firms engage in identical pricing, this gives Equation (24) in the text.

The New Keynesian Phillips Curve. If we log linearise (24) about the non-inflationary steady state, one can yield the standard NKPC. To show this, totally differentiate (24):

$$(2\pi - 1)d\pi_t = \frac{\eta - 1}{\kappa} dmc_t + \frac{(\eta - 1)(1 - \tau^S)mc}{\kappa} d\mathcal{M}_t + \beta(2\pi - 1)\mathbb{E}_t d\pi_{t+1},$$

where $\pi = mc = (1 - \tau^S)\mathcal{M} = 1$, and so we have

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

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

To setup the problem of the banker as in Section 3.2.2, first iterate the banker's flow of funds constraint (6) forward by one period, and then divide through by n_t to yield:

$$\begin{aligned}
\frac{n_{t+1}}{n_t} &= \frac{z^k_{t+1} + \lambda Q_{t+1}}{Q_t} \frac{Q_t k^b_t}{n_t} - \frac{R_t}{\pi_{t+1}} \frac{d_t}{n_t} - \frac{R^*_t}{\pi^*_{t+1}} \frac{\epsilon_{t+1}}{\epsilon_t} \frac{\epsilon_t d^*_t}{n_t} \\
&= \frac{z^k_{t+1} + \lambda Q_{t+1}}{Q_t} \phi_t - \frac{R_t}{\pi_{t+1}} \frac{d_t}{n_t} - \frac{R^*_t}{\pi^*_{t+1}} \frac{\epsilon_{t+1}}{\epsilon_t} \frac{\epsilon_t d^*_t}{n_t}.
\end{aligned}$$

Rearrange the balance sheet constraint (5), and use the fact that $\epsilon_t d^*_t / n_t = x_t \phi_t$, to write the following:

$$\frac{d_t}{n_t} = \left(1 + \frac{\varkappa^b}{2} x_t^2\right) \phi_t + \phi_t - (1 - \tau^{D^*}_t) x_t \phi_t - (1 + \tau^N_t).$$

Substitute this value for d_t/n_t back into the expression for n_{t+1}/n_t to get:

$$\frac{n_{t+1}}{n_t} = \left(\frac{z^k_{t+1} + \lambda Q_{t+1}}{Q_t} - \frac{R_t}{\pi_{t+1}}\right)\phi_t + \left(1 + \tau^N_t - \frac{\varkappa^b}{2}x_t^2\phi_t\right)\frac{R_t}{\pi_{t+1}} + \left[(1-\tau^{D^*}_t)\frac{R_t}{\pi_{t+1}} - \frac{R^*_t}{\pi^*_{t+1}}\frac{\epsilon_{t+1}}{\epsilon_t}\right]x_t\phi_t.$$

Substituting this expression into (8), yields the following:

$$\begin{aligned}\psi_t &= \mathbb{E}_t\left[\Lambda_{t,t+1}(1-\sigma+\sigma\psi_{t+1})\left\{\begin{array}{c}\left(\frac{z^k_{t+1}+\lambda Q_{t+1}}{Q_t} - \frac{R_t}{\pi_{t+1}}\right)\phi_t + \left(1+\tau^N_t - \frac{\varkappa^b}{2}x_t^2\phi_t\right)\frac{R_t}{\pi_{t+1}} \\ + \left[(1-\tau^{D^*}_t)\frac{R_t}{\pi_{t+1}} - \frac{R^*_t}{\pi^*_{t+1}}\frac{\epsilon_{t+1}}{\epsilon_t}\right]x_t\phi_t.\end{array}\right\}\right] \\ &= \mu_t\phi_t + \left(1+\tau^N_t - \frac{\varkappa^b}{2}x_t^2\phi_t\right)\upsilon_t + \mu^*_t x_t\phi_t,\end{aligned}$$

which sets up (10) in the text.

With $\mu_t, \mu^*_t > 0$, the banker's incentive constraint binds with equality, and so we can write the Lagrangian as:

$$\mathcal{L} = \psi_t + \lambda_t(\psi_t - \theta\phi_t),$$

where λ_t is the Lagrangian multiplier. The FOCs with respect to ϕ_t and x_t are:

$$\frac{\partial\mathcal{L}}{\partial\phi_t} : (1+\lambda_t)\left[\mu_t + \mu^*_t x_t - \frac{\varkappa^b}{2}x_t^2\upsilon_t\right] = \lambda_t\theta, \tag{A5}$$

$$\frac{\partial\mathcal{L}}{\partial x_t} : \varkappa^b x_t\upsilon_t - \mu^*_t = 0, \tag{A6}$$

$$\frac{\partial\mathcal{L}}{\partial\lambda_t} : \psi_t = \theta\phi_t. \tag{A7}$$

Use (A7) and substitute into the banker's objective function to yield:

$$\phi_t = \frac{(1+\tau^N_t)\upsilon_t}{\theta - \mu_t - \mu^*_t x_t + \frac{\varkappa^b}{2}x_t^2\upsilon_t},$$

which then gives (12).

A.4. Shock processes

The stochastic shock processes in the model are:

$$
\begin{aligned}
\xi_t^h &= \rho_h \xi_{t-1}^h + \varepsilon_t^h, \quad \varepsilon_t^h \sim \text{IID}(0, \sigma_h^2), \\
\xi_t^L &= \rho_L \xi_{t-1}^L + \varepsilon_t^L, \quad \varepsilon_t^L \sim \text{IID}(0, \sigma_L^2), \\
\xi_t^K &= \rho_K \xi_{t-1}^K + \varepsilon_t^K, \quad \varepsilon_t^K \sim \text{IID}(0, \sigma_K^2), \\
\ln \mathcal{M}_t &= (1 - \rho_{\mathcal{M}}) \ln \mathcal{M} + \rho_{\mathcal{M}} \ln \mathcal{M}_{t-1} + \varepsilon_t^{\mathcal{M}}, \quad \varepsilon_t^{\mathcal{M}} \sim \text{IID}(0, \sigma_{\mathcal{M}}^2), \\
\ln A_t &= (1 - \rho_A) \ln A + \rho_A \ln A_{t-1} + \varepsilon_t^A, \quad \varepsilon_t^A \sim \text{IID}(0, \sigma_A^2), \\
\ln A_t^L &= (1 - \rho_{A^L}) \ln A^L + \rho_{A^L} \ln A_{t-1}^L + \varepsilon_t^{A^L}, \quad \varepsilon_t^{A^L} \sim \text{IID}(0, \sigma_{A^L}^2), \\
\ln A_t^I &= (1 - \rho_{A^I}) \ln A^I + \rho_{A^I} \ln A_{t-1}^I + \varepsilon_t^{A^I}, \quad \varepsilon_t^{A^I} \sim \text{IID}(0, \sigma_{A^I}^2), \\
\varepsilon_t^R &\sim \text{IID}(0, \sigma_R^2), \\
\varepsilon_t^{y^*} &\sim \text{IID}(0, \sigma_{y^*}^2), \\
\varepsilon_t^{\pi^*} &\sim \text{IID}(0, \sigma_{\pi^*}^2), \\
\varepsilon_t^{R^*} &\sim \text{IID}(0, \sigma_{R^*}^2).
\end{aligned}
$$

A.5. Steady state

This appendix outlines the non-stochastic steady state of the model economy. It is broadly based on the solution method of ABK, though I make explicit the expressions for steady state inflation and tax rates for future optimal policy extensions. As the model abstracts from trend inflation, we can write:

$$
\begin{aligned}
\pi &= 1 + \pi = 1, \\
\pi^* &= 1 + \pi^* = 1,
\end{aligned}
$$

and

$$
\begin{aligned}
E &= 1, \\
\epsilon &= 1.
\end{aligned}
$$

Then from (26) when $I_t = I$ we have:

$$
Q = 1.
$$

Then from the household Euler equation (A3), we get:

$$\frac{R}{\pi} = \frac{1}{\beta}.$$

In equilibrium, the incentive compatibility constraint of the bank (4) is binding. Define the discounted spread between equity and domestic deposits, s, and the discounted spread between foreign deposits and domestic deposits, s^*, as:

$$s = \beta[z^k + (1 - \delta)] - \beta\frac{R}{\pi} = \beta[z^k + (1 - \delta)] - 1, \tag{A8}$$

$$s^* = \beta\frac{R}{\pi} - \beta\frac{R^*}{\pi^*} = 1 - \beta\frac{R^*}{\pi^*}, \tag{A9}$$

which is considered to be endogenous and exogenous, respectively.

From the household's FOC with respect to equity, (A2), we have:

$$\begin{aligned} 1 &= \beta\left[\frac{z^k + (1 - \delta)}{1 + \varkappa^h \frac{K^h}{K}}\right] \\ 1 + \varkappa^h\frac{K^h}{K} &= \beta\left[z^k + (1 - \delta)\right] \\ \frac{K^h}{K} &= \frac{s}{\varkappa^h}. \end{aligned} \tag{A10}$$

Additionally, in steady state we have:

$$\begin{aligned} \Omega &= \beta(1 - \sigma + \sigma\psi), \\ \upsilon &= \frac{\Omega}{\beta}, \\ \mu &= \Omega\left[z^k + (1 - \delta) - \frac{1}{\beta}\right], \\ \mu^* &= \Omega\left[(1 - \tau^{D^*})\frac{1}{\beta} - \frac{R^*}{\pi^*}\right], \end{aligned}$$

and so, using (A8) and (A9), we can write:

$$\begin{aligned} \frac{\mu}{\upsilon} &= s, \\ \frac{\mu^*}{\upsilon} &= s^* - \tau^{D^*}. \end{aligned}$$

Then, from (13) we can write:

$$x = \frac{s^* - \tau^{D^*}}{\varkappa^b}.$$

Next, use the fact that the government maintains a balanced budget through taxes and subsidies,[37] define J as:

$$J = \frac{n_{t+1}}{n_t} = \left[z^k + (1-\delta)\right]\frac{K^b}{N} - \frac{R}{\pi}\frac{D}{N} - \frac{R^*}{\pi^*}\frac{D^*}{N},$$

and use the following:

$$\begin{aligned}\frac{D}{N} &= \frac{\varkappa^b}{2}\phi x^2 + \phi - x\phi - 1,\\ \phi &= \frac{K^b}{N},\\ \frac{D^*}{N} &= \phi x,\end{aligned}$$

to write J as:

$$\begin{aligned}J &= \left(z^k + (1-\delta) - \frac{R}{\pi}\right)\phi + \left(1 - \frac{\varkappa^b}{2}x^2\phi\right)\frac{R}{\pi} + \left(\frac{R}{\pi} - \frac{R^*}{\pi^*}\right)x\phi\\ &= \frac{1}{\beta}\left[p(s, s^*, \tau^{D^*})\phi + 1\right],\end{aligned}$$

where

$$p(s, s^*, \tau^{D^*}) \equiv s + s^* x - \frac{\varkappa^b}{2}x^2$$

is defined as the return premium.

[37] Also assume a revenue neutrality condition:

$$\tau^s Y = \tau.$$

Then, from (36) we have:

$$
\begin{aligned}
N &= \sigma \left\{ \left[z^k + (1-\delta) \right] K^b - \frac{R}{\pi} D - \frac{R^*}{\pi^*} D^* \right\} + \gamma \left[z^k + (1-\delta) \right] K \\
\frac{N}{N} &= \sigma \left\{ \left[z^k + (1-\delta) \right] \frac{K^b}{N} - \frac{R}{\pi} \frac{D}{N} - \frac{R^*}{\pi^*} \frac{D^*}{N} \right\} + \frac{\gamma}{N} \left[z^k + (1-\delta) \right] K \\
\beta &= \sigma\beta J + \frac{\gamma}{N} \beta \left[z^k + (1-\delta) \right] K \\
&= \sigma\beta J + \frac{\gamma K^b}{N} \left(1 + \varkappa^h \frac{K^h}{K} \right) \frac{K}{K^b} \\
&= \sigma\beta J + \gamma(1+s)\phi \frac{1}{\frac{K^b}{K}} \\
&= \sigma\beta J + \gamma(1+s)\phi \frac{1}{\frac{K-K^h}{K}} \\
&= \sigma \left[p(s, s^*, \tau^{D^*})\phi + 1 \right] + \gamma(1+s)\phi \frac{1}{1 - \frac{s}{\varkappa^h}} \\
\beta &= \sigma + \left[\sigma\, p(s, s^*, \tau^{D^*}) + \gamma \frac{1+s}{1 - \frac{s}{\varkappa^h}} \right] \phi,
\end{aligned}
$$

or

$$
\phi = \frac{\beta - \sigma}{\sigma\, p(s, s^*, \tau^{D^*}) + \gamma \frac{1+s}{1 - \frac{s}{\varkappa^h}}}.
$$

Equation (8) in steady state gives us:

$$
\begin{aligned}
\psi &= \beta(1 - \sigma + \sigma\psi) J \\
&= \beta J - \beta\sigma J + \beta\sigma\psi J \\
&= \beta(1-\sigma) J + \beta\sigma\psi J \\
&= \frac{\beta(1-\sigma) J}{1 - \beta\sigma J} \\
&= \frac{(1-\sigma) \left[p(s, s^*, \tau^{D^*})\phi + 1 \right]}{1 - \sigma \left[p(s, s^*, \tau^{D^*})\phi + 1 \right]} \\
&= \frac{(1-\sigma) \left[p(s, s^*, \tau^{D^*})\phi + 1 \right]}{1 - \sigma - \sigma\, p(s, s^*, \tau^{D*})\phi},
\end{aligned}
$$

and from (11) we have

$$
\psi = \theta\phi.
$$

Combine the expressions for ϕ and ψ to get:

$$\frac{\theta(\beta-\sigma)}{\sigma\, p(s,s^*,\tau^{D^*})+\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}} = \frac{(1-\sigma)\left[\frac{p(s,s^*,\tau^{D^*})(\beta-\sigma)}{\sigma\, p(s,s^*,\tau^{D^*})+\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}}+1\right]}{1-\sigma-\sigma\left[\frac{p(s,s^*,\tau^{D^*})(\beta-\sigma)}{\sigma\, p(s,s^*,\tau^{D^*})+\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}}\right]},$$

then rearrange:

$$\begin{aligned}
0 &= H(s,s^*,\tau^{D^*}) \\
&= (1-\sigma)\left[\beta\, p(s,s^*,\tau^{D^*})+\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}\right]\left[\sigma\, p(s,s^*,\tau^{D^*})+\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}\right] \\
&\quad -\theta(\beta-\sigma)\left[\sigma(1-\beta)\, p(s,s^*,\tau^{D^*})+(1-\sigma)\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}\right].
\end{aligned}$$

In the absence of any taxes or subsidies, and as $\theta \to 0$, we can write the risk premium as

$$p(s,s^*,0) \to s+\frac{(s^*)^2}{2\varkappa^b},$$

and

$$\begin{aligned}
H(s,s^*,0) = (1-\sigma)&\left[\beta\left(s+\frac{(s^*)^2}{2\varkappa^b}\right)+\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}\right]\left[\sigma\left(s+\frac{(s^*)^2}{2\varkappa^b}\right)+\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}\right] \\
&-\theta(\beta-\sigma)\left[\sigma(1-\beta)\left(s+\frac{(s^*)^2}{2\varkappa^b}\right)+(1-\sigma)\gamma\frac{1+s}{1-\frac{s}{\varkappa^h}}\right].
\end{aligned}$$

We can observe that as $\gamma \to 0$,

$$\begin{aligned}
&H(s,s^*,0) = (1-\sigma)\left(s+\frac{(s^*)^2}{2\varkappa^b}\right)^2\beta\sigma-\theta(\beta-\sigma)\left[\sigma(1-\beta)\left(s+\frac{(s^*)^2}{2\varkappa^b}\right)\right] \\
\implies\ & s+\frac{(s^*)^2}{2\varkappa^b} \to \theta\frac{(\beta-\sigma)(1-\beta)}{(1-\sigma)\beta}.
\end{aligned}$$

Thus, there exists a unique steady state equilibrium with positive spread $s > 0$ for a small enough γ, s^*, and tax rates.

