Capital Flows and Exchange Rates:
A Quantitative Assessment of the Dilemma Hypothesis*

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Abstract

In response to an unanticipated monetary policy tightening in the US, real GDP and exports of a typical small open economy fall, despite a depreciation of the local currency. The reason is that the financial channel of the transmission of monetary policy shocks across countries dominates over the traditional expenditure-switching effect. The dominant role of the reserve currency in trade and global financial transactions can account for the evidence in an otherwise standard two-country open economy model with nominal and real rigidities. Yet, even in the presence of a global financial cycle, the exchange rate regime matters. In particular, a peg substantially increases macroeconomic volatility. The introduction of an additional policy instrument to manage capital flows dampens economic fluctuations. A tax on domestic credit achieves nearly equivalent results. Both these instruments can insulate the effects of foreign monetary policy shocks on real economic activity in a fixed exchange rate regime, but not on inflation.

Keywords: Exchange rates flexibility, Currency invoicing, Dilemma, Expenditure Switching, Foreign exchange liabilities, Global financial cycle, Trilemma.
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1 Introduction

As central banks around the world started their tightening cycle following the recovery from the Covid crisis, issues related to exchange rate volatility and capital flows became once again front and center in the debate on the cross-country transmission of monetary policy.

The reference framework for this discussion often relies on the notion of a 'Trilemma.' The Trilemma is a cornerstone proposition in international macroeconomics according to which a country can only attain two of the following three policy objectives: independent monetary policy, a fixed exchange rate, and free capital mobility.

Rey (2013) challenged this traditional view. Her critique contains two key points. The first is an empirical observation. Following a monetary policy shock in the US, asset prices and capital flows move together across countries, giving rise to a 'Global Financial Cycle' (GFC). Subsequent work (e.g. Miranda-Agrippino and Rey, 2020, di Giovanni et al., 2022) has confirmed and extended these findings. The second point focuses on the policy implications. Since the GFC holds regardless of the exchange rate regime, the key policy choice is not a Trilemma, but a 'Dilemma' between retaining monetary policy independence and allowing for free international capital mobility. A central bank can pursue inflation stability only if additional instruments, such as capital flows management and/or macroprudential tools, are available.

In this paper, we offer a quantitative evaluation of the Dilemma hypothesis. Our analysis proceeds in three steps. First, we show empirically that indeed a flexible exchange rate regime is not enough to insulate countries from the consequences of the GFC. In response to a contractionary monetary policy shock in the US, the nominal exchange rate of countries with a flexible exchange rate depreciates. Yet, exports and real GDP fall. The expenditure-switching channel (Engel, 2003) does not offset the negative consequences of lower global aggregate demand.

Second, we develop a two-country open economy model with real, nominal, and financial frictions that matches our empirical evidence. In the model, the GFC arises because of the cross-country links in the financial sector and the existence of a global reserve currency in trade and financial transactions. We estimate the model by matching its impulse responses to a foreign monetary policy shock to those of the VAR. Several counterfactual experiments highlight the crucial interplay between financial frictions and trade pricing frictions. The former are necessary for the amplification of the shock. The latter allow the model to replicate the empirical response of exports and inflation.

Third, endowed with the estimated model, we perform a number of policy experiments. In the model, GFC notwithstanding, abandoning a more flexible exchange rate regime in favor of a peg increases macroeconomic volatility because of the negative effects of higher interest rates on domestic demand. Conversely, the introduction of countercyclical tax instruments that respond to credit growth reduces macroeconomic volatility. Our experiments show that a financial stability tool (a tax on domestic credit) or a capital flows management tool (a tax on borrowing in foreign currency) have similar effects on real GDP and spreads, but difference consequences for inflation and the nominal interest rate. The introduction of one of these two instruments in a country that adopts a peg can approximately generate the same response of domestic output to a foreign monetary policy contraction as with more a flexible exchange rate regime. However, inflation volatility remains higher. Therefore, the tradeoff between inflation and output stabilization is worse under a peg than under a flexible exchange rate regime, even in the presence of additional policy instruments.

The early empirical literature on the GFC has largely emphasized the response of financial variables to US monetary policy shocks. More recently, a number of contributions, such as Dedola et al. (2017), Han and Wei (2018), Degasperi et al. (2020), Flaccadoro and Nispi Landi (2022), and De Leo et al. (2023), have extended the focus on to macro variables.[1] While we share the interest of these papers in the joint dynamics of financial and macroeconomic variables, our empirical analysis relies solely on a sample of countries with a flexible exchange arrangement. Under the Trilemma paradigm, exchange rate flexibility should insulate countries from external shocks, including those driving the GFC. The fact that we observe the typical elements of the transmission of a US monetary policy shock even when we exclusively focus on countries with flexible exchange rates strikes a key point in favor of the GFC.[2]

Our model is closely related to Dedola and Lombardo (2012), Aoki et al. (2020), and, especially, Akinci and Queralto (2019). The common element in those papers, as well as in ours, is the presence of a moral hazard friction between households and banks, as in Gertler and Karadi (2011). In open economy, the distinguishing feature is that the friction depends on the currency composition of the private sector's balance sheet, which gives rise to an endogenous wedge in the uncovered interest rate parity (UIP) condition (Gabaix and Maggiori, 2015).[3] An international interbank market links domestic and foreign financial intermediaries, thus amplifying the transmission of foreign monetary policy shocks. On

[1]The empirical literature on the GFC, in turn, builds on an broader literature on the international transmission of monetary policy (see, for example, Kim, 2001; Faust and Rogers, 2003; Canova, 2005; and Ilzetzki and Jin, 2021).

[2]Georgiadis et al. (forthcoming) study global risk shocks in a similar empirical setting to ours, while Georgiadis et al. (2023) distinguish between price of risk (related to risk aversion) and quantity of risk (related to uncertainty).

[3]Itskhoki and Mukhin (2021) show that shocks to the UIP condition can rationalize several outstanding exchange rate puzzles.

the trade side, two pricing frictions determine the propagation of exchange rate movements on to exports and inflation. In line with the recent evidence on the 'Dominant Currency Paradigm' (Gopinath et al., 2020), domestic firms price their exports in the reserve currency, allowing the model to match the decline of exports despite the depreciation of the domestic currency. The depreciation of the exchange rate has also a limited effect on domestic inflation because of imperfect pass-through (Monacelli, 2005). Overall, our framework thus features a dominant currency both in trade and finance, as in Gopinath and Stein (2018).[4]

In our estimated model, as in Akinci and Queralto (2019), the volatility of output and inflation increases under a peg, while taxes on either foreign borrowing or domestic credit reduce macroeconomic volatility.[5] This result is consistent with Farhi and Werning (2016), who find that this kind of taxes are generally desirable because of the interaction between nominal rigidities and imperfections in financial markets. In a small open economy with nominal rigidities and incomplete international financial markets, Farhi and Werning (2012) show that, under a peg, capital controls can restore domestic monetary policy independence, especially in response to risk-premium shocks.[6] In our setting, under a peg, we can design a countercyclical tax, either on foreign liabilities or domestic credit, that replicates the same response of output as under flexible exchange rates. The tax alleviates the negative consequences of the peg on real activity by reducing financial frictions. Nonetheless, inflation falls significantly more than with a flexible exchange rate because in a fixed exchange rate regime the domestic central bank must track the higher foreign nominal interest rate, thus lowering domestic demand.

Our paper is also closely related to the IMF Integrated Policy Framework. Basu et al. (2020) develop a three-period model with trade and financial frictions similar to those present in our setup. Adrian et al. (2020) add several quantitative features, including extending the model to an infinite horizon and allowing for behavioral features (a fraction of agents with adaptive expectations, and discounting in both aggregate demand and supply). Our estimation exercise complements this work and provides a solid empirical grounding to the literature on the GFC.

The rest of the paper is organized as follows. Section 2 introduces the empirical evidence. Section 3 presents the model. Section 4 reports the estimation results and several

[4]The dominance of the dollar in international finance markets is also the focus of a recent literature that studies its insurance value (Gourinchas et al., 2010), liquidity characteristics (Bianchi et al., 2022), convenience yield (Kekre and Lenel, 2024; Jiang et al., 2021), and collateral properties (Devereux et al., 2023).

[5]Rebucci and Ma (2020) survey the literature on the use of macroprudential instruments, and in particular capital controls, to address the inefficiencies arising from pecuniary externalities, which our model abstracts from.

[6]Schmitt-Grohé and Uribe (2016) reach a similar result in a model with downward wage rigidities.

counterfactuals that highlight the role of the key frictions in the model. Section 5 compares the effects of alternative policies. Finally, Section 6 concludes. The Appendix contains additional empirical results and details of the model.

2 Revisiting the GFC Evidence

In this section, we estimate a panel VAR (PVAR) on a sample of countries with a flexible exchange rate. The frequency is monthly and the data cover 15 countries (Australia, Canada, Chile, Germany, Japan, Korea, Mexico, New Zealand, Norway, Singapore, South Africa, Sweden, Switzerland, Thailand and the United Kingdom) during the period 1997M1–2019M12. In this group of countries, the cross-sectional average of the classification of exchange rates by Ilzetzki et al. (2019) during the 1997–2019 period is 11.6, with a minimum value of 9.0 for Sweden (higher values correspond to a more flexible exchange rate regime).[7]

The empirical VAR specification for each country i is

$$x_{it} = a_i + b_i t + \sum_{\ell=1}^{L} F_{i\ell} x_{it-\ell} + u_{it}, \tag{1}$$

where x_{it} is the vector of endogenous variables at time t, a_i is a vector of constants, t is a deterministic time trend, each $F_{i\ell}$ is a matrix of coefficients, and u_{it} is a vector of reduced form residuals with variance-covariance matrix Σ_{iu}. The vector x_{it} includes three US-specific variables and six country-specific variables. The US-specific variables are the monetary policy shock (ϵ_t^{US}), the excess bond premium (EBP_t^{US}) from Gilchrist and Zakrajsek (2012) and the log of real GDP (GDP_t^{US}). The country-specific variables are the log of real GDP (GDP_{it}), the CPI level (CPI_{it}), the log of exports in real terms (EX_{it}), the level of the nominal policy interest rate (INT_{it}), the log of the nominal exchange rate (FX_{it}), and the level of a measure of credit spreads (CS_{it}).[8]

To identify a US monetary policy shock, we employ the high-frequency monetary policy surprises constructed by Jarocinski and Karadi (2020) as an 'internal instrument' (Plagborg-Møller and Wolf, 2021).[9] Specifically, we include the series of monetary surprises as the first

[7]For robustness, we also consider a larger panel of 24 countries, for which the average value of the exchange rate classification is 11.1, with a minimum value of 8.0 for Argentina. See Appendix A for details.

[8]Following Miranda-Agrippino and Rey (2020), we interpolate macroeconomic quantities (real GDP and exports) at monthly level. Appendix A provides additional details on the definition and sources of the data.

[9]We downloaded the updated series of surprises from Marek Jarocinski's website (`https://marekjarocinski.github.io/`).

element of the vector of endogenous variables

$$x_{it} = \left[\begin{array}{ccccccccc} \epsilon_t^{US} & EBP_t^{US} & GDP_t^{US} & GDP_{it} & CPI_{it} & EX_{it} & INT_{it} & FX_{it} & CS_{it} \end{array} \right].$$

The introduction of the excess bond premium in the vector of endogenous variables is important for two reasons. First, given the small scale of our empirical model, this variable helps with the correct specification because of its strong predictive power for real economic activity, thus expanding the VAR information set (Caldara and Herbst, 2019). Second, the EBP can provide useful information about the quantitative strength of financial frictions in the transmission of monetary policy shocks (Gertler and Karadi, 2015).