Given s, we then yield:

$$z^k = \frac{1}{\beta}(1+s) - (1-\delta).$$

In the steady state, we know

$$MC \equiv \frac{1}{(1-\tau^s)\mathcal{M}}.$$

Then use (20), (21), (22), and (23) to write $MC \times Y$ as

$$\frac{Y}{(1-\tau^s)\mathcal{M}} = \frac{z^k K}{\alpha_K} MC - \frac{A^f c_f}{(1-\tau^s)\mathcal{M}},$$

to get the capital-output ratio

$$\frac{K}{Y} = \frac{\alpha_K}{z^k}.$$

In absence of trend inflation note that $c_f = Y(1/MC - 1)$ (Christiano, Trabandt, and Walentin 2011).

From (22), (23), and (A1), write

$$M = \frac{\alpha_M}{\alpha_K}\frac{z^k K}{\epsilon},$$

$$L = \left(\frac{\alpha_L}{\alpha_K}\frac{z^k K}{\zeta_0}\right)^{\frac{1}{1+\zeta}},$$

and combine these with (21) to get

$$z^k = \left\{ \left(\left\{ 1 + A^f \left[(1-\tau^s)\mathcal{M} - 1 \right] \right\} \frac{Y \epsilon^{\alpha_M}}{A} \right)^{1+\zeta} \left(\frac{\alpha_K}{K} \right)^{1+\zeta(\alpha_K+\alpha_M)} \left(\frac{\alpha_L^{\zeta} \zeta_0}{(A^L)^{1+\zeta}} \right)^{\alpha_L} \right\}^{\frac{1}{1-\alpha_K+\zeta\alpha_M}}.$$

Use the above expression for z^k and combine it with (20), (21), and (A1) to get:

$$MC = \left\{ \begin{array}{l} \left[\frac{\epsilon^{\alpha_M}}{A} \left(\frac{\alpha_K Y \left\{ 1 + A^f \left[(1-\tau^s)\mathcal{M} - 1 \right] \right\}}{K} \right)^{\alpha_K} \right]^{1+\zeta} \\ \times \left(\frac{\left[\alpha_L Y \left\{ 1 + A^f \left[(1-\tau^s)\mathcal{M} - 1 \right] \right\} \right]^{\zeta} \zeta_0}{(A^L)^{1+\zeta}} \right)^{\alpha_L} \end{array} \right\}^{\frac{1}{1-\alpha_K+\zeta\alpha_M}}.$$

Rearrange this to write

$$Y = \frac{(A^L)^{\frac{1+\zeta}{\zeta}}}{\alpha_L \left\{1 + A^f \left[(1-\tau^s)\mathcal{M} - 1\right]\right\} \zeta_0^{\frac{1}{\zeta}}}$$
$$\times \left\{ MC^{1-\alpha_K+\zeta\alpha_M} \left(\frac{A}{\epsilon^{\alpha_M}(z^k)^{\alpha_K} \left\{1 + A^f \left[(1-\tau^s)\mathcal{M} - 1\right]\right\}^{\alpha_K}} \right)^{1+\zeta} \right\}^{\frac{1}{\zeta\alpha_L}}.$$

Under the baseline calibration, $A^f = 1$, $\tau^s = 0$, and $MC = 1 - \frac{1}{\eta}$, allowing the above expression to be written in a more compact form.

With s we then get K^h/K, which allows us to get K and K^h. We also get

$$I = (1-\lambda)K = (1-\lambda)\alpha_K \frac{Y}{z^k},$$

and

$$K^b = K - K^h.$$

Use (27) and (35) to write

$$\frac{\epsilon^\varphi Y^*}{Y} = \frac{\epsilon M}{Y} + \left(\frac{R^*}{\pi^*} - 1\right)\frac{\epsilon D^*}{Y}.$$

Then note from (39), we have

$$\epsilon D^* = xQK^b = x\phi N.$$

Combine this with our expressions for the capital-output ratio and M to write $\frac{\epsilon^\varphi Y^*}{Y}$ as

$$\frac{\epsilon^\varphi Y^*}{Y} = \alpha_M + \left(\frac{R^*}{\pi^*} - 1\right) x \left(1 - \frac{s}{\varkappa^h}\right)\frac{K}{Y}.$$

Then, from the aggregate resource constraint (33), we have

$$\frac{C}{Y} = 1 - (1-\lambda)\frac{K}{Y} - \epsilon^\varphi \frac{Y^*}{Y} - \frac{s^2}{2\varkappa^h}\frac{K}{Y} - \frac{\varkappa^b}{2}x^2\left(1 - \frac{s}{\varkappa^h}\right)\frac{K}{Y}.$$