We obtain impulse responses from a Cholesky factorization of the reduced-form variance-covariance matrix of the VAR residuals. For the estimation of the VAR and the construction of confidence intervals, we rely on the the mean group estimator of Pesaran and Smith (1995), as pooled estimators are not consistent in dynamic panel data with heterogeneous (in our case, different across countries) slope coefficients. The Hannan–Quinn information criterion suggest 4 lags for the majority of countries (12 out of 15). We thus set $L = 4$, but the Appendix shows that the results are robust to using different lag information criteria.

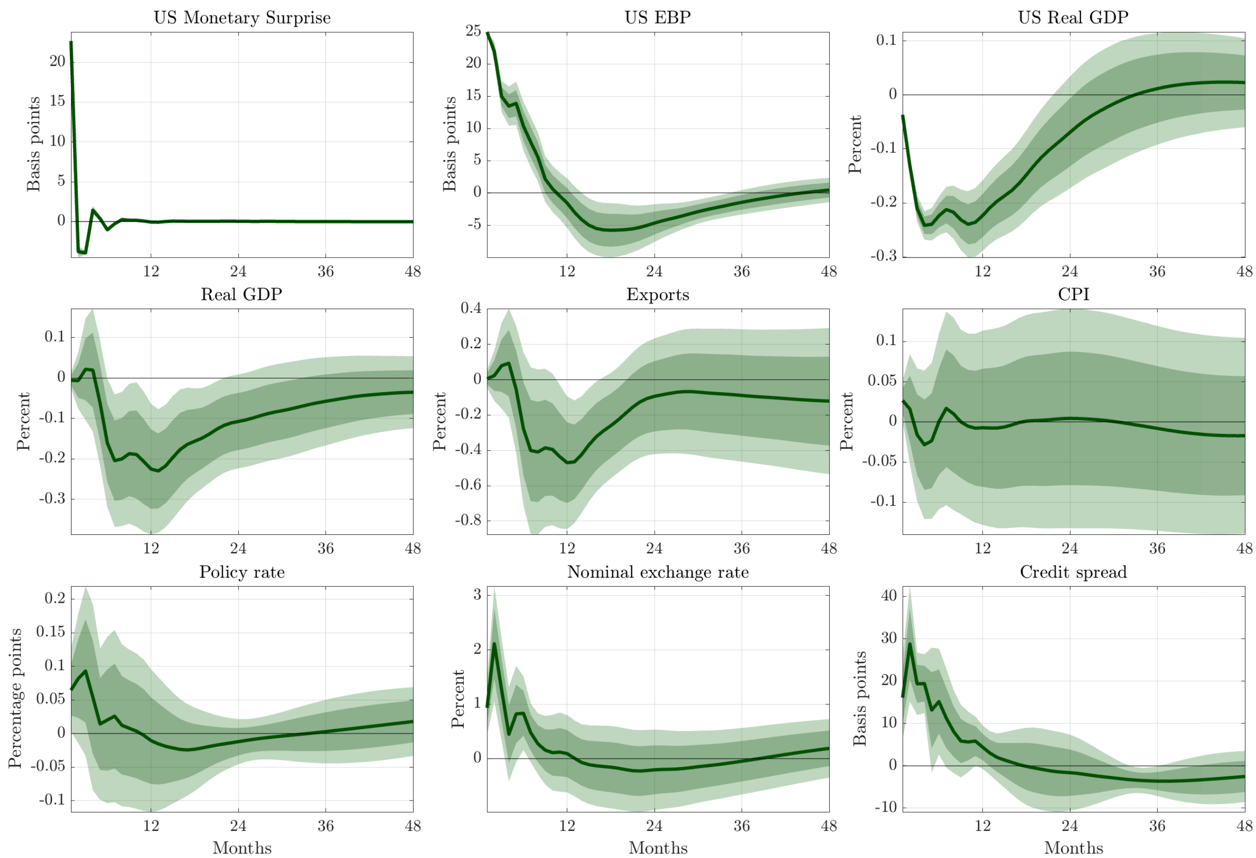
2.1 PVAR Baseline Estimation Results

Figure 1 reports the impulse responses of the variables in the panel VAR to an identified US monetary policy tightening. We pick the size of the shock to generate a 25 basis points increase in the EBP, which roughly corresponds to a two-standard-deviation shock or, equivalently, to a 40 basis points increase in the 1-year rate in Gertler and Karadi (2015). The solid line is the mean group estimator. The dark and light shaded areas represent the 68% and 90% confidence bands, respectively.

The shock (top-left panel) leads to an increase of the EBP (top-center panel) and a persistent and hump-shaped decline of US real GDP (top-right panel), as in the closed economy analysis of Gertler and Karadi (2015) and Caldara and Herbst (2019).

The remaining impulse responses show the average response of macroeconomic and financial variables in our sample of countries with flexible exchange rates. As expected, the monetary policy tightening in the US causes a depreciation of the local currency (bottom-center panel). A persistent contraction of credit conditions in the typical small open economy (bottom-right panel) is a first indication of the GFC, since domestic spreads closely co-move with those in the US. The persistent fall of real GDP (middle-left panel) and exports (middle-center panel) are also in line with the idea of a GFC, in the sense that the

Figure 1: Impulse responses to a US monetary policy tightening.



NOTE: Impulse responses to a contractionary monetary policy shock in the US. The solid line is the mean group estimate. The dark and light shaded areas are the 68% and 90% confidence intervals, respectively. Interest rates and credit spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

financial channel of the transmission mechanism dominates over the expenditure-switching effect. In a Mundellian framework, the depreciation of the nominal exchange rate should boost exports and insulate, at least in part, the small open economy from the foreign monetary policy shock. While this mechanism may be operative in partial equilibrium, the data highlight the strength of the transmission through financial variables. In general equilibrium, the negative effect of the monetary policy tightening on foreign demand explains the fall of exports in the small open economy. Finally, also in line with the GFC evidence in Rey (2013), the nominal interest rate initially increases (bottom-left panel), although the response is just marginally statistically significant on impact and becomes non-significant thereafter. The response of the CPI (middle-right) is not significant over the entire horizon and the mean group estimate is extremely close to zero.[10] Appendix A shows that these

[10] The non-significant response of inflation among countries with flexible exchange rates is in line with the

results are robust to a number of variations.[11]

In short, our PVAR evidence is broadly consistent with the GFC hypothesis. In response to a contractionary monetary policy in the US, the nominal exchange rate of a typical small open economy that adopts a flexible exchange rate regime depreciates while credit spreads increase. The tightening of domestic financial conditions leads to a fall in real GDP and exports, despite the exchange rate depreciation. The central bank in the small open economy moderately tightens monetary policy on impact, while inflation remains stable. Thus, flexible exchange rates do not fully insulate the country from a monetary policy shock that originates in the US. The next section develops and estimates a two-country DSGE model with financial frictions to account for the evidence from the PVAR.

3 A Model of the Global Financial Cycle

The model that we use is closely related to Akinci and Queralto (2019). The world consists of two countries, Home (of size n) and Foreign (of size $1-n$). Households in each country consume Home and Foreign goods, supply labor, and can save via deposits in financial intermediaries (banks). Foreign banks operate both domestically and internationally, whereas Home banks only operate domestically. On the supply side, intermediate goods firms combine labor and capital to produce differentiated varieties. Retailers combine these varieties to bring the final good to consumers, and set prices on a staggered basis. Capital producers transform the final consumption good into investment goods subject to an adjustment cost function. In each country, a central bank sets monetary policy. In what follows, we describe the model from the perspective of the Home country. Where necessary, an asterisk denotes Foreign variables.

3.1 Households

In the Home country, the representative household consists of a continuum of members $i \in (0, n)$ who supply differentiated labor inputs $\ell_t(i)$. A representative union combines

evidence in Flaccadoro and Nispi Landi (2022).

[11] The alternative specifications that we consider include extending the sample to a larger set of small open economies, setting the number of lags according to different criteria, dropping the deterministic time trend, considering a longer sample period starting in 1985, using a measure of short-term market interest rates instead of policy rates, and including additional variables (e.g. US CPI, the price of oil, or equity prices in the small open economies).

labor inputs into a homogeneous aggregate

$$\ell_t \equiv \left[\left(\frac{1}{n} \right)^{\frac{1}{\nu}} \int_0^n \ell_t(i)^{\frac{\nu-1}{\nu}} di \right]^{\frac{\nu}{\nu-1}}, \tag{2}$$

where $\nu > 1$ is the elasticity of substitution among labor inputs. The demand for the i^{th} labor variety is

$$\ell_t(i) = \frac{1}{n} \left[\frac{W_t(i)}{W_t} \right]^{-\nu} \ell_t, \tag{3}$$

where $W_t(i)$ is the nominal wage specific to type$-i$ labor input and the aggregate wage index is

$$W_t = \left[\frac{1}{n} \int_0^n W_t(i)^{1-\nu} di \right]^{\frac{1}{1-\nu}}. \tag{4}$$

The representative household takes labor demand (3) as given, and sets wages on a staggered basis, where $\xi_w \in (0,1)$ is the probability of keeping the wage fixed.

Because of perfect risk sharing among its members, the household chooses consumption c_t and savings in nominal deposits D_t on behalf of all its members to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \beta^j \left[\ln(c_{t+j} - h\bar{c}_{t+j-1}) - \frac{\chi}{1+\zeta} \int_0^n \ell_{t+j}(i)^{1+\zeta} di \right], \tag{5}$$

where $\bar{c}_{t-1}$ is a reference consumption level that the household takes as given, $h \in (0,1)$ is the habits parameter, $\zeta > 0$ is the inverse Frisch elasticity of labor supply, and $\chi > 0$ is a parameter that pins down the steady state level of hours worked. The budget constraint at time t is

$$P_t c_t + D_t = \int_0^n W_t(i)\ell_t(i) di + R_{t-1}D_{t-1} + T_t, \tag{6}$$

where P_t is the consumer price index (CPI), R_t is the nominal gross nominal interest rate on deposits, and T_t are profits from ownership of banks and firms net of lump-sum taxes.

The overall consumption bundle is a CES aggregator defined over goods produced in the Home and Foreign country

$$c_t \equiv \left[a^{\frac{1}{\epsilon}} c_{Ht}^{\frac{\epsilon-1}{\epsilon}} + (1-a)^{\frac{1}{\epsilon}} c_{Ft}^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}, \tag{7}$$

where $\epsilon > 0$ is the elasticity of substitution between Home and Foreign goods, and $a \in (n,1)$ is the degree of home bias.[12] Expenditure minimization implies that the consumer price

[12] We assume that $a \equiv 1 - \o(1-n)$, where $\o \in (0,1)$ is the degree of openness. Similarly, for the Foreign country, we have $a^* = n\o$.

index is

$$P_t = \left[a P_{Ht}^{1-\epsilon} + (1-a) P_{Ft}^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}, \tag{8}$$

where P_{Ht} and P_{Ft} are the Home currency prices of goods produced in the Home and Foreign country, respectively. In turn, the consumption bundle for Home-produced goods consists of a continuum of varieties whose measure corresponds to the country size

$$c_{Ht} = \left[\left(\frac{1}{n} \right)^{\frac{1}{\varrho}} \int_0^n c_t(h)^{\frac{\varrho-1}{\varrho}} dh \right]^{\frac{\varrho}{\varrho-1}} \tag{9}$$

where $\varrho > 0$ is the elasticity of substitution among varieties. The implied price index for the Home goods bundle is

$$P_{Ht} = \left[\frac{1}{n} \int_0^n P_t(h)^{1-\varrho} dh \right]^{\frac{1}{1-\varrho}}. \tag{10}$$

Similarly, the consumption bundle for Foreign-produced goods is

$$c_{Ft} = \left[\left(\frac{1}{1-n} \right)^{\frac{1}{\varrho}} \int_n^1 c_t(f)^{\frac{\varrho-1}{\varrho}} df \right]^{\frac{\varrho}{\varrho-1}}, \tag{11}$$

and the corresponding price index is

$$P_{Ft} = \left[\frac{1}{1-n} \int_n^1 P_t(f)^{1-\varrho} df \right]^{\frac{1}{1-\varrho}}. \tag{12}$$

The structure for the Foreign country is symmetric (adjusting for country size), except that the degree of home bias may be different.

3.2 Financial Intermediation

We assume an asymmetric international financial structure. Foreign banks operate both domestically and internationally, whereas Home banks only operate domestically.[13] As a consequence of this asymmetric financial structure, we interpret the Home country as the typical small open economy and the Foreign country as a financial hegemon (e.g. the US).

[13] Our international financial structure is slightly different from Akinci and Queralto (2019), who do not model banking frictions in the Foreign country. This different assumption has some consequences on the degree of amplification of financial frictions, which we discuss below.

3.2.1 Foreign Banks

Foreign banks fund their operations with domestic deposits and net worth, which in real terms we denote with n_t^*. Their assets consists of loans to both Foreign firms and Home banks, whose market value in real terms are $q_t^* z_t^*$ and $b_t^* \equiv B_t^*/P_t^*$, respectively.[14] International interbank borrowing and lending takes place in Foreign currency. The balance sheet of Foreign banks in real terms at the end of time t is

$$q_t^* z_t^* + b_t^* = d_t^* + n_t^*, \tag{13}$$

where $d_t^* \equiv D_t^*/P_t^*$. Net worth is the difference between the gross return on assets and liabilities

$$n_t^* = r_{kt}^* q_{t-1}^* z_{t-1}^* + \frac{R_{bt-1}^*}{\Pi_t^*} b_{t-1}^* - \frac{R_{t-1}^*}{\Pi_t^*} d_{t-1}^*, \tag{14}$$

where r_{Kt}^* is the real return on capital, R_{bt}^* is the gross nominal interest rate on loans to Home banks, and $\Pi_t^* \equiv P_t^*/P_{t-1}^*$ is the gross inflation rate.

As in Gertler and Karadi (2011), we assume that in each period banks continue their operations with probability ω. With the complementary probability, banks exit the industry, turn their net worth to households, and are replaced by an equal mass of new banks that start operating with a small transfer from households. The objective function of banks is the expected value of terminal wealth, which we can write in recursive form as

$$V(n_t^*) = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1}^* [(1-\omega) n_{t+1}^* + \omega V(n_{t+1}^*)] \right\}, \tag{15}$$

where $\mathcal{M}_{t,t+1}^*$ is the Foreign representative household's stochastic discount factor for real payoffs.

If a bank fails, a fraction $\theta^* \in (0,1)$ of its assets gets lost in the bankruptcy process. Without any constraint, banks would seek to expand their balance sheet indefinitely to minimize their bankruptcy costs. Thus, the incentive compatibility constraint for banks must be such that the value of the bank is greater than the value of the assets lost in case of bankruptcy

$$V(n_t^*) \geq \theta^* \left(q_t^* z_t^* + b_t^* \right), \tag{16}$$

where $\theta^* > 0$.

The problem of a banker consists of maximizing (15) subject to the balance sheet constraint (13), the evolution of net worth (14) and the incentive compatibility constraint (16). In an equilibrium in which the incentive compatibility constraint binds, the solution to the

[14] Formally, firms issue financial securities in exchange for the loans obtained from the bank.

bankers' problem implies

$$\lambda_t^* = \frac{\mu_{dt}^*}{\theta^* - \mu_{kt}^*}, \tag{17}$$

where $\lambda_t^* \equiv (q_t^* z_t^* + b_t^*)/n_t^*$ is the leverage ratio.[15] The numerator of (17) is the discounted expected real return on deposits

$$\mu_{dt}^* = \mathbb{E}_t \left(\mathcal{M}_{t,t+1}^* \Omega_{t,t+1}^* \frac{R_t^*}{\Pi_{t+1}^*} \right),$$

where $\Omega_{t,t+1}^* \equiv 1 - \omega + \omega \kappa_{t+1}^*$ is an additional discount rate that banks apply to future returns due to the probability of exiting, and $\kappa_t^* \equiv V(n_t^*)/n_t^* = \theta^* \lambda_t^*$ is the franchise value of the bank per unit of net worth. The denominator of (17) is instead the discounted expected excess return of capital over deposits

$$\mu_{kt}^* = \mathbb{E}_t \left[\mathcal{M}_{t,t+1}^* \Omega_{t,t+1}^* \left(r_{kt+1}^* - \frac{R_t^*}{\Pi_{t+1}^*} \right) \right].$$

As Gertler and Karadi (2011) stress, in the absence of financial frictions, μ_{kt} would be zero. In order to satisfy the incentive compatibility constraint (16), banks need to earn an excess return in expectation.

3.2.2 Home Banks

Home banks raise deposits from domestic households, borrow from Foreign banks, and use their net worth to lend to Home firms in domestic currency. Their balance sheet in real terms is

$$q_t z_t = d_t + s_t b_t^* + n_t, \tag{18}$$

where $s_t \equiv \mathcal{E}_t P_t^*/P_t$ is the real exchange rate and $\mathcal{E}_t$ is the nominal exchange rate from the perspective of the Home country (units of Home currency per unit of Foreign currency). Their net worth evolves according to

$$n_t = r_{kt} q_{t-1} z_{t-1} - \frac{R_{t-1}}{\Pi_t} d_{t-1} - \frac{R_{bt-1}^*}{\Pi_t^*} s_t b_{t-1}^*. \tag{19}$$

The presence of liabilities denominated in Foreign currency creates a balance sheet mismatch. For example, a depreciation of the Home currency for a given value of assets implies a reduction of the banks' net worth.[16]

[15] Appendix B reports the details of the derivations.

[16] In practice, large financial intermediaries may hedge some portion of the currency exposure on their balance sheet. Yet, currency hedging is far from complete. Agarwal (2021) shows that the appreciation

Home banks are subject to a similar moral hazard problem as Foreign banks. The key difference is that, as in Akinci and Queralto (2019), we assume that the fraction of assets that are lost in the bankruptcy process is an increasing function of the share of foreign currency liabilities

$$V(n_t) \geq \Theta(x_t) q_t z_t, \tag{20}$$

where

$$\Theta(x_t) \equiv \theta \left(1 + \frac{\gamma}{2} x_t^2\right), \tag{21}$$

and $x_t \equiv s_t b_t^* / (q_t z_t)$, with θ and $\gamma > 0$. The parameter θ governs the tightness of the financial friction, while γ determines the extent to which the financial friction varies with the share of foreign currency liabilities.

The problem of Home banks consists of maximizing

$$V(n_t) = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} [(1-\omega) n_{t+1} + \omega V(n_{t+1})] \right\}, \tag{22}$$

subject to (18), (19) and (20). Similarly to Foreign banks, we can write the solution to this problem as

$$\lambda_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt} x_t)}, \tag{23}$$

where $\lambda_t \equiv q_t z_t / n_t$ is the leverage ratio for Home banks. The definitions of the expected discounted real return on deposits μ_{dt} and of the expected discounted excess return of capital over deposits μ_{kt} correspond to their counterparts in the Foreign country

$$\mu_{dt} = \mathbb{E}_t \left(\mathcal{M}_{t,t+1} \Omega_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right), \tag{24}$$

$$\mu_{kt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t,t+1} \left(r_{kt+1} - \frac{R_t}{\Pi_{t+1}} \right) \right], \tag{25}$$

where $\Omega_{t,t+1} \equiv 1 - \omega + \omega \kappa_{t+1}$ is the additional discount factor and $\kappa_t \equiv V(n_t)/n_t = \Theta(x_t)\lambda_t$ is the franchise value of Home banks. Home banks also arbitrage between domestic deposits and funds raised in foreign currency from the international interbank market. Financial frictions limit this arbitrage activity that banks perform and create an endogenous wedge in the uncovered interest rate parity condition, in line with a large body of empirical evidence

of the Swiss Franc in 2015 had a significant effect on lending for banks with net foreign currency liability exposure. Krogstrup and Tille (2018) find that banks' foreign currency mismatch affects both the sign and the size of the response of their cross border positions to global risk factors. More broadly, the balance sheet mismatch in the model can be interpreted to capture the overall exposure of the private sector in the small open economy.

since Fama (1984)

$$\mu_{bt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t,t+1} \left(\frac{R_t}{\Pi_{t+1}} - \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right) \right]. \tag{26}$$

Given the functional form assumed for $\Theta(\cdot)$, we can solve for optimal proportion of foreign currency debt

$$x_t = \frac{1}{\mu_t} \left(\sqrt{1 + \frac{2\mu_t^2}{\gamma}} - 1 \right), \tag{27}$$

where $\mu_t \equiv \mu_{bt}/\mu_{kt}$. Since interbank borrowing corresponds to the net external position, equation (27) in steady state pins down net foreign liabilities.

3.3 Firms

Four types of firms operate in the Home country: capital producers, importers, intermediate goods producers and final goods producers. This rich production structure allows us to introduce a number of key pricing frictions in the model.

As in Akinci and Queralto (2019), final goods producers in both countries set prices on a staggered basis (Calvo, 1983). In the Home country, these firms price their products in the currency of the market of destination. In a two-country setting, this assumption is consistent with the evidence on 'dominant currency pricing' emphasized by Gopinath et al. (2020).

The presence of importers in the Home country distinguishes our framework from Akinci and Queralto (2019). Following Monacelli (2005), we assume that the law of one price for imported goods holds at the dock but importers adjust their price in domestic currency infrequently. This friction introduces imperfect exchange rate pass-through to the Home economy and is a key ingredient for matching the empirical response of inflation to a Foreign monetary policy shocks in the model, as we later demonstrate.

Production in the Foreign country is symmetric except that we abstract from importers since Home final goods producers price their exports in Foreign currency.

3.3.1 Capital Producers

Capital producers transform final goods into capital goods. On top of the cost of acquiring one unit of final good, capital producers pay an adjustment cost, which we assume to be quadratic in the growth rate of investment. The problem of capital producers in the Home country is to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \mathcal{M}_{t,t+j} \left[q_{t+j} - 1 - \frac{\varphi_i}{2} \left(\frac{i_{t+j}}{i_{t+j-1}} - 1 \right)^2 \right] i_{t+j}, \tag{28}$$

where $\varphi_i > 0$.

3.3.2 Intermediate Goods Producers

Competitive intermediate goods producers have access to a Cobb-Douglas technology in capital and labor

$$y_t = A_t k_{t-1}^{\alpha} \ell_t^{1-\alpha}, \tag{29}$$

where $\alpha \in (0,1)$ is the capital share. At the end of each period, firms issue securities to acquire capital for production in the subsequent period. After production takes place in a period, firms sell the undepreciated capital on the open market. Therefore, their balance sheet at time t is

$$q_t z_t = q_t k_t, \tag{30}$$

and their profits are

$$\mathcal{P}_t = p_{mt} y_t - w_t \ell_t - r_{kt} q_{t-1} z_{t-1} + (1-\delta) q_t k_{t-1}, \tag{31}$$

where p_{mt} is the relative price of intermediate goods and $w_t \equiv W_t / P_t$ is the real wage. The first order condition for labor is standard

$$w_t = (1-\alpha) p_{mt} A_t k_{t-1}^{\alpha} \ell_t^{-\alpha}. \tag{32}$$

Plugging this expression back into the profits of intermediate goods producers, we obtain

$$\mathcal{P}_t = \alpha p_{mt} y_t - r_{kt} q_{t-1} k_{t-1} + (1-\delta) q_t k_{t-1}. \tag{33}$$

Since intermediate goods producers are perfectly competitive, zero profits implies

$$r_{kt} = \frac{\alpha p_{mt} A_t k_{t-1}^{\alpha-1} \ell_t^{1-\alpha} + (1-\delta) q_t}{q_{t-1}}. \tag{34}$$

3.3.3 Final Goods Producers

Final goods producers operate in monopolistic competition and set prices on a staggered basis (Calvo, 1983). In each period, the probability that the price remains unchanged is

$\xi_p \in (0,1)$.