A.6. Additional IRFs

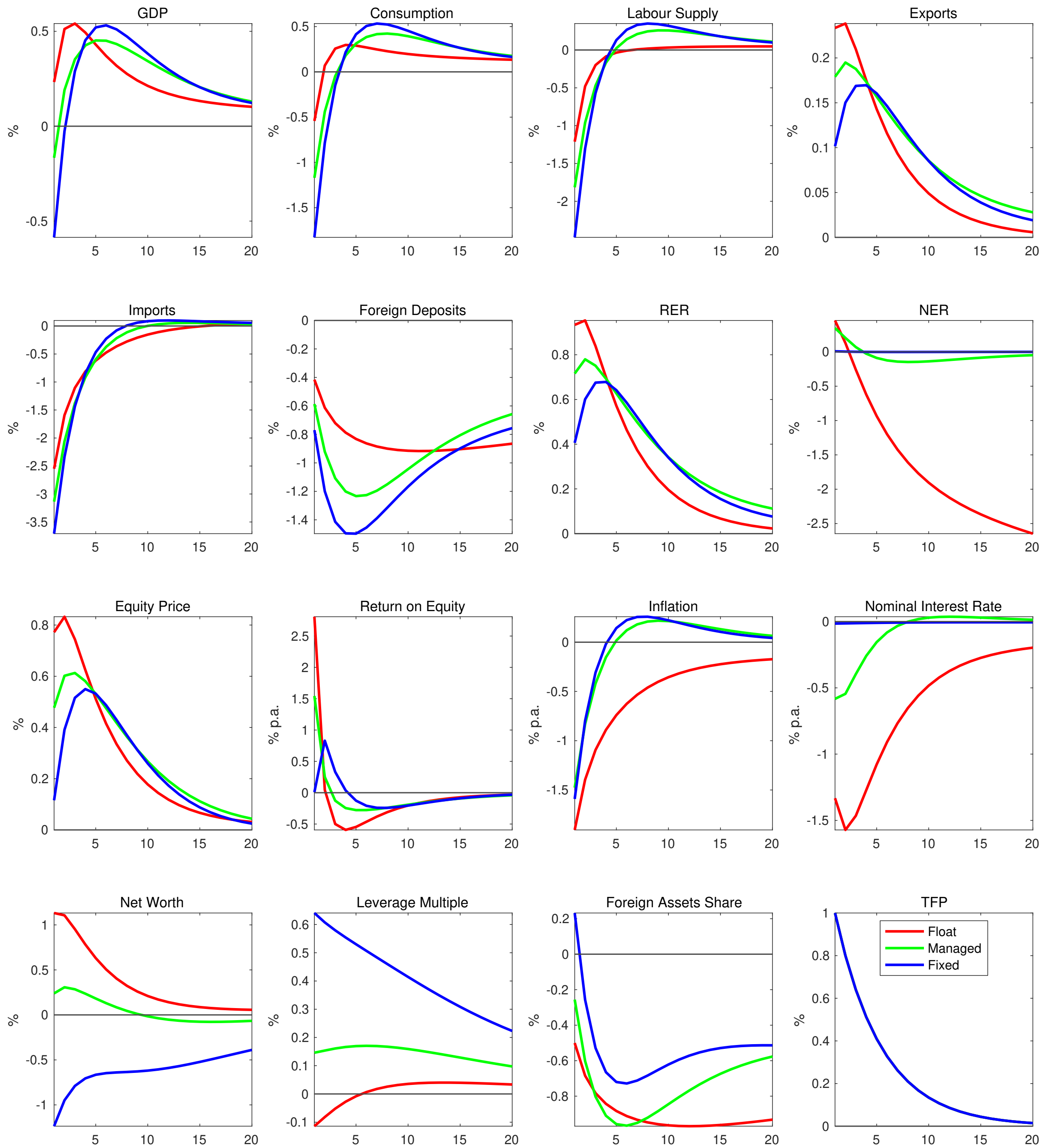

FIGURE A1. IRFs to a 1% innovation to TFP

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

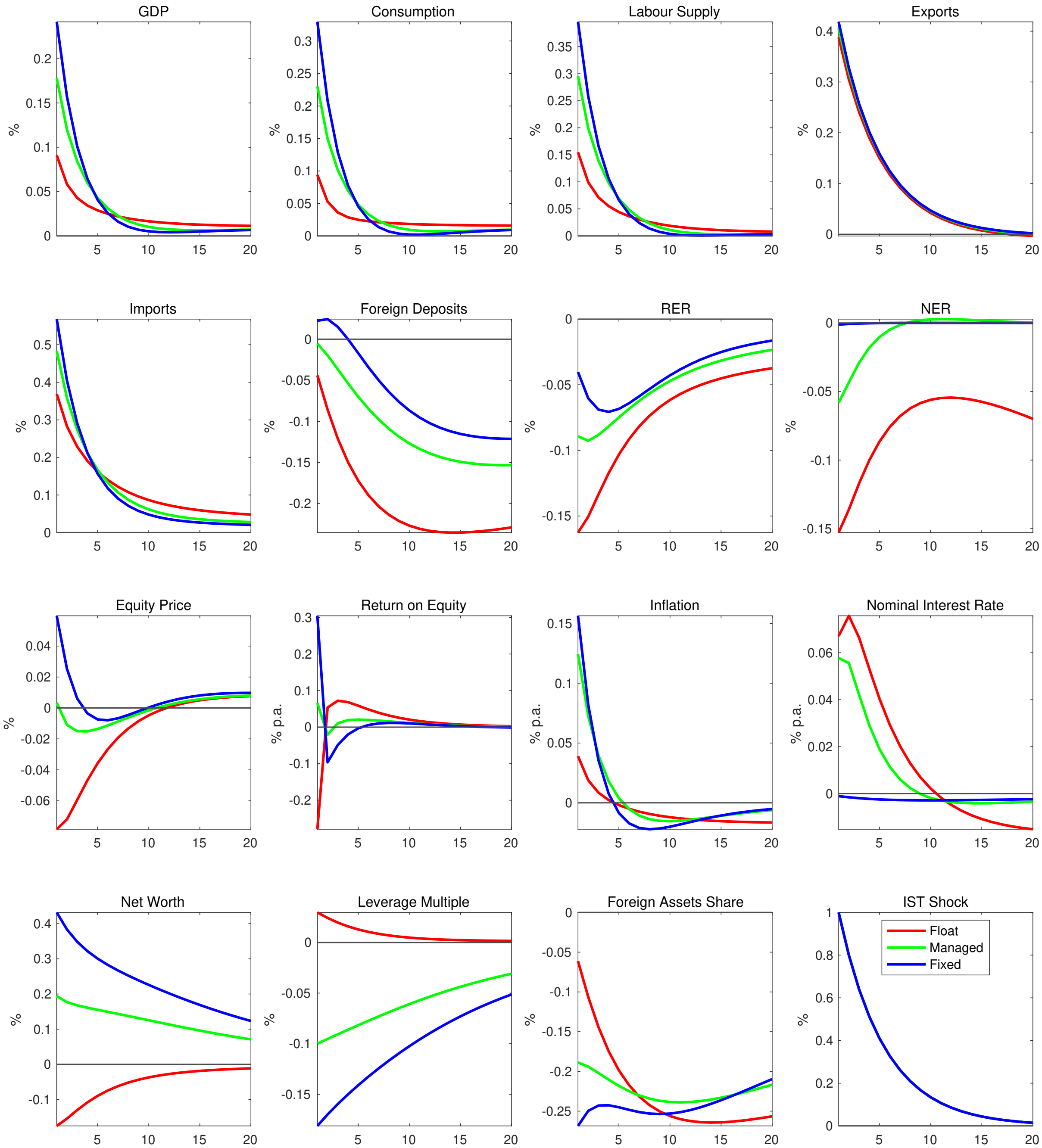

FIGURE A2. IRFs to a 1% innovation to Investment Specific Technology

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

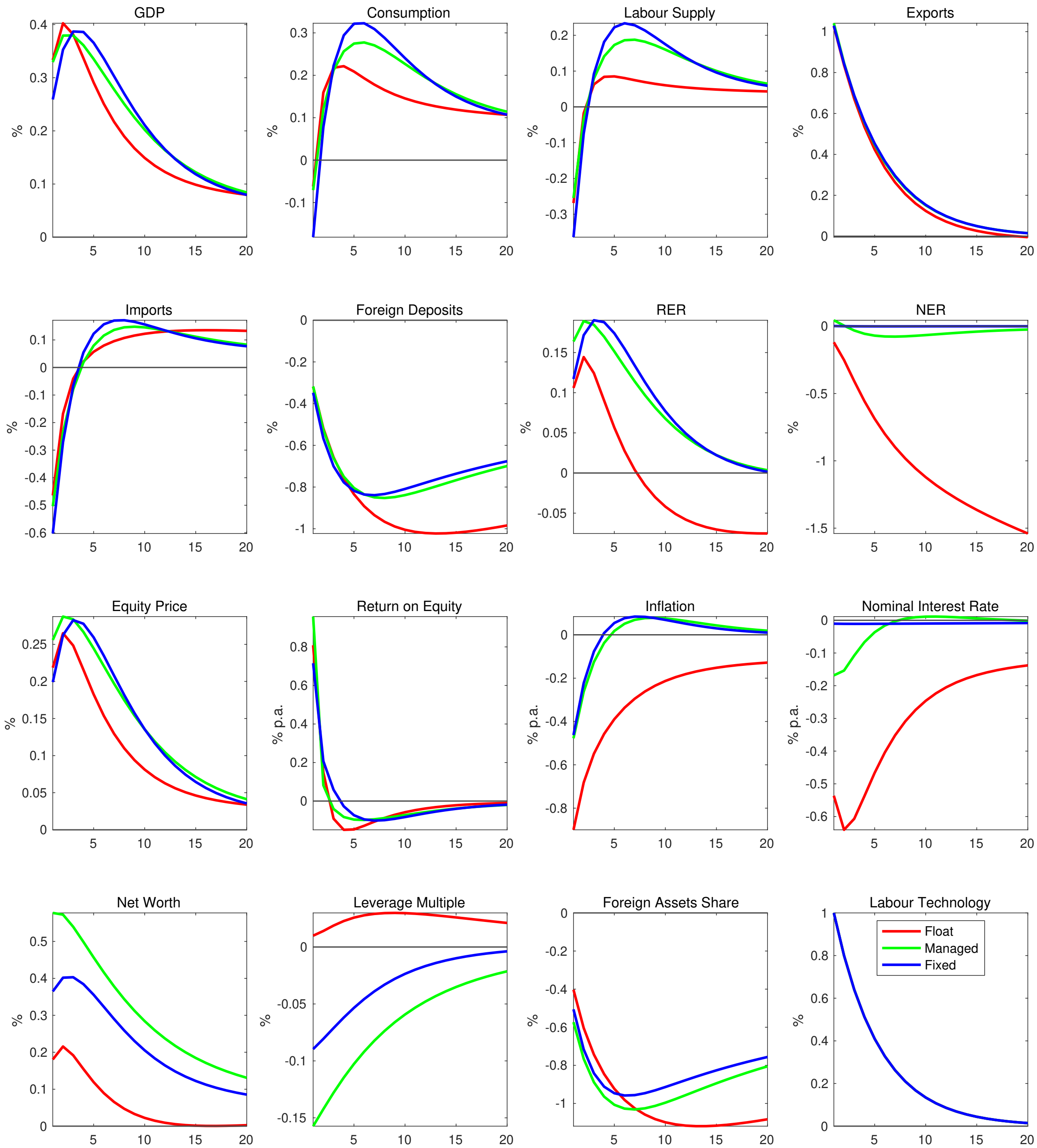

FIGURE A3. IRFs to a 1% innovation to Labour-Augmenting Technology

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

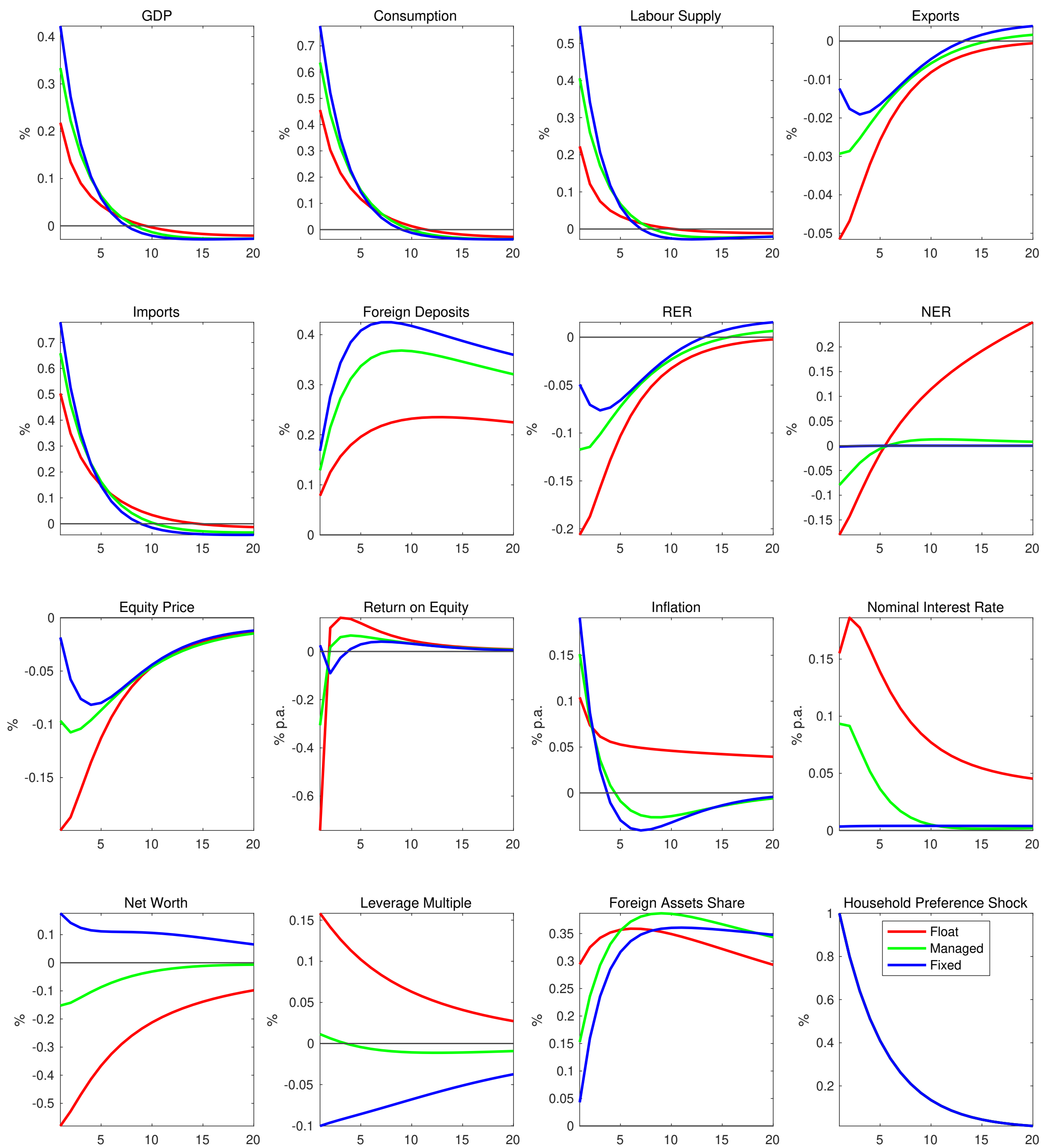

FIGURE A4. IRFs to a 1% innovation to Household Preference shock

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

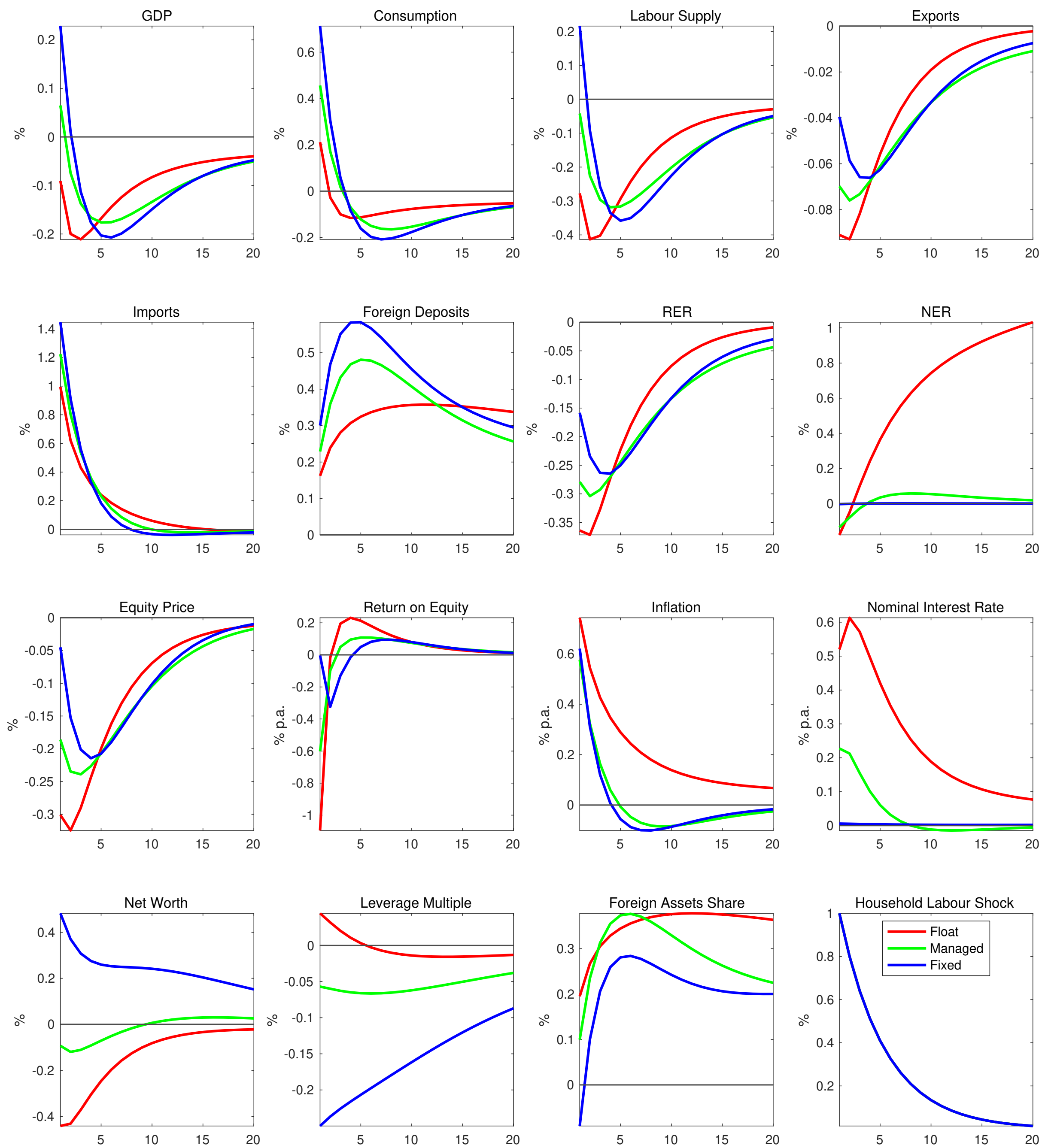

FIGURE A5. IRFs to a 1& innovation to Household Labour shock

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

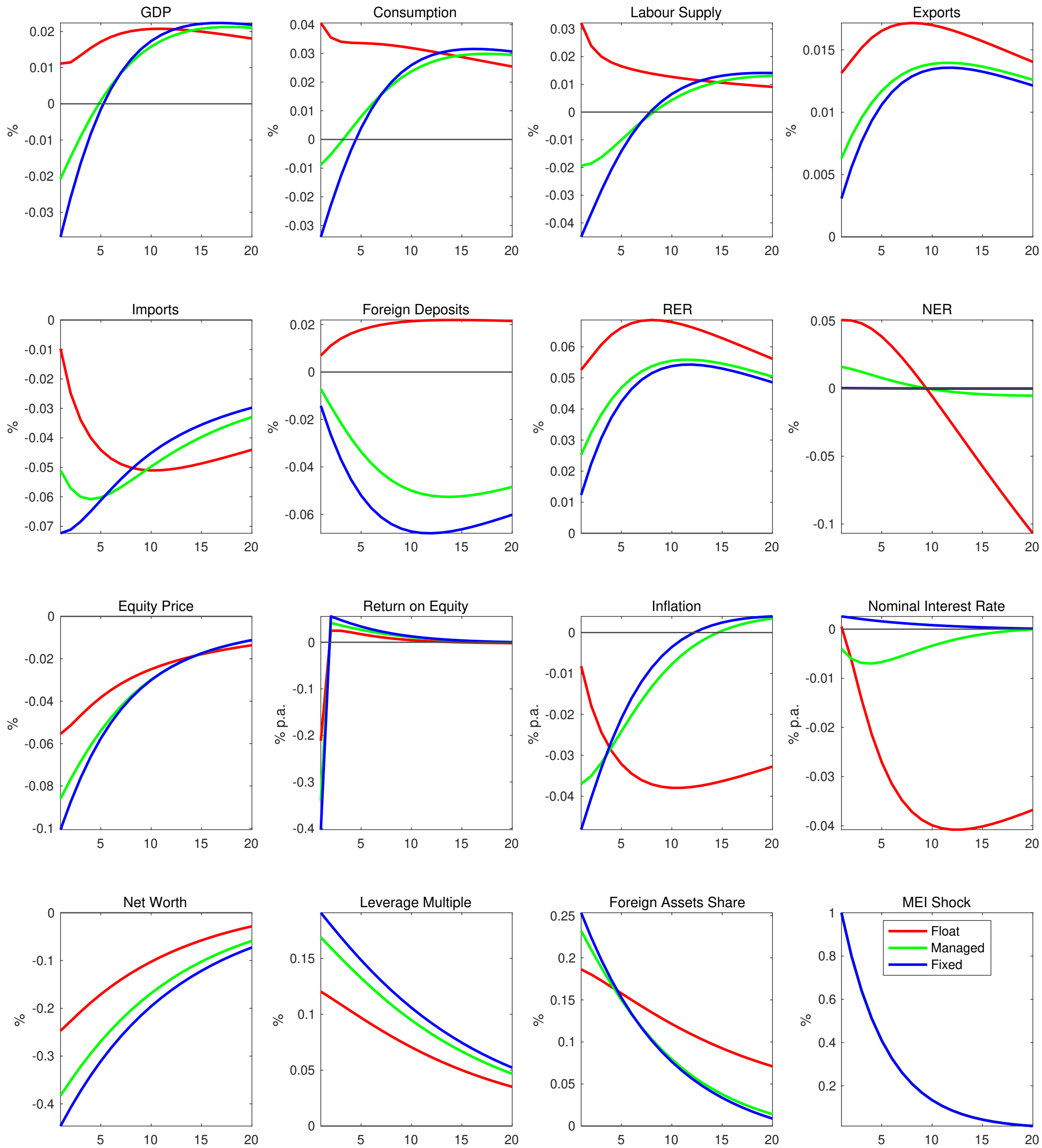

FIGURE A6. IRFs to a 1% innovation to Marginal Efficiency of Investment

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

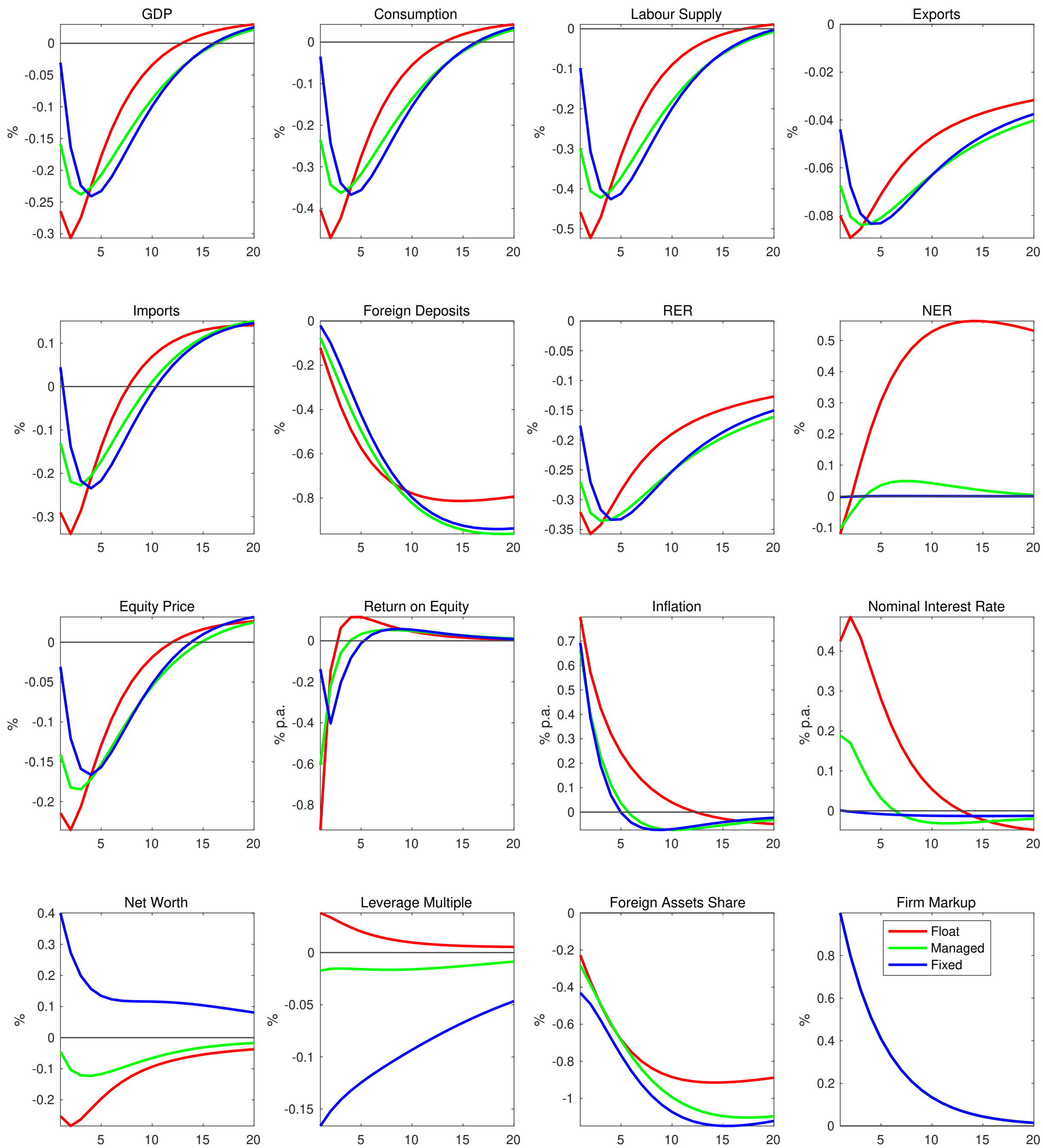

FIGURE A7. IRFs to a 1% innovation to Firm Markup

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

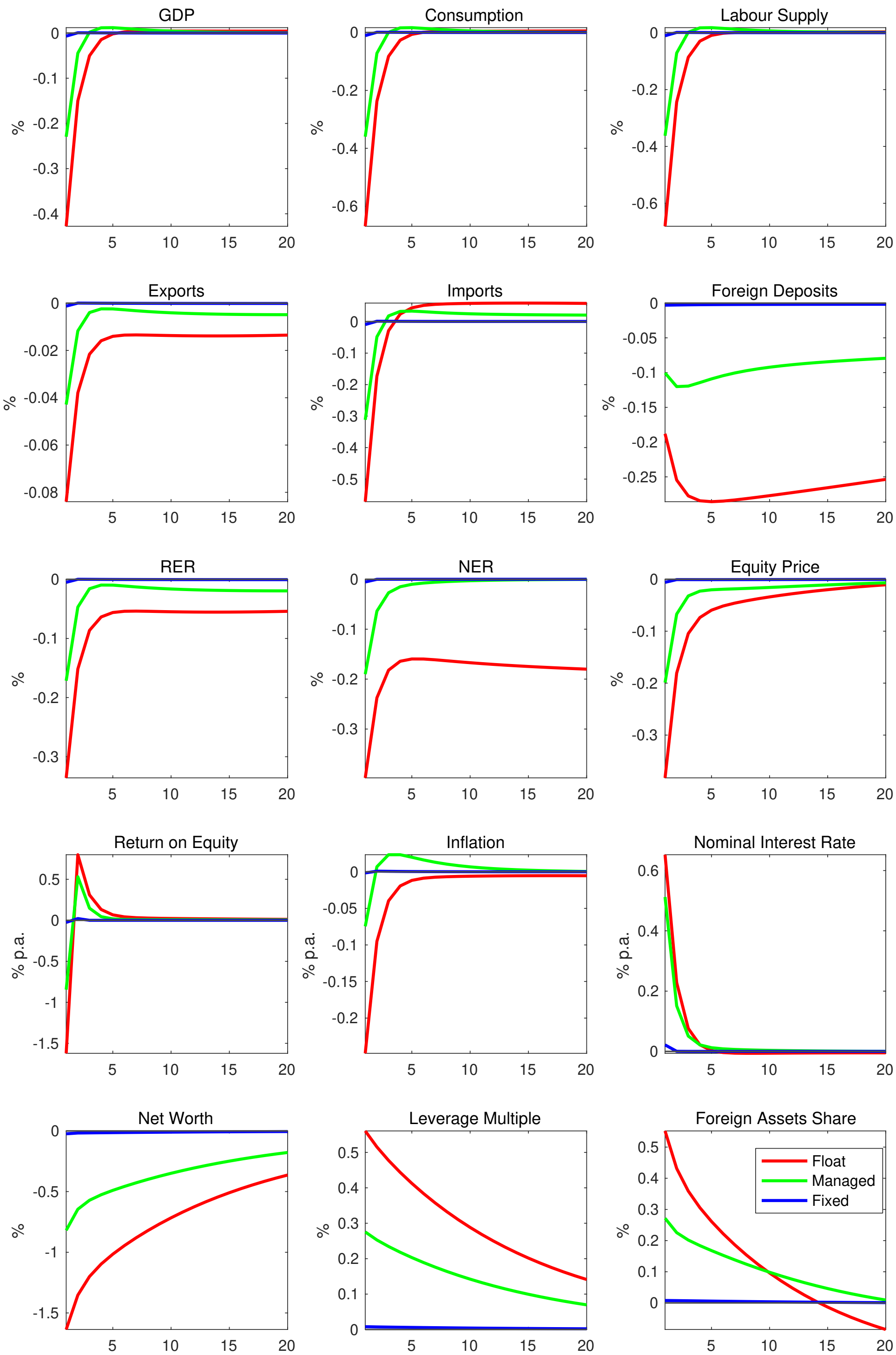

FIGURE A8. IRFs to an annualised 1% Monetary Policy Shock

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

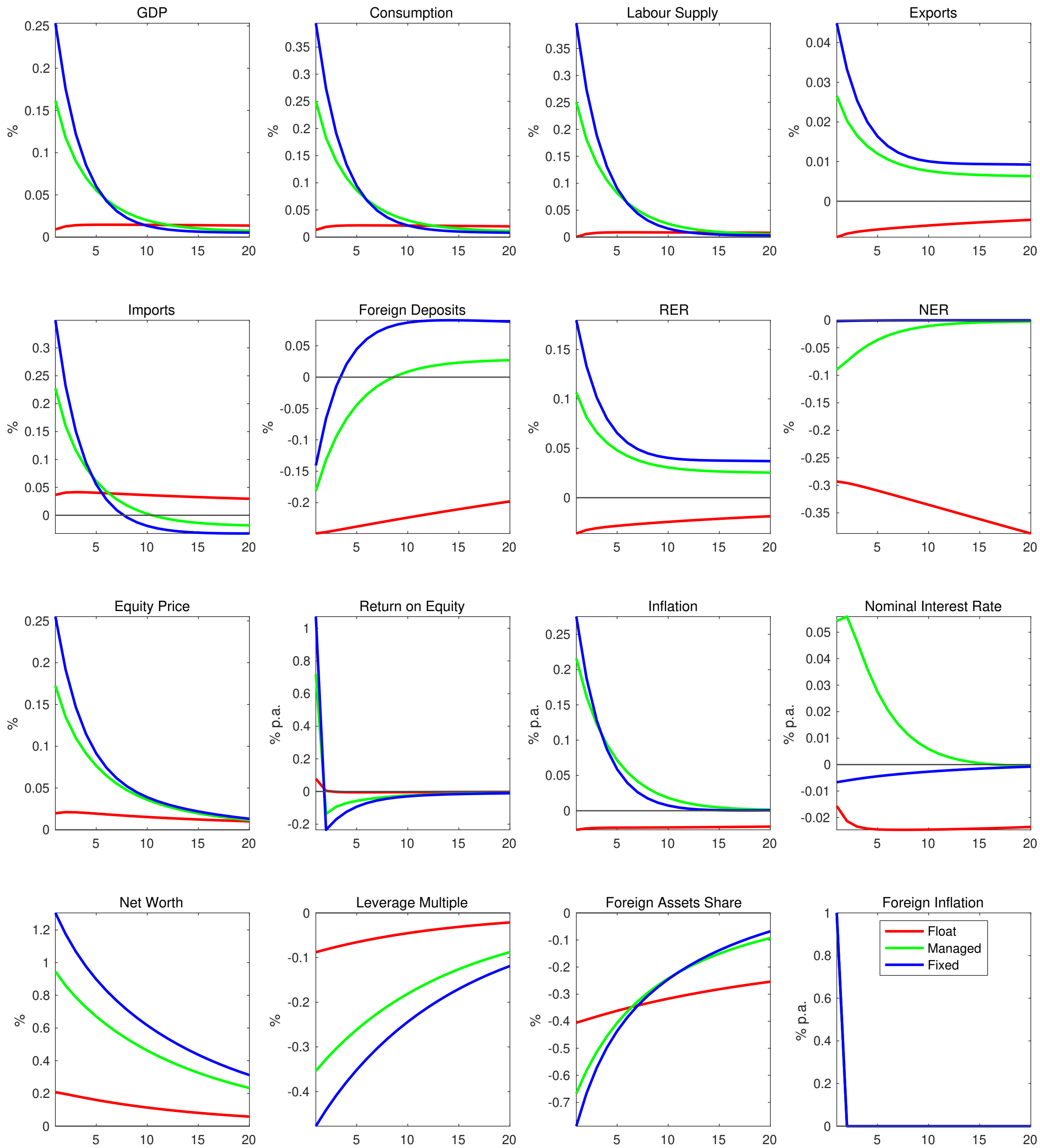

FIGURE A9. IRFs to a 1% innovation to Foreign Inflation

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

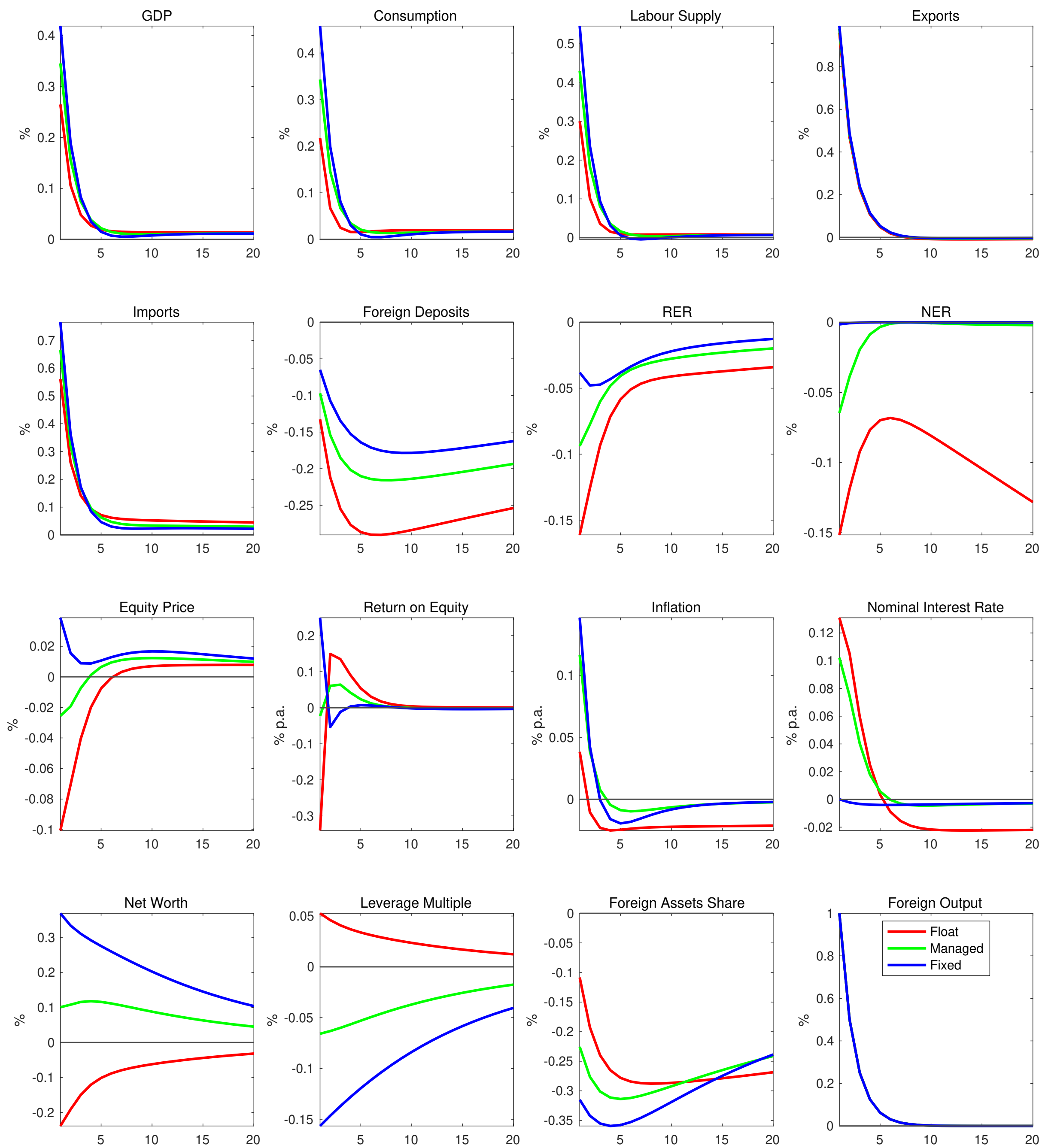

FIGURE A10. IRFs to a 1% innovation to Foreign Demand

Variables are expressed in percent changes from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Responses shown correspond to three exchange rate regimes: $\phi_E = 0$ (red), $\phi_E = 1$ (green), and $\phi_E = 100$ (blue), which correspond to a float, managed float, and a fixed exchange regime, respectively.