In the Home country, final goods producers set prices in the currency of the destination market (i.e., local currency pricing, or LCP). This assumption captures the idea that the Foreign country currency is 'dominant' in goods markets, as we have also assumed for financial markets.

The problem for Home producers consists of choosing $\widetilde{P}_t(h)$ and $\widetilde{P}_t^*(h)$ to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \xi_p^j \mathcal{M}_{t,t+j} \left\{ \left[\frac{\widetilde{P}_t(h)}{P_{t+j}} - p_{mt+j} \right] y_{t,t+j}(h) + \left[\frac{\mathcal{E}_{t+j} \widetilde{P}_t^*(h)}{P_{t+j}} - p_{mt+j} \right] y_{t,t+j}^*(h) \right\}, \tag{35}$$

where

$$y_{t,t+j}(h) = \left[\frac{\widetilde{P}_t(h)}{P_{Ht+j}} \right]^{-\varrho} y_{Ht+j} \qquad \text{and} \qquad y_{t,t+j}^*(h) = \left[\frac{\widetilde{P}_t^*(h)}{P_{Ht+j}^*} \right]^{-\varrho} y_{Ht+j}^*,$$

and the demand for Home goods by Home and Foreign households, respectively, are

$$y_{Ht} = a \left(\frac{P_{Ht}}{P_t} \right)^{-\epsilon} \left[c_t + i_t + \frac{\varphi_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 i_t \right],$$

and

$$y_{Ht}^* = a^* \left(\frac{P_{Ht}^*}{P_t^*} \right)^{-\epsilon} \left[c_t^* + i_t^* + \frac{\varphi_i}{2} \left(\frac{i_t^*}{i_{t-1}^*} - 1 \right)^2 i_t^* \right].$$

The first-order conditions for $\widetilde{P}_t(h)$ and $\widetilde{P}_t^*(h)$ are standard and, together with the price indexes, determine two Phillips curves.

The problem for final goods producers in the Foreign country is similar, except that those firms price in their domestic currency independently of the market of destination. As a consequence, the solution of their problem gives rise only to one Phillips curve.

3.3.4 Importers

The law of one price for imported goods holds at the dock, that is, $P_t^{im}(f) = \mathcal{E}_t P_t^*(f)$. However, in the Home country, the retailers that distribute imported goods change their prices with probability $\xi_{im} \in (0,1)$ in each period. Their problem is to choose the price $\widetilde{P}_t(f)$ to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \xi_{im}^j \mathcal{M}_{t,t+j} \left[\frac{\widetilde{P}_t(f)}{P_{t+j}} - \frac{P_{t+j}^{im}(f)}{P_{t+j}} \right] y_{t,t+j}(f), \tag{36}$$

where

$$y_{t,t+j}(f) = \left[\frac{\widetilde{P}_t(f)}{P_{Ft+j}} \right]^{-\varrho} y_{Ft+j},$$

and

$$y_{Ft} = (1-a) \left(\frac{P_{Ft}}{P_t} \right)^{-\epsilon} \left[c_t + i_t + \frac{\varphi_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 i_t \right].$$

The first-order condition for this problem is a Phillips curve that links the inflation rate of imported goods in domestic currency to the law of one price gap, that is, the difference between the price of imports in Foreign currency converted in domestic currency using the nominal exchange rate and the price of imports in domestic currency (Monacelli, 2005).

3.4 Monetary Policy

The baseline monetary policy configuration for the Home country assumes that the central bank sets the nominal interest rate according to a feedback rule (Taylor, 1993), augmented with inertia as in Clarida et al. (2000),

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R} \right)^{\rho_R} \left[\Pi_t^{\phi_\pi} \left(\frac{y_t}{y_{t-1}} \right)^{\phi_y} \left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}} \right)^{\phi_{\mathcal{E}}} \right]^{1-\rho_R}, \tag{37}$$

where $\rho_R \in (0,1)$ is the inertia parameter, $\phi_\pi > 1$ and $\phi_y > 0$ are the feedback coefficients on inflation and output growth, respectively, and $R = 1/\beta$ is the steady state nominal interest rate consistent with zero inflation (assumed to be the target for the central bank). We also allow the nominal interest rate to respond to the depreciation of the nominal exchange rate with a coefficient $\phi_{\mathcal{E}} > 0$. Although the countries in our sample have the most (de facto) flexible exchange regime, the classification in Ilzetzki et al. (2019) does not exclude a priori that monetary policy responds to the exchange rate (Lubik and Schorfheide, 2007).

The monetary policy rule in the Foreign country is similar, except that we assume no exchange rate response. In addition, we include a monetary policy innovation $\varepsilon^*_{Rt} \sim \mathcal{N}(0, \sigma^2_{R^*})$, which is the focus of our empirical analysis.

3.5 Equilibrium

The labor and capital markets clear nationally within each country. From the perspective of the Home country, net foreign liabilities correspond to the amount of interbank borrowing.

Their evolution, in real units of Foreign currency, is

$$b_t^* = \frac{R_{bt-1}^* b_{t-1}^*}{\Pi_t^*} + p_{Ft}^* y_{Ft} - \left(\frac{1-n}{n}\right) p_{Ht}^* y_{Ht}^*$$

Accordingly, the Home current account balance in real units of domestic currency is

$$ca_t \equiv -s_t(b_t^* - b_{t-1}^*).$$

4 Estimation and Counterfactuals

The quantitative assessment of the model relies on a mix of calibrated and estimated parameters. We calibrate all the parameters for the Foreign country, except those of the monetary policy rule, and some of the parameters of the Home country (Table 1).

The values for the Foreign country are consistent with the estimated values for the US economy in Smets and Wouters (2007), and whenever possible we maintain symmetry across countries. The relative size of the Home country is equal to 0.1, which corresponds to the average size of the countries in our sample relative to the US. Given the calibrated individual discount factors, the steady state real interest rate in annualized terms is 3% in the Home country and 1% in the Foreign country. The home bias parameter implies that the export share of GDP for the Home country is about 35%, in line with the average in our sample.[17] The choice of parameters for the US banks gives a steady state leverage ratio of 5 and a credit spread of 150 basis points annualized, which are standard values in literature (see, e.g., Gertler and Karadi, 2011).

We estimate the remaining parameters by minimizing the distance between the model-implied impulse responses to a Foreign monetary policy shock and the impulse responses of the PVAR presented in section 2 for the typical small open economy (the mean group estimates).[18] Formally, the estimator $\hat{\eta}$ solves

$$\min_{\eta} \left\{ \left[\widehat{\Psi} - \Psi(\eta)\right]' \widehat{W}^{-1} \left[\widehat{\Psi} - \Psi(\eta)\right] \right\},$$

where η is the vector of parameters to be estimated, $\widehat{\Psi}$ is the vector of impulse responses from the PVAR, $\Psi(\eta)$ is the vector containing of impulse responses from the DSGE model

[17] Given the relative country size, we pick the openness parameter ø to match the steady state export share of GDP, which in turn, determines a and a^*.

[18] To better align the model with the data, we convert all PVAR impulse responses to quarterly frequency by taking quarterly averages of the monthly responses. In additon, we compute the response of CPI inflation and the nominal exchange rate depreciation by taking first differences of the log-level responses.

Table 1: Calibrated parameters

Parameter	Description	Home	Foreign
n	Relative size of country H	0.1	0.9
β	Individual discount factor	0.9926	0.9975
h	Habits in consumption	–	0.71
σ	Relative risk aversion	–	1.38
χ	Relative weight on disutility of labor	28	1276
ζ	Inverse Frisch elasticity	1	1
ϱ	Elasticity of substitution among goods varieties	6	6
a	Home bias in consumption	0.66	0.85
ϵ	Elasticity of substitution between H and F goods	1.5	1.5
ν	Elasticity of substitution among labor varieties	6	6
ξ_w	Wage rigidity	0.66	0.66
ξ_p	Price rigidity	–	0.66
α	Capital share	0.33	0.33
δ	Depreciation rate	0.025	0.025
φ_i	Investment adjustment cost	–	5.74
ω	Bank survival rate	0.97	0.97
θ	Proportion of divertible funds	–	0.51
ξ_b	Bank transfer rate	–	0.002

Note: The missing parameters for the Home country are estimated.

and $\widehat{W}$ is a diagonal matrix collecting the estimated variances of each impulse response from the PVAR (i.e., the width of the error bands).

As in Christiano et al. (2011), we follow a Bayesian approach to estimate the parameters of the model with impulse response matching. Table 2 reports the list of estimated parameters (first column), their prior distributions (second to fourth columns), and their posteriors (fifth to eight column). We specify a prior directly on the steady state value of the leverage ratio of Home banks (λ) and on the steady state share of foreign currency debt (x). The data are particularly informative for the latter. At the posterior mode, the estimated values for these two variables imply a fraction of divertible funds θ equal to 0.500 (very close to the assumed value for θ^*), a degree of Home bias for bank funding γ equal to 2.131, and a bank transfer rate ξ_b equal to 0.0012, which is about half of the assumed value for Foreign banks.

The estimates of the other parameters are reasonably standard and the data are generally informative about their values.[19] The degree of price stickiness is fairly high, but very much

[19] Appendix A reports a systematic comparison of prior and posterior distributions.

Table 2: Estimated parameters

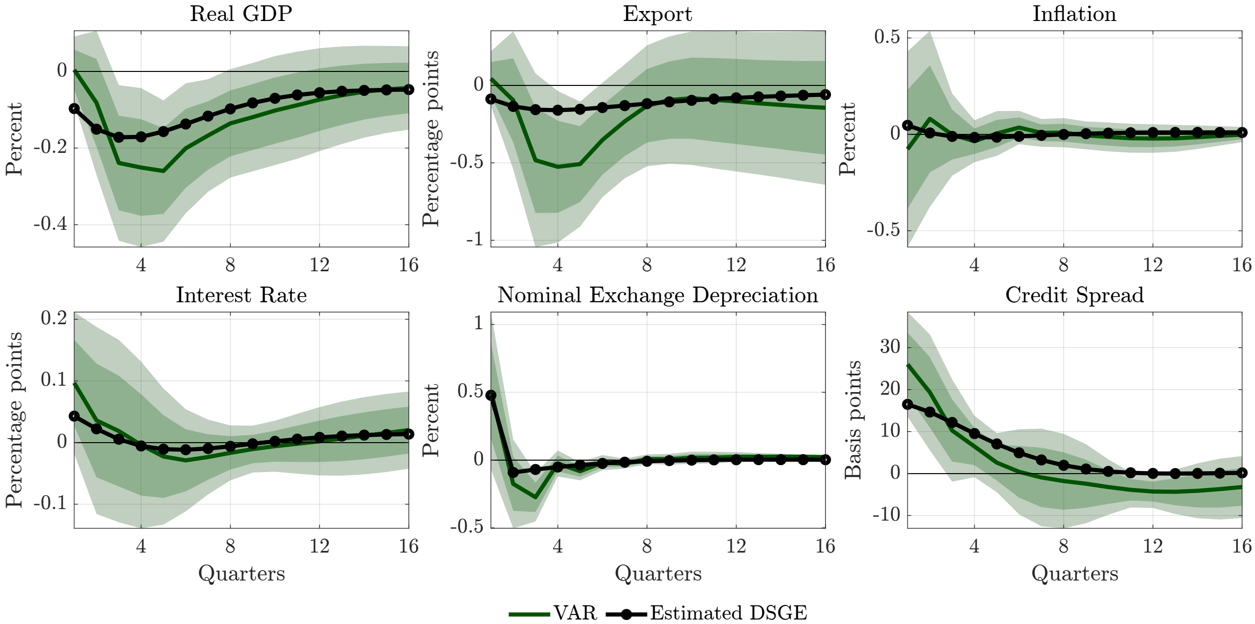
Parameter	Prior			Posterior			
	Distribution	Mean	SD	Mode	Median	5%	95%
h	Beta	0.650	0.1	0.716	0.709	0.568	0.856
σ	Gamma	1	0.375	1.136	1.286	0.794	1.882
λ	Gamma	5	1	4.661	4.678	3.455	6.069
x	Beta	0.240	0.15	0.154	0.258	0.047	0.480
φ_i	Gamma	2.850	2	0.578	0.717	0.168	1.584
ξ_p	Beta	0.660	0.14	0.853	0.763	0.542	0.957
ξ_{im}	Beta	0.660	0.14	0.720	0.674	0.450	0.896
ρ_R	Beta	0.750	0.1	0.758	0.752	0.594	0.907
ϕ_π	Gamma	1.500	0.25	1.442	1.487	1.140	1.876
ϕ_y	Gamma	0.125	0.05	0.108	0.117	0.044	0.197
$\phi_\mathcal{E}$	Gamma	0.100	0.05	0.076	0.091	0.025	0.167
ρ_R^*	Beta	0.750	0.1	0.892	0.840	0.731	0.937
ϕ_π^*	Gamma	1.500	0.25	1.414	1.450	1.072	1.800
ϕ_y^*	Gamma	0.125	0.05	0.105	0.119	0.044	0.203

NOTE:

comparable to recent estimates that include data after the financial crisis (Del Negro et al., 2015). Conversely, the degree of import price stickiness is significantly lower, implying an average contract duration between three and four quarters. The coefficients on inflation and output growth in the interest rate rule are very close across countries. Interest rate inertia is slightly higher in the Foreign country than in the Home country. In line with the notion that the countries in our sample adopt a flexible exchange rate regime, the coefficient on the depreciation of the nominal exchange rate is small, albeit non-zero.