Appendix B. Computational appendix

B.1. Data sources

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

- US monetary policy shocks: From Jarociński and Karadi (2020).[38]
- US excess bond premium: From Gilchrist and Zakrajšek (2012); Favara et al. (2016).[39]
- US real GDP: See Table A1. Quarterly data interpolated to monthly data following Miranda-Agrippino and Rey (2020).
- US 1-year Treasury Bill rate: Market Yield on U.S. Treasury Securities at 1-Year Constant Maturity, Quoted on an Investment Basis [DGS1], FRED.
- Korea real GDP: See Table A1. Quarterly data interpolated to monthly data following Miranda-Agrippino and Rey (2020).
- Korea inflation: GDP deflator, The Bank of Korea.
- Korea real exports: See Table A1. Quarterly data interpolated to monthly data following Miranda-Agrippino and Rey (2020).
- US-Korea nominal exchange rate: Korean Won to U.S. Dollar Spot Exchange Rate [DEXKOUS] (direct quote), retrieved from FRED.
- Korea short-term interest rate: 3-Month or 90-Day Rates and Yields Total for Korea [IR3TIB01KRM156N], retrieved from FRED; OECD.
- Korea corporate spreads: 3-year bond spread (AA- corporate and government), The Bank of Korea.

DSGE model data sources. Country level variables such as real gross domestic product (GDP), consumer price index (CPI), unemployment rate, money market interest rates, and exchange rates are collected from International Financial Statistics (IFS) of the International Monetary Fund (IMF), as well as the Bank of Korea and the Korean Ministry

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