Figure 2 presents the mean group estimate of the impulse responses for the typical small open economy to a contractionary US monetary policy shocks at a quarterly frequency (solid green line), as well as the 68% (dark shaded areas) and the 90% (lighter shaded areas) confidence bands. The solid black lines with markers in the same figure correspond to the impulse responses to a Foreign monetary policy shock of the same variables in the model at the posterior mode. The model fits the response of real GDP, inflation, the nominal interest rate, and the depreciation of the nominal exchange rate very well. On impact, the response of credit spreads is very close to its empirical counterpart. Over time, the response in the model is somewhat more persistent than in the data, although within the 90% confidence bands throughout the four-year horizon that we report. The response of exports is quantitatively

Figure 2: Impulse response matching.



Note: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in a typical small open economy to a US contractionary monetary policy shock, comparing the VAR (solid green lines) and the DSGE model (solid black lines with markers). The light and dark grey shaded areas are the PVAR 68% and 90% confidence intervals from the VAR, respectively. Inflation, the nominal interest rate and spreads are in annualized terms.

less impressive but qualitatively in line with the data, and lies at least within the 10-90 confidence bands throughout the simulation horizon.

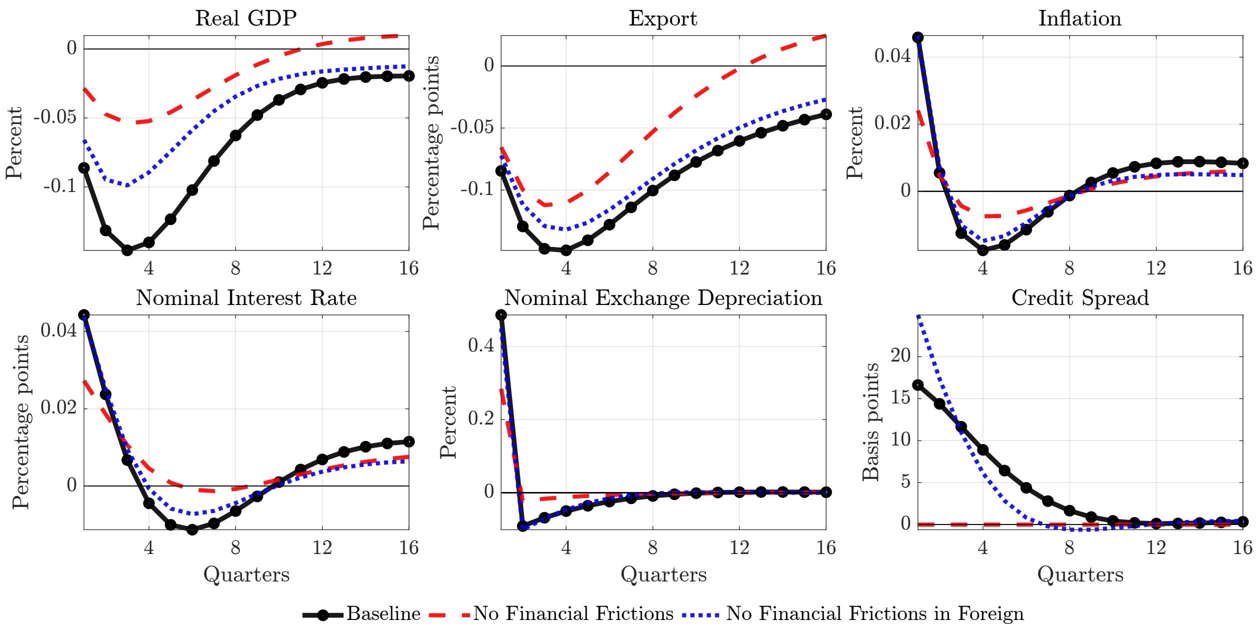
The model, therefore, is able to replicate the dominant role of the financial channel in propagating Foreign monetary policy shocks to the domestic economy that we have highlighted in section 2. We investigate the key ingredients of transmission mechanism by way of three counterfactual exercises.

4.1 The Role of Financial Frictions

In the first counterfactual exercise, we shut down financial frictions, either in both countries or in the Foreign country.

With no financial frictions in both countries, the difference with the baseline model is that households invest directly in physical capital and in nominal bonds. Bonds denominated in Foreign currency are internationally traded, whereas bond denominated in Home currency only circulate domestically and are in zero net supply. These assumptions preserve the dominance of the Foreign currency (in practice the US dollar) in international financial

Figure 3: No financial frictions.



Note: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country without financial frictions in both countries (dashed red line) and in the Foreign country only (dotted blue line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

markets even in the absence of global banks.[20] In order to ensure stationarity of the net foreign asset position, we introduce a small portfolio-adjustment cost for trading bonds (Schmitt-Grohé and Uribe, 2003). The resulting model is thus a standard two-country open economy framework with incomplete international financial markets, similar to Baxter and Crucini (1995) and Kollmann (1996). Without financial frictions only in the Foreign country, the structure of international financial markets replicates Akinci and Queralto (2019). We perform this experiment to isolate the quantitative contribution of introducing financial frictions in both economies.

Figure 3 highlights the amplification effect of financial frictions on macroeconomic and financial outcomes. The dashed red line in the figure reports the response to a foreign monetary policy shocks with no financial frictions in both countries, while the dotted blue line corresponds to the case of no financial frictions in the Foreign economy. The solid black line is the estimated response from the baseline model at the posterior mode of the parameters.

With no financial frictions in both countries, output drops by less than 0.05% at the

[20]Without financial frictions the composition of the private sector balance sheet does not affect investment above and beyond the direct valuation effect associated with borrowing in foreign currency.

trough, compared to slightly less than 0.2% in the baseline. The absence of an endogenous UIP wedge halves the depreciation of the Home currency. The second effect (smaller depreciation) quantitatively dominates over the first (smaller recession), implying somewhat less inflation than in the baseline. As a consequence, the central bank increases the nominal interest rate less and for a shorter period.

Financial frictions also significantly amplify the response of exports. In the frictionless model, the negative response is smaller on impact and much less persistent than in the baseline case, turning positive after ten quarters. The reason is that foreign demand drops much less than in the baseline, thus allowing exports to recover more quickly.

The case of no financial frictions in the Foreign country is qualitatively similar. Quantitatively, the main difference with the case of no financial frictions in both countries concerns the persistence of the response of exports, which is closer to the baseline. One reason is the relatively higher foreign demand. The other reason is that financial frictions in the Home country reduce the amount of capital intermediate goods producing firms can acquire compared to the frictionless case. Thus, the relative price of intermediate goods rises, and exporting firms that can adjust increase the relative price of their products in response to higher marginal costs. This second channel is the key driver of the difference in the response of exports without financial frictions in the Foreign country only compared to no financial frictions in either country.

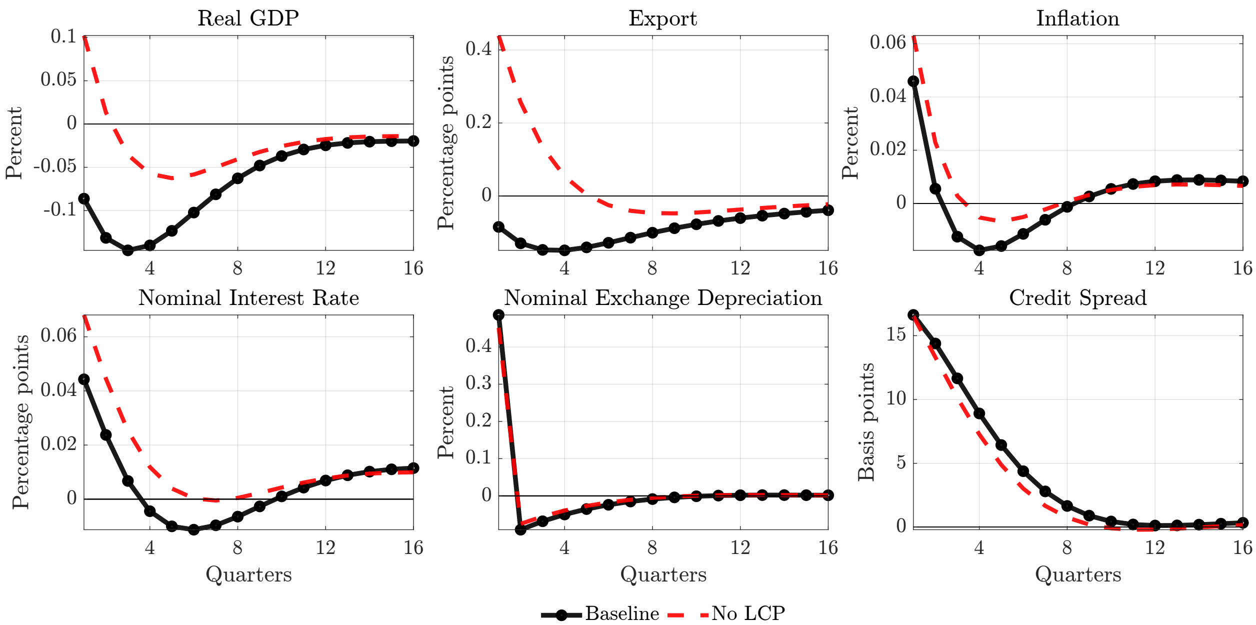
4.2 The Role of Trade Frictions

The key element of the model that explains the sign of the response of exports is the assumption about the currency of invoicing. Under our baseline assumption of LCP in the Home country, aimed at mimicking the dominance of the US dollar in goods price invoicing, exports fall following a monetary policy contraction in the Foreign country.

In general, the response of exports is the result of two channels. On the one hand, the depreciation of the Home currency makes domestic goods more competitive and increases the demand for exports (expenditure-switching channel). On the other hand, the fall of Foreign demand reduces demand for Home exports (global-demand channel). Under LCP, exports are not very sensitive to the nominal exchange rate depreciation. Conversely, financial frictions make the global demand channel even stronger by amplifying the drop of Foreign output.

Figure 4 illustrates the importance of the LCP assumption. The figure compares the baseline case (solid black line) with the impulse response functions under PCP (red dashed lines). In the counterfactual experiment, exports increase and return to steady state after about six quarters. The positive effect of the depreciation pushes real GDP in positive

Figure 4: No LCP in the Home country.