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

of Employment and Labor. Financial depth is from the World bank database. US real GDP and unemployment rates are collected from the Federal Reserve Economics Data (FRED) database.

TABLE A1. Data Sources for DSGE Estimation

Variables	Data sources
Nominal Interest Rate	Overnight interbank call-rate, The Bank of Korea
Domestic Inflation	GDP deflator, National Accounts, The Bank of Korea
CPI Inflation	Headline consumer price index, Statistics Korea
Investment Inflation	National Accounts, The Bank of Korea
Foreign Inflation	US Gross Domestic Product, Implicit Price Deflator, FRED
Foreign Nominal Interest Rate	Federal Funds Rate, FRED
Total Hours Worked	All industries, Ministry of Employment and Labor, Korea
GDP	Gross Domestic Product, National Accounts, The Bank of Korea
Consumption	Private consumption, National Accounts, The Bank of Korea
Investment	Gross Fixed Capital Formation, National Accounts, The Bank of Korea
Exports	Exports of goods and services, National Accounts, The Bank of Korea
Imports	Imports of goods and services, National Accounts, The Bank of Korea
Government Expenditure	National Accounts, The Bank of Korea
Real Hourly Wages	All industries, Ministry of Employment and Labor, Korea
Real Exchange Rate	The Bank of Korea, FRED, Statistics Korea
Nominal Exchange Rate	FRED, Statistics Korea
Real Stock Price	Equities prices / Consumer Price Index, IMF, Statistics Korea
Corporate Interest Rate Spread	3-year spread (AA- corporate and treasury), The Bank of Korea
Unemployment Rate	Statistics Korea
Foreign GDP	US Gross Domestic Product, FRED

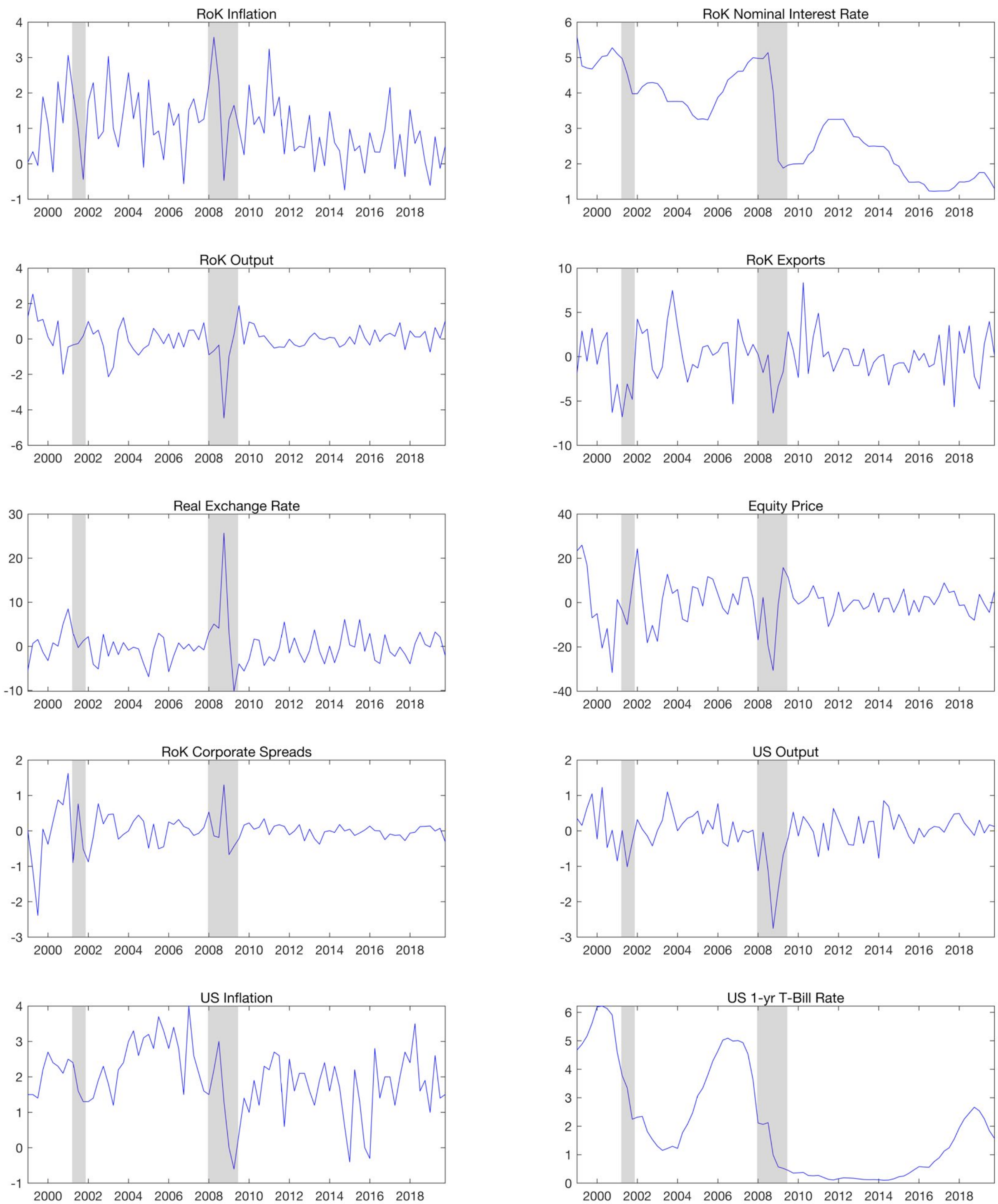

FIGURE A11. Plot of Korean and US (starred) time series data (1999Q1-2019Q4)