Note: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country with PCP (dashed red line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

territory, at least temporarily. Furthermore, the response of inflation is somewhat larger, and remains positive almost throughout the simulation horizon despite tighter domestic monetary policy. Under PCP, differently from the baseline, the Home central bank does not face a tradeoff between stabilizing inflation and output in response to the foreign monetary policy shock.

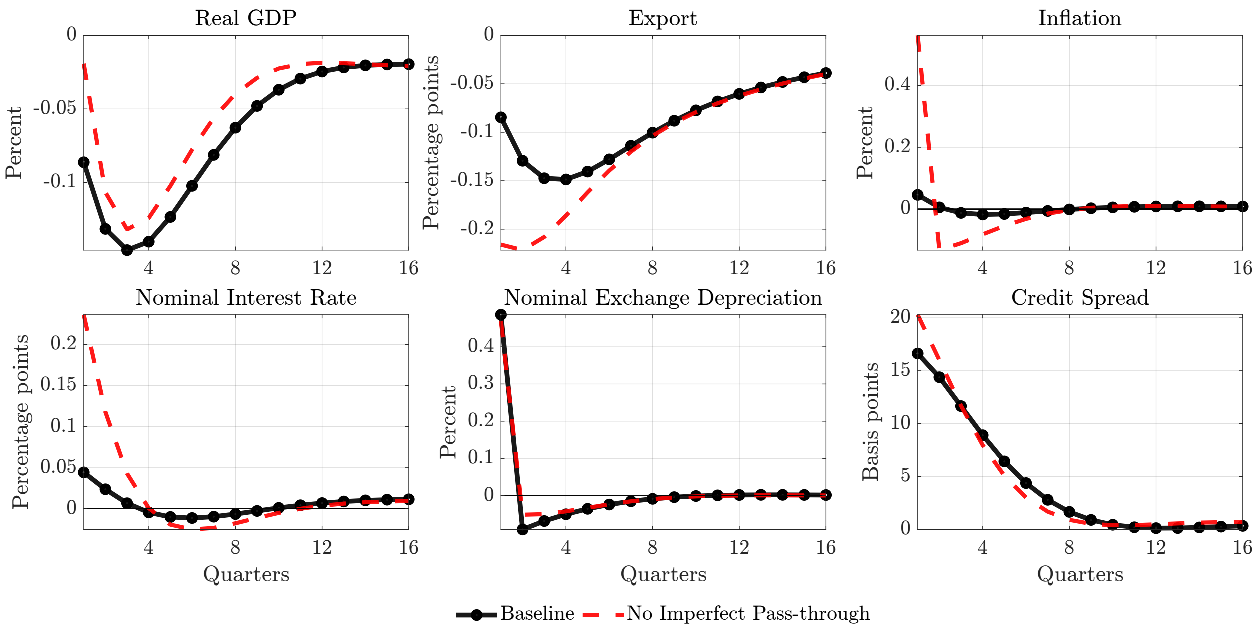
Overall, these first two counterfactual exercises clarify that the combination of financial and trade frictions is indeed crucial in accounting for the key empirical features of the GFC.

4.3 The Response of Inflation

From the perspective of monetary policy stabilization, the response of domestic inflation in a small open economy following a foreign monetary policy shock is an important dimension of the GFC evidence and the related Trilemma versus Dilemma debate. As Rey (2013) emphasizes, if a country with a flexible exchange rate regime does not manage to stabilize domestic inflation in the face of foreign shocks, the benefits of floating its currency may indeed prove elusive.

Our evidence suggests that the response of inflation to a contractionary foreign monetary policy shock is small and not statistically significant. This result is consistent with the

Figure 5: No imperfect pass-through.



Note: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign without price rigidities for importers (dashed red line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

findings in Passari and Rey (2016) for the UK, in Rey (2016) for Sweden, and in Flaccadoro and Nispi Landi (2022) for their overall sample.[21]

Figure 5 shows that imperfect pass-through plays a key role in aligning the model with the evidence for the response of inflation, above and beyond the contribution of financial and trade frictions discussed in the previous two counterfactual exercises. The dashed red line in the figure reports the response to a foreign monetary policy shocks when the law of one price holds at the consumer level. In this variant of the model, importers are perfectly competitive firms that deliver foreign goods to final consumers without pricing frictions ($\xi_{im} = 0$). The solid black line is the estimated response from the baseline model.

The figure shows that the same depreciation of the nominal exchange rate makes inflation jump in positive territory by more than 60 basis points in annualized terms, compared to less than 10 in the baseline. Without pricing frictions on importers, the exchange rate pass-through coefficient on impact is approximately 1, compared to about 0.1 in the baseline. In the counterfactual, the inflation increase forces the central bank to raise the nominal interest

[21] In Rey (2016), the median response of inflation for Canada, the UK and New Zealand is positive but generally not significant. The response of inflation for floaters is negative and significant in Miranda-Agrippino and Rey (2020) and Degasperi et al. (2020), reinforcing the narrative that a flexible exchange rate regime provides little insulation against foreign monetary policy shocks.

rate by a factor of five compared to the baseline formulation of the model. Therefore, if the law of one price holds, the foreign monetary policy shock creates a substantial tradeoff between inflation and output stabilization, quantitatively much more significant than in the baseline.

5 Policy Analysis

In this section, we study two questions. First, we revisit the benefits of flexible exchange rates using our estimated model. Second, we analyze the extent to which the introduction of two additional policy instruments (a tax on either foreign borrowing or domestic credit) affects welfare and the volatility of macroeconomic and financial variables induced by foreign monetary policy shocks.[22]

5.1 The Benefits of a Flexible Exchange Rate

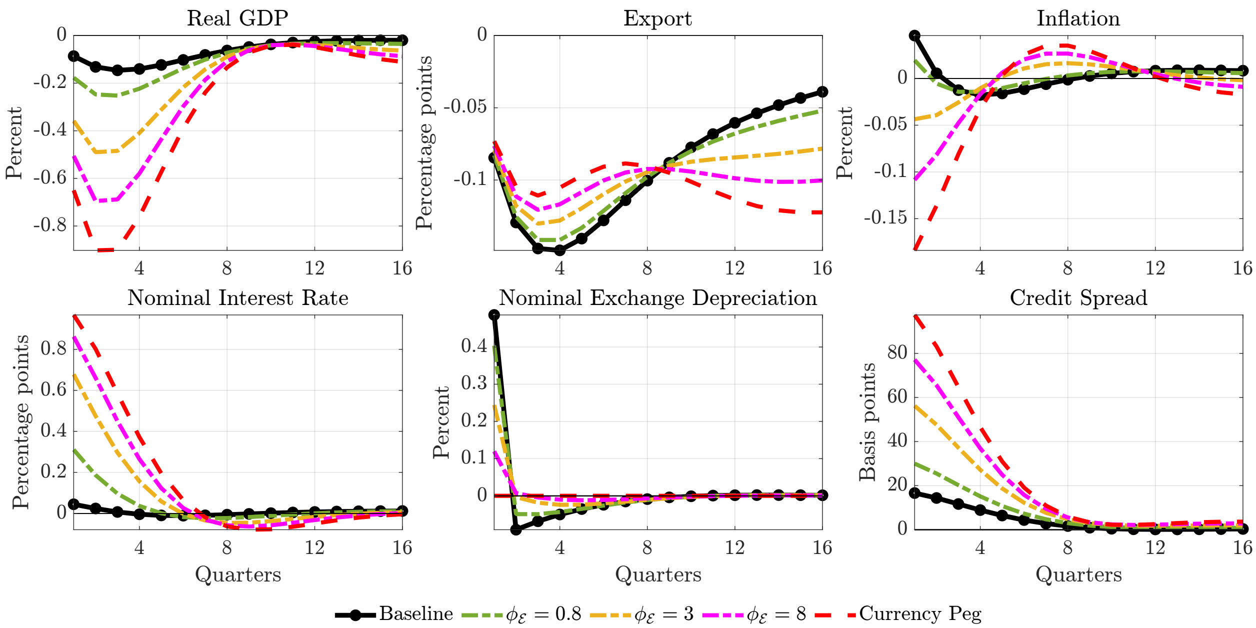
The model developed in section 3 can match the empirical evidence on the GFC presented in section 2, according to which the financial channel dominates over the trade channel in the international transmission of monetary policy shocks. An interest rate increase in the Foreign country determines a tightening of domestic financial conditions. In spite of the depreciation of the domestic currency, exports decline and so does real GDP. Thus, exchange rate flexibility is not enough to provide full insulation for the domestic economy. In fact, the depreciation of the exchange rate increases the cost of foreign funds for domestic financial intermediaries and thus contributes to exacerbate the negative impact of the shock.

Even without full insulation, Figure 6 shows that a flexible exchange rate limits macroeconomic volatility compared to a managed float or a peg.[23] In the extreme case when the nominal exchange rate is fixed (the limit for $\phi_{\mathcal{E}} \to \infty$, represented by the dashed red line in Figure 6), the central bank of the Home country must increase the nominal interest rate to track the monetary policy tightening abroad. Interestingly, in the model, the domestic nominal interest rate increases slightly more than one to one with the Foreign rate because of the endogenous wedge in the UIP condition. As a result, domestic financial conditions significantly worsen, with spreads increasing by a factor of six compared to the baseline. Real GDP falls by more than 1 percentage points at the trough, compared to less than 0.2

[22] Fanelli and Straub (2021) study the optimal design of another instrument—foreign exchange interventions—in a model with financial frictions similar to Gabaix and Maggiori (2015) and a pecuniary externality with domestic distributional effects.

[23] The baseline is very close to an effective flexible exchange rate regime given the small estimated coefficient on the depreciation of the nominal exchange rate at the posterior mode ($\phi_{\mathcal{E}} = 0.074$).

Figure 6: Managed nominal exchange rate.



NOTE: The figure compares the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country under a progressively more aggressive managed float, in which the central bank of the Home country responds to the depreciation of the nominal exchange rate with increasingly higher coefficients (dashed-dotted green line with $\phi_{\mathcal{E}} = 0.8$, dashed-dotted yellow line with $\phi_{\mathcal{E}} = 3$, dashed-dotted magenta line with $\phi_{\mathcal{E}} = 8$, respectively) and under a peg (dashed red line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

percentage points under the baseline regime, in which the exchange rate is nearly fully flexible. The Home country also experiences a decline of inflation and a much more persistent fall in exports compared with the baseline.

The row 'Peg' of Table 3 reports the welfare cost, measured in terms of consumption equivalent, of a fixed exchange rate relative to the baseline. The Home representative household is willing to give up 13.27% of its consumption to avoid moving from the baseline regime to a peg. The volatility of real GDP is especially higher than in the baseline, but inflation volatility increases significantly too. Interestingly, the table shows that, in our model, a fully flexible regime is actually not optimal, although the welfare costs are very small. This result is not necessarily surprising for two reasons. First, we are measuring welfare only for the Home country, taking Foreign country policy as given. Second, the model features a host of frictions that may imply the suboptimality of flexible exchange rates more generally.[24] For example, as discussed earlier, the Home country may benefit from a more stable nominal exchange rate given the currency mismatch in the balance sheet of its banks (Bianchi and

[24]We leave the full exploration of unilateral and joint optimal policy in this model for future research.

Table 3: Welfare and volatilities.

Regime	Std. of real GDP	Std. of inflation
Fully flexible exchange rate	0.0024	0.0001
Baseline	0.0028	0.0001
Baseline + tax on domestic credit	0.0002	0.0001
Baseline + tax on foreign borrowing	0.0009	0.0001
Peg	0.0852	0.0017
Peg + tax on domestic credit	0.0035	0.0026
Peg + tax on foreign borrowing	0.0069	0.0013

NOTE: The second and third columns report the standard deviation of real GDP and inflation (also in percent) under each policy regime.

Coulibaly, 2023). In addition, real frictions, such as LCP and imperfect pass-through, per se provide another rationale for targeting the nominal exchange rate (Devereux and Engel, 2003; Monacelli, 2005).