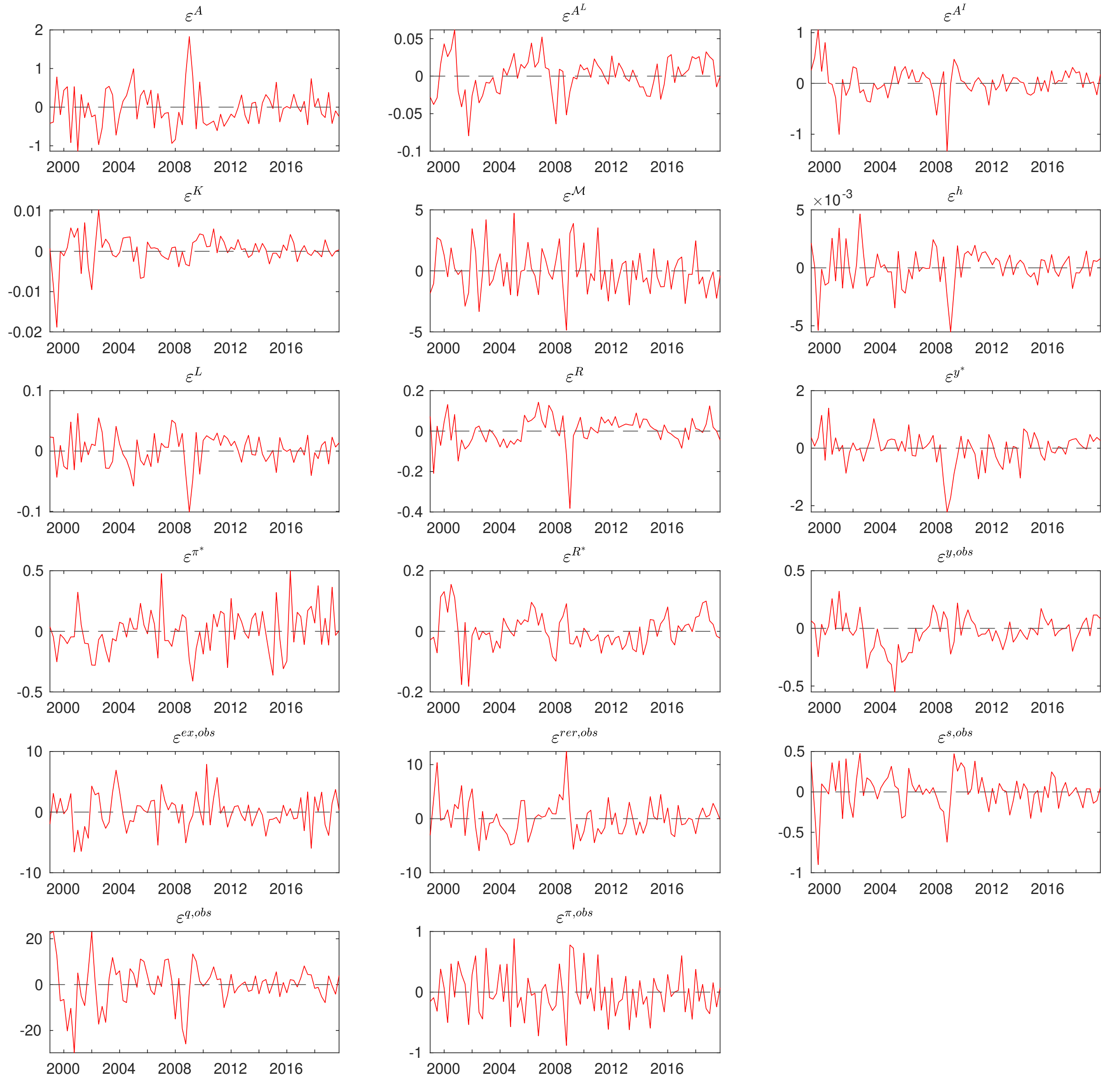

FIGURE A12. Smoothed shock processes

B.2. Additional estimation results

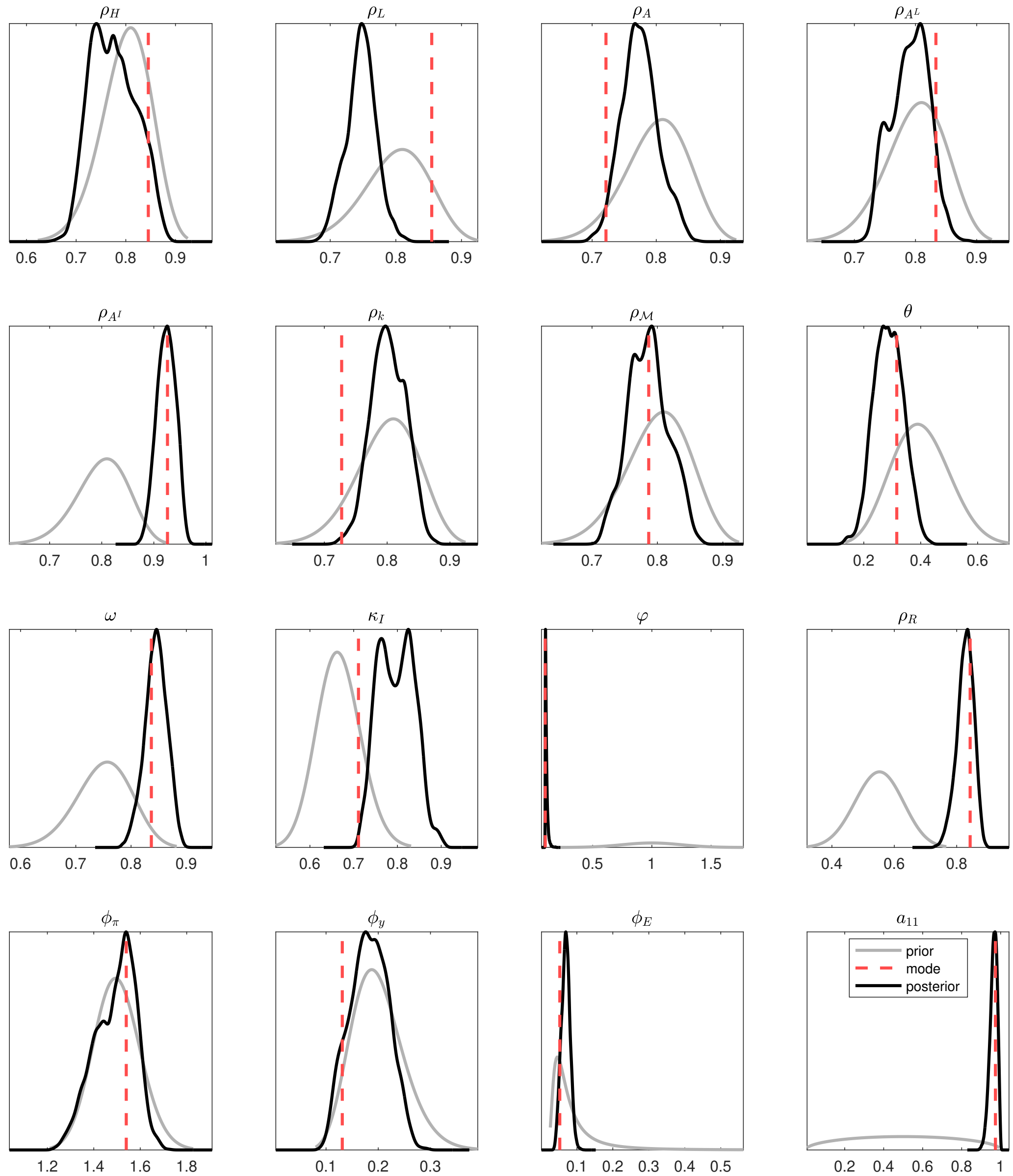

FIGURE A13. Parameter prior and posterior distributions

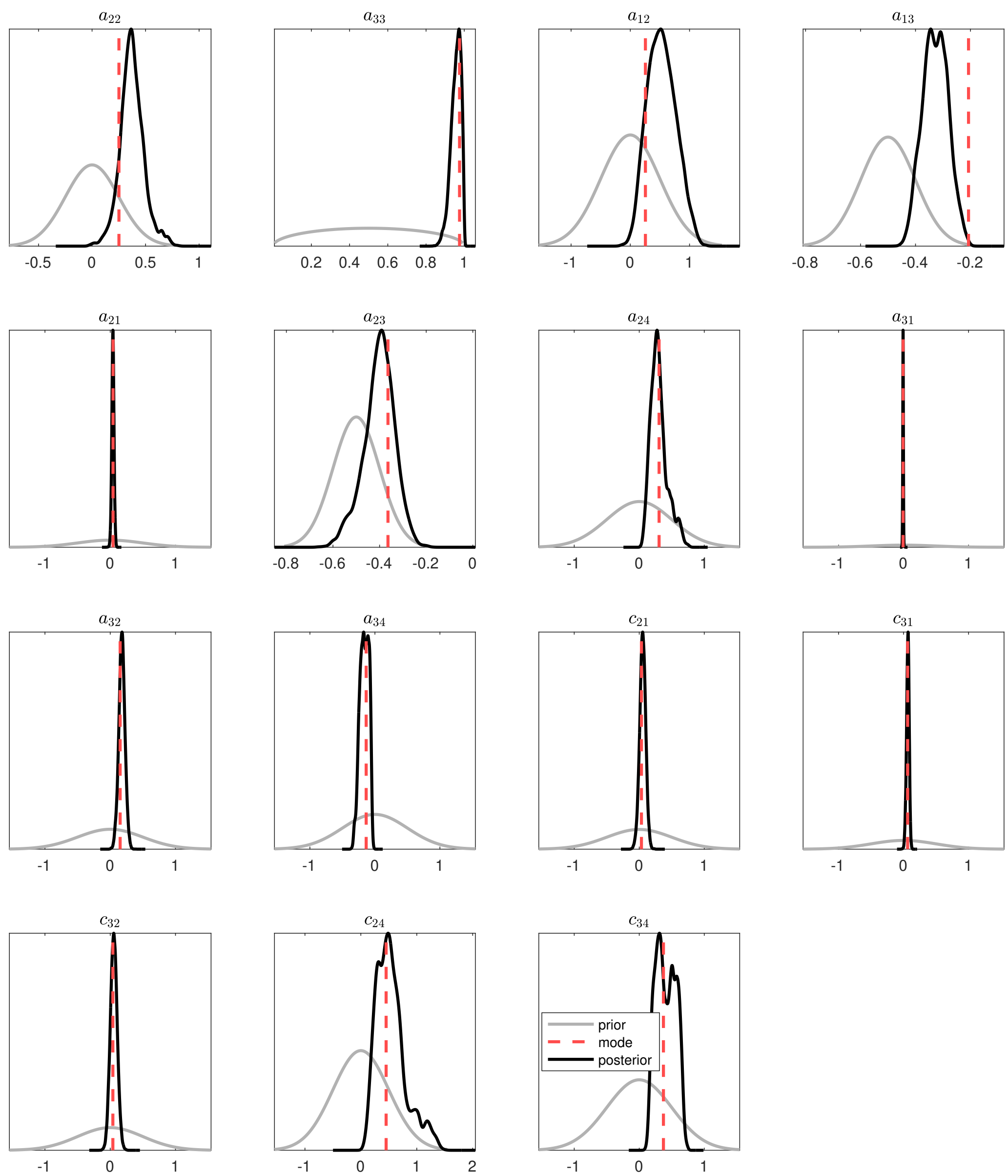

FIGURE A13. Parameter prior and posterior distributions (cont.)

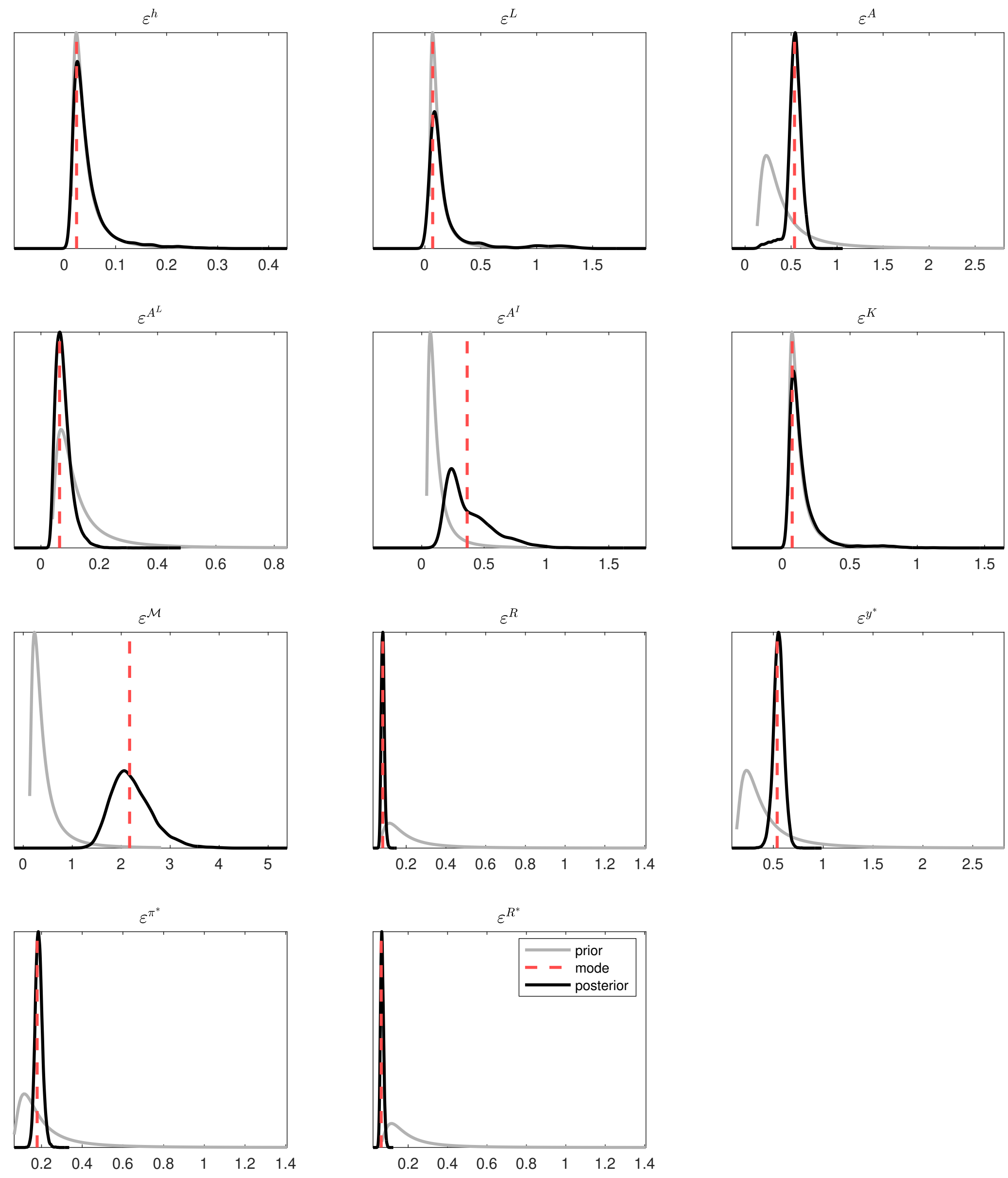

FIGURE A13. Shock standard deviation prior and posterior distributions

TABLE A2. Conditional forecast error variance decomposition (in percent); Eight quarters forecast horizon

Variable\Shocks	ε^{A}	ε^{A^L}	ε^{A^I}	ε^{h}	ε^{L}	ε^{K}	$\varepsilon^{\mathcal{M}}$	ε^{R}	ε^{y^*}	ε^{π^*}	ε^{R^*}
Y^{GDP}	2.36	1.3	67.45	0.01	0.13	0	5.12	1.78	10.13	1.84	9.9
	(1.32,3.93)	(0.00,3.42)	(51.01,85.46)	(0.00,0.02)	(0.00,0.20)	(0.00,0.00)	(2.29,7.66)	(0.83,2.72)	(0.02,21.28)	(0.03,3.92)	(3.31,16.93)
C	10.27	0.92	60.82	0.02	0.53	0	8.96	3.02	6.94	1.19	7.33
	(5.35,16.55)	(0.00,2.41)	(45.87,75.22)	(0.00,0.05)	(0.01,0.95)	(0.00,0.00)	(4.30,13.35)	(1.38,4.48)	(0.01,15.66)	(0.03,2.60)	(1.27,12.60)
L	39.41	0.3	23.33	0.01	0.4	0	22.58	5.42	5.5	0.75	2.3
	(26.05,54.57)	(0.00,0.79)	(9.91,33.81)	(0.00,0.03)	(0.00,0.50)	(0.00,0.00)	(13.24,32.24)	(2.69,7.97)	(0.19,10.28)	(0.11,1.43)	(0.52,3.75)
K	3.54	1.4	69.39	0	0.17	0.53	2.43	1.52	3.12	4	13.89
	(1.57,5.88)	(0.00,3.69)	(55.31,83.56)	(0.00,0.01)	(0.00,0.27)	(0.01,0.87)	(0.93,3.88)	(0.69,2.49)	(0.00,8.47)	(0.00,7.57)	(5.36,23.53)
I	3.49	1.4	70.26	0	0.17	0.01	2.42	1.59	3.18	3.97	13.5
	(1.66,5.99)	(0.00,3.74)	(55.97,84.03)	(0.00,0.01)	(0.00,0.27)	(0.00,0.02)	(0.93,3.84)	(0.71,2.51)	(0.00,8.58)	(0.02,7.48)	(5.12,23.04)
EX	0.23	1.35	4.44	0	0.01	0	1.09	0.1	81.06	7.72	4
	(0.02,0.42)	(0.04,3.05)	(0.02,9.72)	(0.00,0.00)	(0.00,0.02)	(0.00,0.00)	(0.35,1.82)	(0.03,0.16)	(64.82,92.71)	(0.79,14.89)	(1.20,6.66)
N	0.06	1.35	71.87	0	0	0.01	0.12	3.08	4.2	3.1	16.2
	(0.00,0.13)	(0.00,3.52)	(57.09,88.87)	(0.00,0.00)	(0.00,0.00)	(0.00,0.02)	(0.00,0.28)	(1.40,4.76)	(0.00,10.82)	(0.00,6.24)	(5.90,25.77)
Q	3.49	1.4	70.26	0	0.17	0.01	2.42	1.59	3.18	3.97	13.5
	(1.66,5.99)	(0.00,3.74)	(55.97,84.03)	(0.00,0.01)	(0.00,0.27)	(0.00,0.02)	(0.93,3.84)	(0.71,2.51)	(0.00,8.58)	(0.02,7.48)	(5.12,23.04)
D^*	39.57	0.61	14.58	0.02	2.09	0	22.73	4.94	3.22	3.26	8.98
	(26.11,56.76)	(0.00,1.44)	(0.26,25.42)	(0.00,0.03)	(0.02,3.11)	(0.00,0.00)	(12.90,32.64)	(2.00,7.42)	(0.02,7.27)	(0.93,5.83)	(0.85,16.79)
ϵ	0.97	0.92	65.46	0	0.05	0	4.46	0.39	6.99	6.06	14.69
	(0.19,1.79)	(0.00,2.40)	(48.91,81.75)	(0.00,0.00)	(0.00,0.07)	(0.00,0.01)	(1.64,7.00)	(0.15,0.62)	(0.00,15.87)	(1.08,11.17)	(5.83,22.95)
R	32.8	0.35	7.69	0.02	1.76	0	25.31	15.73	2.19	9.18	4.96
	(20.72,47.07)	(0.00,0.95)	(0.01,14.78)	(0.00,0.03)	(0.01,2.78)	(0.00,0.01)	(14.53,33.83)	(7.83,23.20)	(0.00,4.85)	(3.62,14.70)	(1.05,8.21)
π	20.44	0.25	4.06	0	1.23	0.01	68.12	0.78	0.63	3.5	0.98
	(8.79,34.53)	(0.00,0.62)	(0.02,9.29)	(0.00,0.00)	(0.00,1.81)	(0.00,0.02)	(53.24,82.69)	(0.10,1.55)	(0.00,1.68)	(1.19,5.62)	(0.11,1.83)

Forecast posterior mean values with 90% HPD (in brackets).

Table A3. Conditional forecast error variance decomposition (in percent); 20 quarters forecast horizon

Variable\Shocks	ε^{A}	ε^{A^L}	ε^{A^I}	ε^{h}	ε^{L}	ε^{K}	$\varepsilon^{\mathcal{M}}$	ε^{R}	ε^{y^*}	ε^{π^*}	ε^{R^*}
Y^{GDP}	1.79	1.26	70.33	0	0.09	0	2.51	0.82	10.43	2.19	10.58
	(0.72,2.97)	(0.00,3.20)	(53.47,89.26)	(0.00,0.01)	(0.00,0.14)	(0.00,0.00)	(1.04,3.83)	(0.35,1.24)	(0.02,21.97)	(0.01,4.55)	(3.57,17.72)
C	5.88	1.07	67.14	0.01	0.31	0	4.87	1.53	8.11	1.82	9.26
	(2.81,9.81)	(0.00,2.78)	(51.43,82.98)	(0.00,0.03)	(0.00,0.55)	(0.00,0.00)	(2.07,7.53)	(0.65,2.35)	(0.03,18.17)	(0.03,3.82)	(2.85,16.03)
L	26.9	0.64	37.13	0.01	0.32	0	17.19	3.63	7.44	1.17	5.57
	(15.55,39.22)	(0.00,1.62)	(22.16,53.46)	(0.00,0.02)	(0.00,0.44)	(0.00,0.00)	(9.43,25.99)	(1.88,5.43)	(0.21,14.86)	(0.16,2.21)	(1.70,8.82)
K	2.49	1.37	74.94	0	0.11	0.22	1.31	0.6	3.79	3.38	11.79
	(1.04,4.50)	(0.00,3.62)	(61.17,89.16)	(0.00,0.00)	(0.00,0.18)	(0.00,0.37)	(0.44,2.16)	(0.23,0.95)	(0.00,9.99)	(0.00,6.42)	(3.81,20.52)
I	2.56	1.34	74.37	0	0.12	0.01	1.62	1	3.98	3.33	11.67
	(1.14,4.62)	(0.00,3.55)	(60.94,88.62)	(0.00,0.00)	(0.00,0.19)	(0.00,0.02)	(0.66,2.66)	(0.39,1.54)	(0.01,10.49)	(0.02,6.35)	(3.61,19.75)
EX	0.11	1.2	20.4	0	0.01	0	0.84	0.05	60.91	4.64	11.85
	(0.01,0.20)	(0.06,2.57)	(2.43,44.95)	(0.00,0.00)	(0.00,0.01)	(0.00,0.00)	(0.16,1.53)	(0.01,0.09)	(30.18,88.11)	(1.26,8.37)	(4.86,18.60)
N	0.05	1.34	72.39	0	0	0.01	0.1	2.89	4.38	2.99	15.85
	(0.00,0.10)	(0.00,3.49)	(57.47,89.41)	(0.00,0.00)	(0.00,0.00)	(0.00,0.02)	(0.00,0.26)	(1.30,4.46)	(0.00,11.16)	(0.00,6.04)	(5.70,25.37)
Q	2.56	1.34	74.37	0	0.12	0.01	1.62	1	3.98	3.33	11.67
	(1.14,4.62)	(0.00,3.55)	(60.94,88.62)	(0.00,0.00)	(0.00,0.19)	(0.00,0.02)	(0.66,2.66)	(0.39,1.54)	(0.01,10.49)	(0.02,6.35)	(3.61,19.75)
D^*	23.67	0.61	14.57	0.01	1.14	0	32.66	3.05	6.49	2.38	15.42
	(12.41,38.16)	(0.00,1.47)	(1.02,30.47)	(0.00,0.02)	(0.01,1.88)	(0.00,0.00)	(18.82,47.44)	(1.20,5.01)	(0.01,14.22)	(0.34,5.21)	(2.25,28.80)
ϵ	0.6	0.89	68.14	0	0.03	0	4.49	0.29	8.94	4.56	12.07
	(0.12,1.14)	(0.00,2.29)	(52.64,87.14)	(0.00,0.00)	(0.00,0.04)	(0.00,0.01)	(1.50,7.28)	(0.11,0.46)	(0.04,19.68)	(0.33,8.28)	(4.15,19.11)
R	28.91	0.65	13.45	0.02	1.5	0.01	23.49	13.24	3.8	9.82	5.11
	(15.71,42.66)	(0.01,1.66)	(0.87,25.08)	(0.00,0.03)	(0.01,2.40)	(0.00,0.02)	(14.36,33.39)	(7.01,20.25)	(0.02,8.83)	(4.41,15.17)	(1.76,8.44)
π	18.66	0.59	8.1	0	1.12	0.01	64.41	0.76	1.14	3.29	1.93
	(7.28,30.87)	(0.01,1.35)	(1.38,14.43)	(0.00,0.00)	(0.00,1.60)	(0.00,0.02)	(49.15,81.50)	(0.10,1.51)	(0.00,2.76)	(1.25,5.39)	(0.32,3.60)

Note: Forecast posterior mean values with 90% HPD (in brackets).

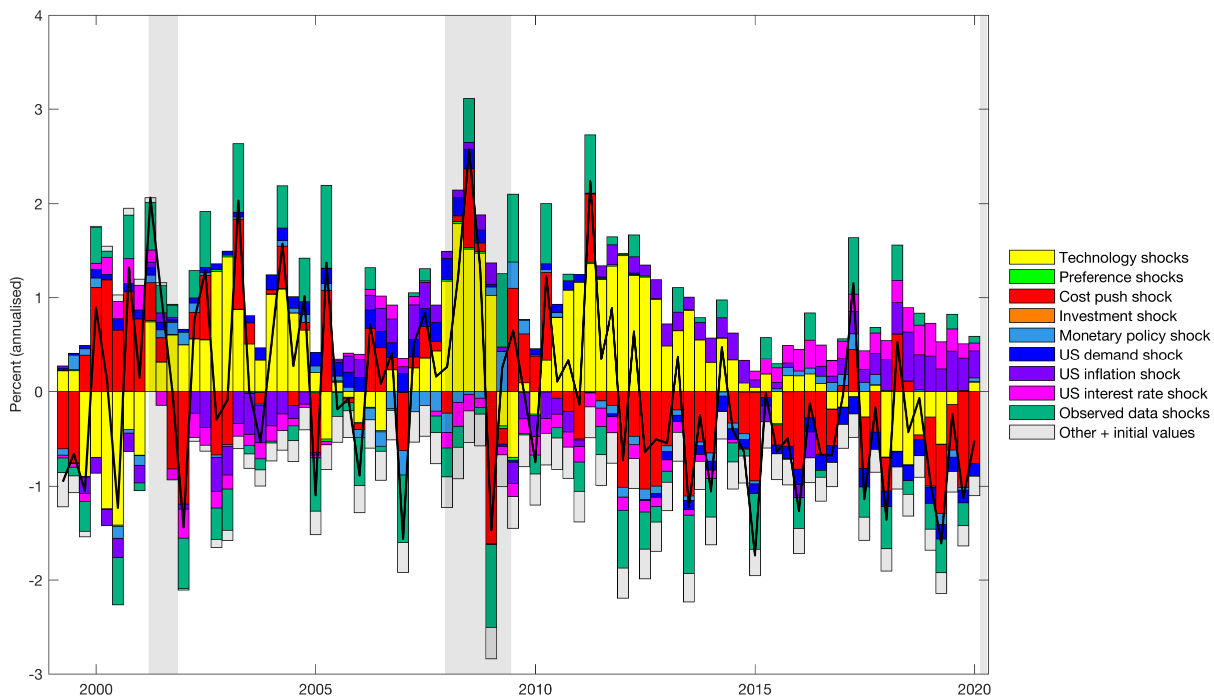

FIGURE A14. Historical shock decomposition of observed Korean CPI inflation (π_t^{obs})

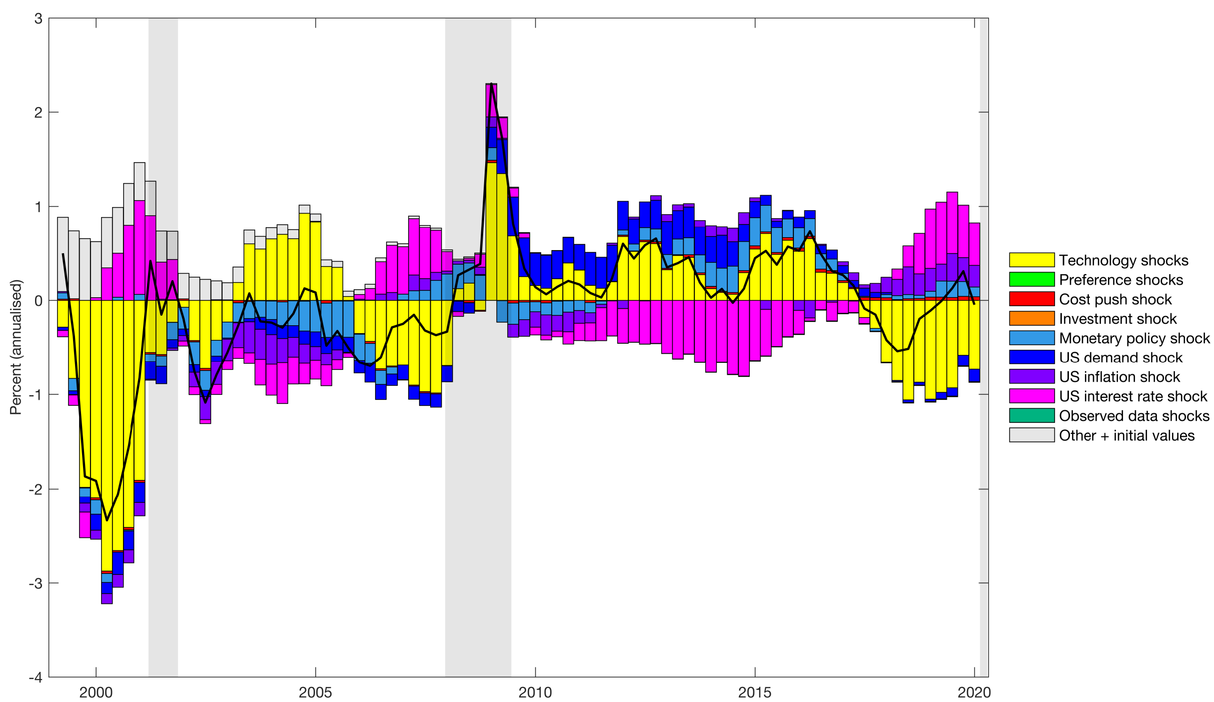

FIGURE A15. Historical shock decomposition of model Excess Return of Capital over Domestic Deposits (μ_t)