The response of real GDP, the nominal interest rate and credit spreads increases monotonically (in absolute value) with the coefficient on the exchange rate depreciation in the monetary policy rule (dashed-dotted magenta, yellow and green lines). If the central bank targets the nominal exchange rate aggressively enough, inflation falls on impact but then overshoots its long-run value after four quarters before reverting back to target by the end of the simulation horizon. Conversely, the nominal exchange rate and exports display a smaller response on impact when monetary policy tries to actively stabilize the nominal exchange rate. The decline in exports, however, worsens after eight quarters, due to the appreciation of the real exchange rate (not shown).

Overall, the results in our model are consistent with the empirical evidence in Obstfeld et al. (2019). While a more flexible exchange rate regime does not fully insulate a country from foreign monetary policy shocks, the transmission is not independent of the exchange rate regime, and a peg substantially increases the volatility of both macroeconomic and financial variables.

5.2 Countercyclical Taxes

In addition to questioning the consensus on the advantages of flexible exchange rates, the recent literature on the GFC has also brought to the fore a discussion on the merits of a number of other policy instruments. In particular, Rey (2013) explicitly mentions the idea of either directly curbing domestic credit or actively managing the capital account as a way to dampen excessive macroeconomic volatility due to global financial shocks.

As in Levine and Lima (2015) and Adrian et al. (2020), we model these instruments as taxes. The tax on domestic credit, which we denote with τ_t^k, reduces the effective return on loans that accrues to Home banks. The tax on borrowing in foreign currency, which we denote with τ_t^b, increases the cost that banks pay on foreign loans. As a result, the net worth of Home banks becomes

$$n_t = (1 - \tau_{t-1}^k) r_{kt} q_{t-1} z_{t-1} - \frac{R_{t-1} d_{t-1}}{\Pi_t} - (1 + \tau_{t-1}^b) \frac{R_{bt-1}^*}{\Pi_t^*} s_t b_{t-1}^*, \tag{38}$$

while their balance sheet remains unchanged.

We assume that the government in country H sets either tax in response to deviations of the value of credit from its steady state value

$$\tau_t^j = \left(\frac{q_t z_t}{qz} \right)^{\phi_j} - 1, \tag{39}$$

where $\phi_j > 0$ for $j = \{k, b\}$. In the exercises of the next two sections, we choose the coefficient ϕ_j to maximize utility of the Home representative household.[25]

With this formulation, the additional policy instrument directly targets the potential inefficiencies associated with fluctuations in the value of credit (Borio and Lowe, 2002). We assume that the government rebates the tax proceedings lump-sum to households.

5.2.1 The Effects of a Tax on Domestic Credit

Figure 7 compares the effects of a tax on domestic credit (dashed red line) against the baseline (solid black line).[26] The impulse responses clearly show that the policy is very effective in reducing the volatility of real GDP following the Foreign monetary tightening. As we can see in Table 3 (row 'Baseline + tax on domestic credit'), the presence of the tax contributes to a non-trivial increase in welfare and a substantial reduction in the volatility of real GDP, while the volatility of inflation is only marginally higher.

The main channel is the reduction of credit spreads, which the tax affects directly

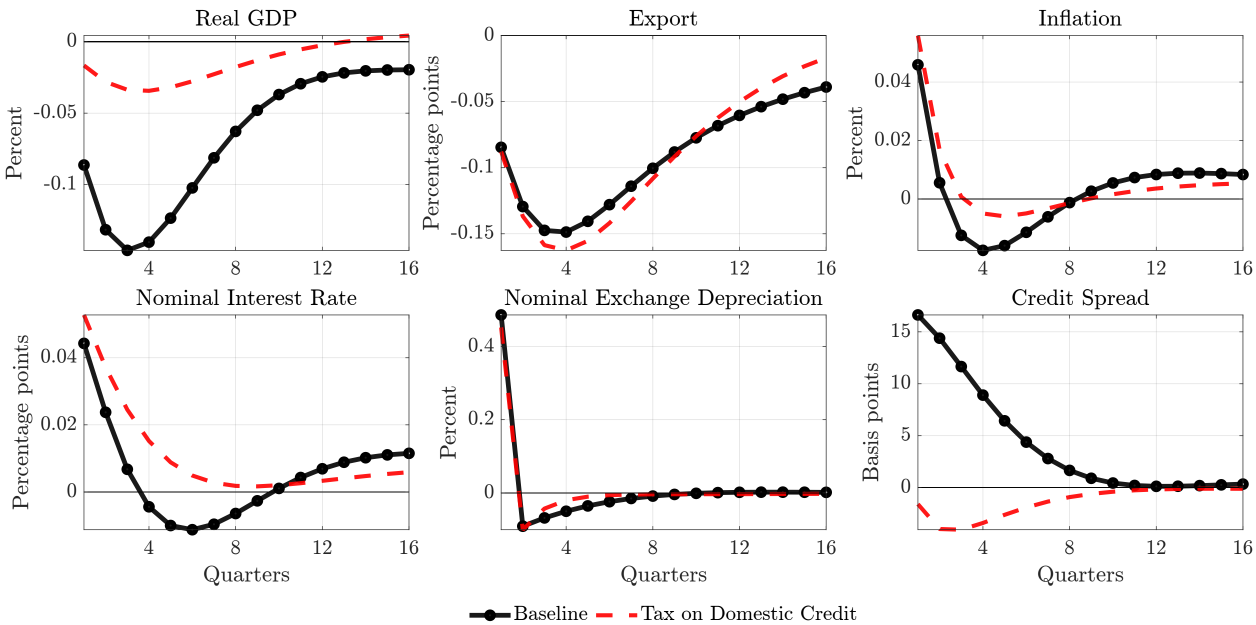
$$\mu_{kt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[(1 - \tau_t^k) r_{kt+1} - \frac{R_t}{\Pi_{t+1}} \right] \right\}. \tag{40}$$

Since the Foreign monetary policy shock has the effect of contracting domestic credit, the

[25] For this purpose, we solve the model and evaluate welfare to the second order conditional on the economy initially being in steady state. In each case, we verify that the impulse responses do not significantly differ with the first-order solution used in the estimation and the counterfactual exercises of section 4.

[26] The coefficient that maximizes welfare for the representative household in the tax feedback rule is $\phi_k^{\text{flex}} = 15.6$.

Figure 7: The effects of a tax on domestic credit.



Note: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country with a tax on domestic credit (dashed red line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

government actually subsidizes domestic banks, almost completely offsetting the initial spike of domestic spreads. As a consequence, economic activity only mildly declines. The presence of the additional policy instrument eases the tradeoff for monetary policy, which needs to be somewhat tighter than in the baseline to contain the inflationary consequences of the exchange rate depreciation.

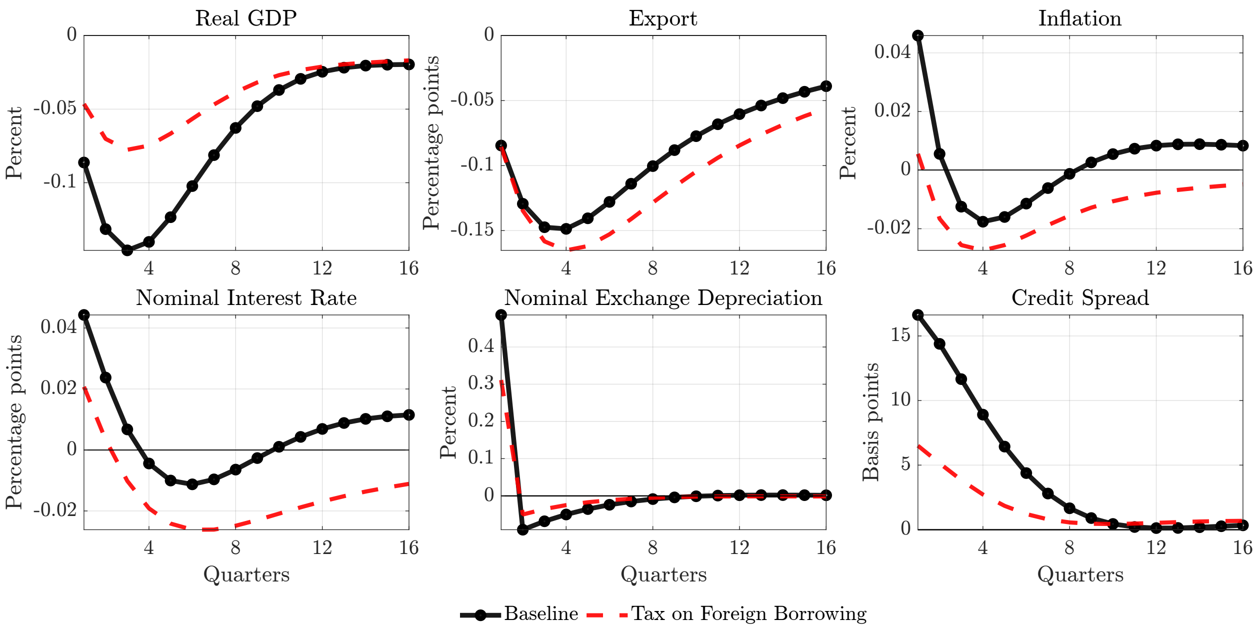
5.2.2 The Effects of a Tax on Foreign Borrowing

Figure 8 compares the effects of a tax on foreign borrowing (dashed red line) against the baseline (solid black line).[27] Like for the tax on domestic credit, the volatility of real GDP falls, by about a third compared to the baseline. In this case, the volatility of inflation falls too, also by a third. The row 'Baseline + tax on foreign borrowing' shows that Home welfare increases by 0.27% relative to the baseline.

The tax on foreign borrowing also reduces domestic spreads, albeit indirectly, since this

[27] The coefficient that maximizes welfare for the representative household in the tax feedback rule is $\phi_b^{\text{flex}} = 0.15$.

Figure 8: The effects of a tax on foreign borrowing.



NOTE: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country with a tax on foreign borrowing (dashed red line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

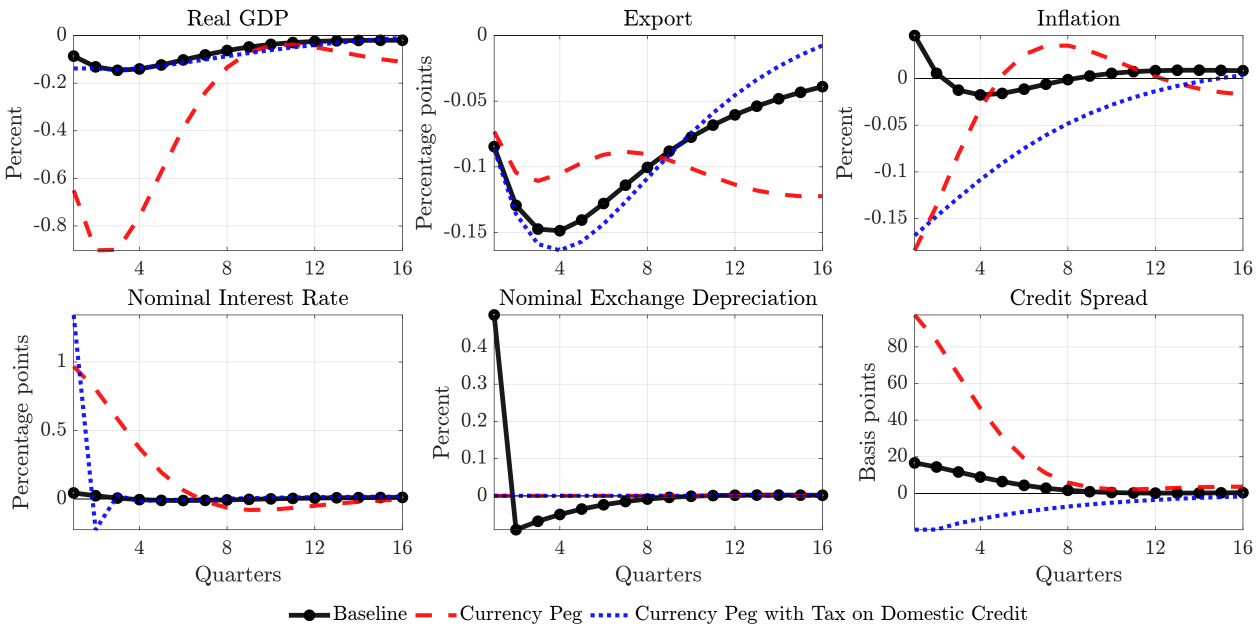
instrument operates by reducing the UIP wedge, which becomes

$$\mu_{bt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[\frac{R_{t+1}}{\Pi_{t+1}} - (1+\tau_t^b) \frac{R_{bt}^*}{\Pi_{t+1}^*} \frac{s_{t+1}}{s_t} \right] \right\}. \quad (41)$$

Given the contractionary monetary policy shock in country F, the active management of the capital account actually requires the government to subsidize borrowing from abroad by reducing its cost. The subsidy narrows the UIP wedge, which in turn limits the leverage ratio of financial intermediaries (23) and reduces the cost of funding in foreign currency.