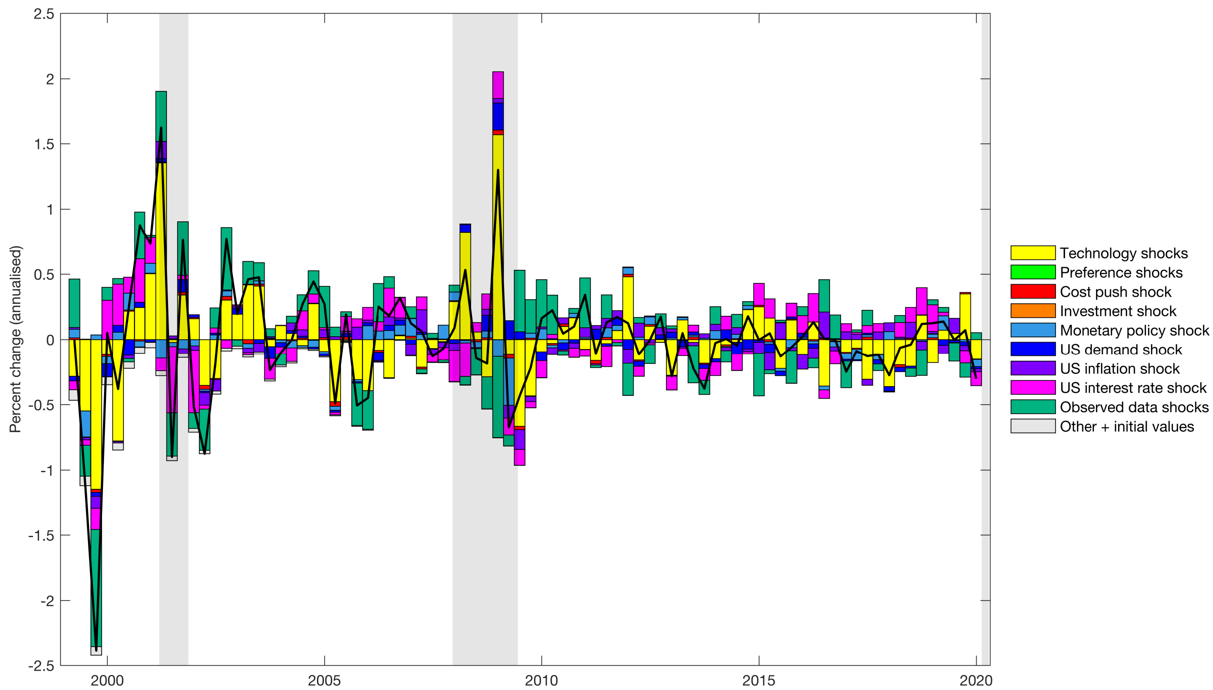

FIGURE A16. Historical shock decomposition of observed Korean Corporate Spreads ($\Delta \text{Spread}_t^{obs}$)

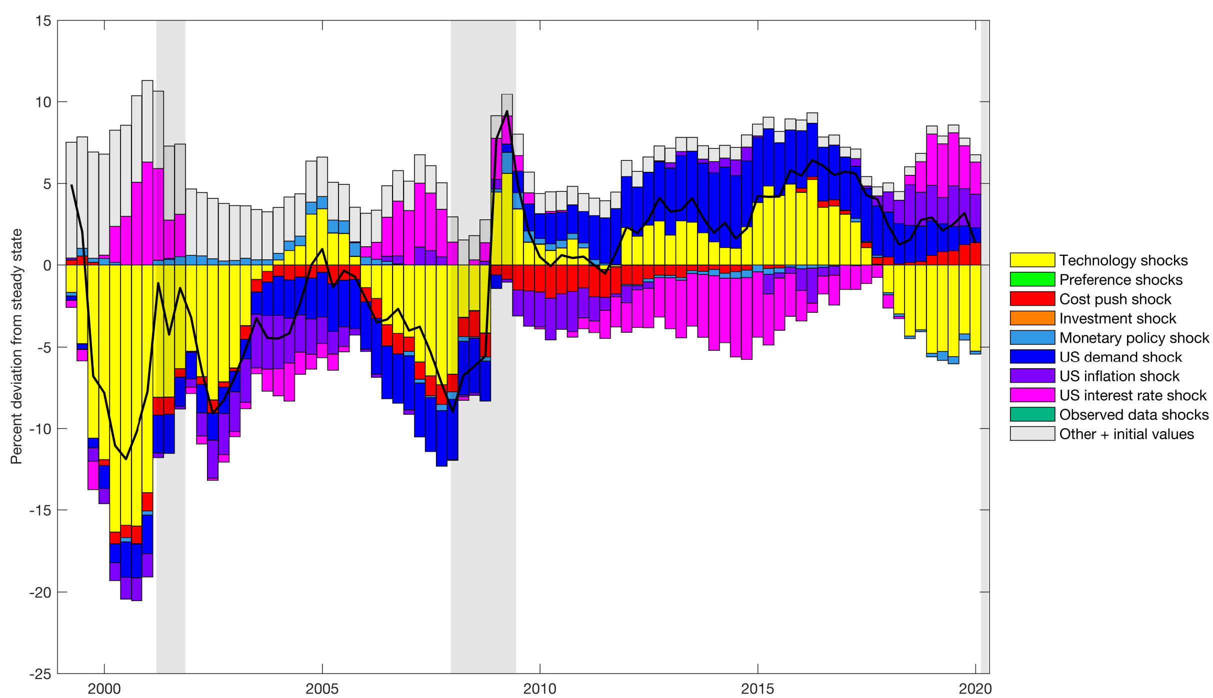

FIGURE A17. Historical shock decomposition of model real exchange rate (ϵ_t)

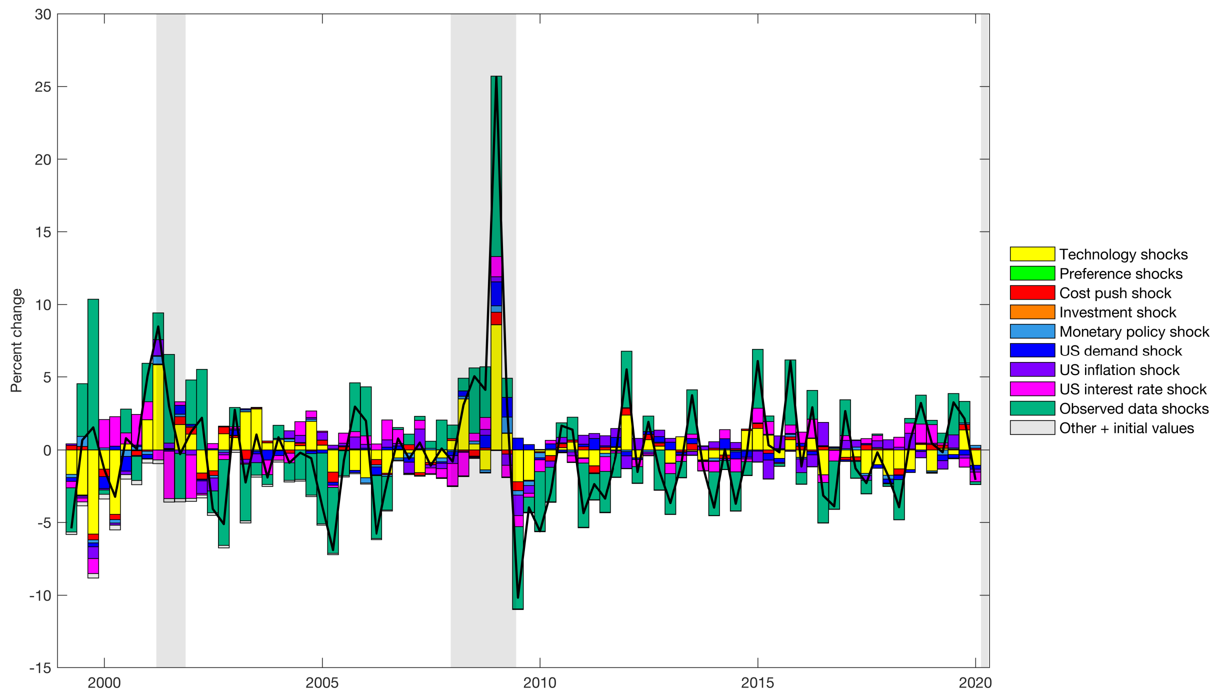

FIGURE A18. Historical shock decomposition of observed Real Exchange Rate ($\Delta\epsilon_t^{obs}$)

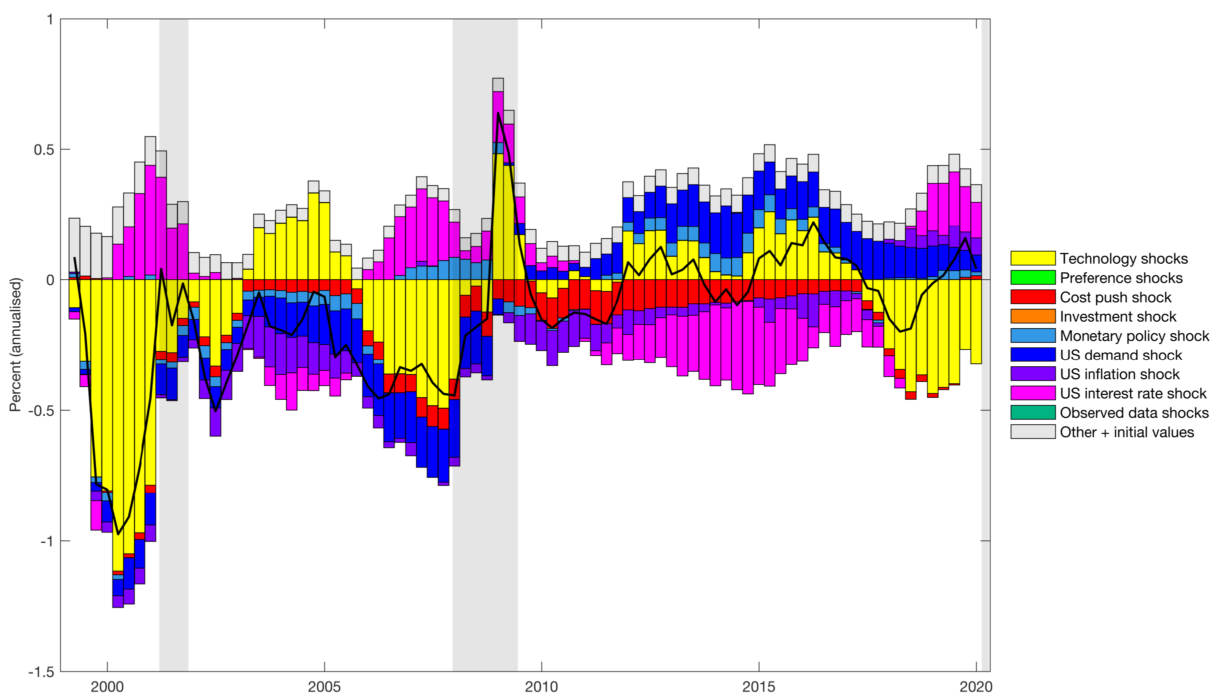

FIGURE A19. Historical shock decomposition of Cost Advantage of Foreign Borrowing over Domestic Deposits (μ_t^*)

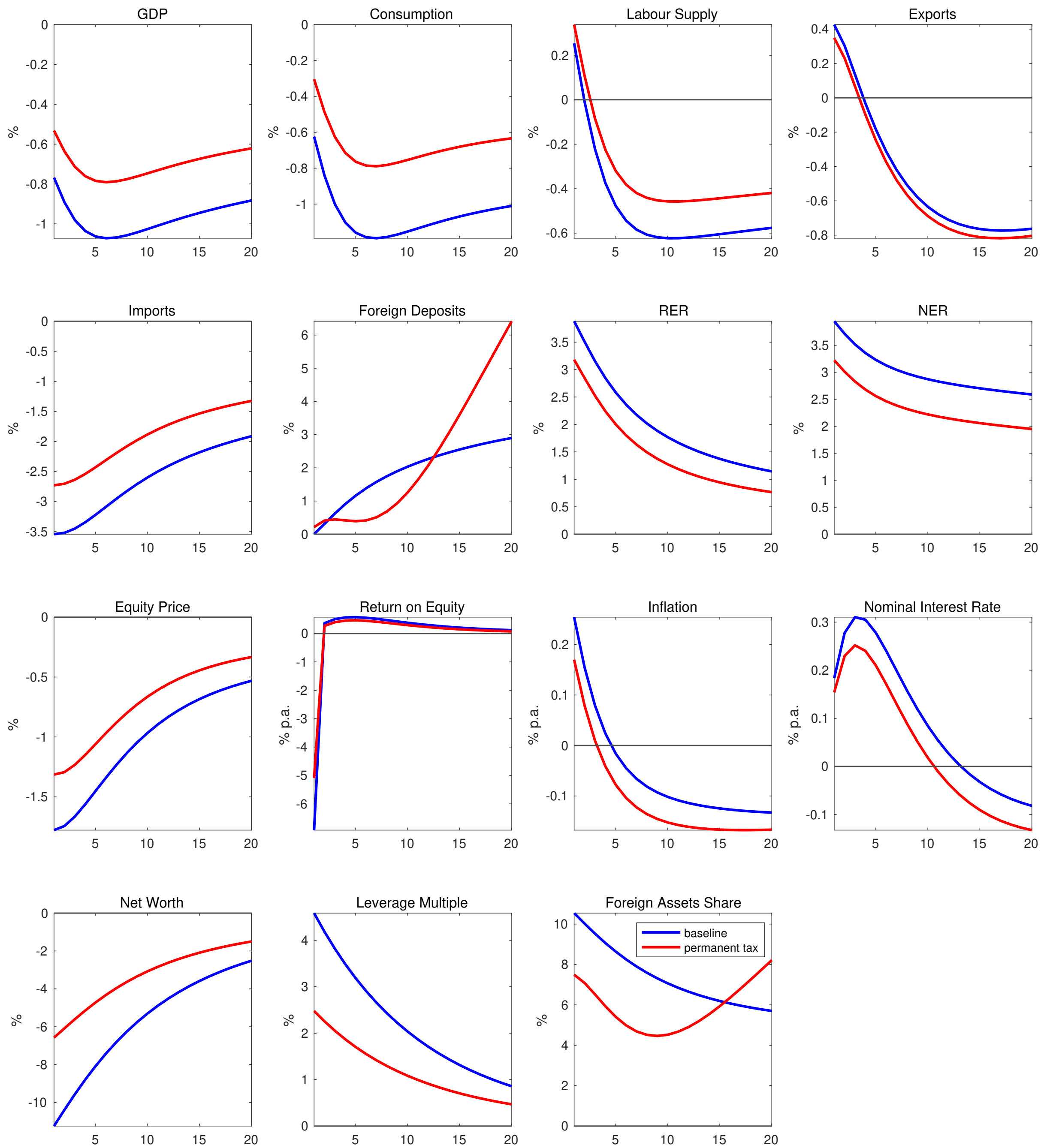

FIGURE A20. IRFs to an annualised 1% shock to the Foreign Interest Rate with and without permanent tax policy

Variables are expressed in percent deviations from their non-stochastic steady state values. Inflation and interest rates are annualised. Exchange rates are quoted on a direct basis; increase (decrease) corresponds to a domestic currency depreciation (appreciation). Blue line denotes baseline (no tax) model responses; red line denotes permanent tax model responses.