A side effect of the smaller UIP wedge is that the nominal exchange rate depreciates less than in the baseline case, which has a negative effect on exports. The smaller decline of domestic GDP associated with the easier financial conditions only partly compensates the smaller exchange rate depreciation so that inflation actually falls more than in the baseline. As a consequence, the profile of the nominal interest rate remains below its counterpart in the baseline policy configuration throughout the simulation horizon.

Figure 9: A tax on domestic credit with a fixed exchange rate.



NOTE: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country under a fixed exchange rate regime with a tax on domestic credit (dotted blue line) and with no taxes (dashed red line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

5.2.3 Countercyclical Taxes with a Peg

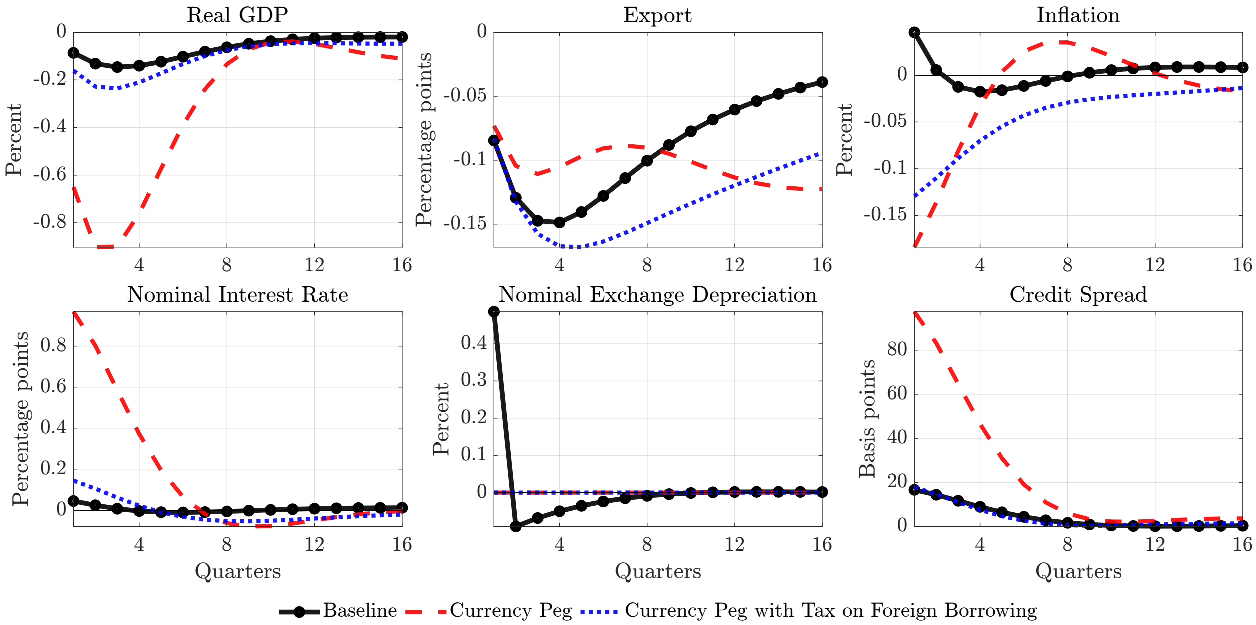
The last policy experiment that we consider asks if the introduction of countercyclical taxes under a peg can approximate the macroeconomic outcomes under flexible exchange rates.

Figure 9 shows the results for a tax on domestic credit. In this case, the coefficient of the feedback rule that maximizes welfare of the representative household is $\phi_k^{\text{peg}} = 3.4$. Therefore, the government needs to responds more aggressively to deviations of the value of credit from steady state than in the case of flexible exchange rates in order to set the tax optimally.

The introduction of the tax substantially reduces the volatility of real GDP under a peg. The government subsidizes credit so that, on impact, domestic spreads are essentially equal to the baseline case. After the initial period, spreads fall below steady state by a few basis points and converge to their long-run value by the end of the simulation horizon. Exports are very close to the baseline case for the first year and then recover faster.

Despite the gains on the real side, the Home nominal interest rate remains elevated in order to track its Foreign counterpart. While the tax mitigates the consequences for real GDP, inflation remains well below target throughout the simulation horizon. As a result,

Figure 10: A tax on foreign borrowing with a fixed exchange rate.



Note: The figure displays the impulse responses of real GDP, CPI inflation, exports, interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country under a fixed exchange rate regime with a tax on foreign borrowing (dotted blue line) and with no taxes (dashed red line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are in annualized terms.

even in the presence of the additional instrument, inflation volatility is significantly higher under a peg than under flexible exchange rates.

Row 'Peg + tax on domestic credit' of Table 3 shows that, despite the higher volatility of real GDP and inflation, this policy configuration actually achieves higher welfare relative to the baseline. The subsidy keeps spreads below steady state throughout the simulation horizon, thus contributing to mitigate the financial frictions in the Home economy, while the peg mitigates the consequences of currency mismatch on the balance sheet. Although these gains do not map into lower output and inflation volatility, welfare nevertheless improves, reinforcing the message that the financial channel plays a crucial role in the model.

Figure 10 presents the same experiment with a tax on foreign borrowing. As in the previous case, the government needs to responds more aggressively to deviations of the value of credit from steady state than under flexible exchange rates in order to set the tax optimally ($\phi_b^{\text{peg}} = 0.11$).

Like for the case of the tax on domestic credit, the tax on foreign borrowing under a peg significantly reduces the volatility of real GDP and inflation. By subsidizing foreign borrowing, the government induces financial intermediaries to take advantage of cheaper funds from abroad. Domestic spreads are essentially identical to the baseline case throughout the simulation horizon. As in the previous case, however, inflation remains persistently below target even though the nominal interest rate is only marginally above the baseline case because the nominal exchange rate is fixed. The main difference with the baseline is the larger fall in exports due to the missing depreciation of the nominal exchange rate.

Row 'Peg + tax on foreign borrowing' of Table 3 shows that this policy configuration comes very close to replicating the welfare of the baseline regime. However, the differences in the volatility of real GDP and inflation, which remain higher, suggest that the gains stem from an increased efficiency of the financial sector, rather than the more traditional reduced volatility of macroeconomic outcomes.

6 Conclusions

Monetary policy shocks originating in large financial centers give rise to a Global Financial Cycle worldwide. Even in the countries with the most flexible exchange rate regime, the expenditure-switching channel is not strong enough to fully offset the headwinds implied by higher credit spreads. Key to this transmission is the role of global banks in propagating the initial shock, and the currency denomination of exports in the receiving country. Imperfect pass-through is crucial in accounting for the muted response of domestic inflation to the depreciation of the exchange rate.

While a flexible exchange rate regime does not insulate countries from foreign financial shocks, a fixed exchange rate substantially increases domestic macroeconomic volatility. Countercyclical taxes, either on domestic credit or on foreign borrowing, are two policy instruments that can mitigate the transmission of foreign monetary policy shocks. With fixed exchange rates, both instruments can approximate the response of economic activity under flexible exchange rates, and in some cases even lead to higher welfare. However, even with the in the presence of these additional instruments, a country adopting a peg continues to experience disinflationary pressures that are absent under a flexible exchange rate regime.

As the world remains as financially interconnected as ever, the results in this paper are informative for the current monetary policy tightening cycle taking place in advanced economies as well as, more generally, for the design of appropriate policy frameworks that address the international transmission of financial shocks.

References

Adrian, T., C. Erceg, J. Lindé, P. Zabczyk, , and J. Zhou (2020): "A Quantitative Model for the Integrated Policy Framework," IMF Working Papers 20/122.

Agarwal, I. (2021): "Banks' Foreign Currency Exposure and the Real Effects of Exchange Rate Shocks," Unpublished.

Akinci, O. and A. Queralto (2019): "Exchange Rate Dynamics and Monetary Spillovers with Imperfect Financial Markets," Federal Reserve Bank of New York Staff Report 849.

Aoki, K., G. Benigno, and N. Kiyotaki (2020): "Monetary and Financial Policies in Emerging Markets," Unpublished.

Basu, S., E. Boz, G. Gopinath, F. Roch, and F. Unsal (2020): "A Conceptual Model for the Integrated Policy Framework," IMF Working Papers 20/121.

Baxter, M. and M. Crucini (1995): "Business Cycles and the Asset Structure of Foreign Trade," *International Economic Review*, 36, 821–854.

Bianchi, J., S. Bigio, and C. Engel (2022): "Scrambling for Dollars: International Liquidity, Banks and Exchange Rates," Unpublished.

Bianchi, J. and L. Coulibaly (2023): "A Theory of Fear of Floating," Unpublished.

Borio, C. and P. Lowe (2002): "Asset Prices, Financial and Monetary Stability: Exploring the Nexus," BIS Working Papers 114.

Caldara, D. and E. Herbst (2019): "Monetary Policy, Real Activity, and Credit Spreads: Evidence from Bayesian Proxy SVARs," *American Economic Journal: Macroeconomics*, 11, 157–192.

Calvo, G. (1983): "Forward and Spot Exchange Rates," *Journal of Monetary Economics*, 12, 383–398.

Canova, F. (2005): "The Transmission of US Shocks to Latin America," *Journal of Applied Econometrics*, 20, 229–251.

Christiano, L., M. Trabandt, and K. Walentin (2011): "DSGE Models for Monetary Policy Analysis," in *Handbook of Monetary Economics*, ed. by B. Friedman and M. Woodford, North-Holland, vol. 3A, chap. 7, 285–367.

Clarida, R., J. Galí, and M. Gertler (2000): "Monetary Policy Rules and Macroeconomic Stability: Evidence and Some Theory," *Quarterly Journal of Economics*, 115, 147–180.

De Leo, P., G. Gopinath, and S. Kalemli-Ozcan (2023): "Monetary Policy Cyclicality in Emerging Economies," NBER Working Paper 30458.

Dedola, L. and G. Lombardo (2012): "Financial Integration, Financial Frictions, and the International Propagation of Shocks," *Economic Policy*, 27, 319–359.

Dedola, L., G. Rivolta, and L. Stracca (2017): "If the Fed Sneezes, Who Catches a Cold?" *Journal of International Economics*, 108, S23–S41.

Degasperi, R., S. Hong, and G. Ricco (2020): "The Global Transmission of U.S. Monetary Policy," CEPR Discussion Papers 14533.

Del Negro, M., M. Giannoni, and F. Schorfheide (2015): "Inflation in the Great Recession and New Keynesian Models," *American Economic Journal: Macroeconomics*, 7, 168–196.

Devereux, M. and C. Engel (2003): "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange-Rate Flexibility," *Review of Economic Studies*, 70, 765–783.

Devereux, M., C. Engel, and S. Wu (2023): "Collateral Advantage: Exchange Rates, Capital Flows, and Global Cycles," Unpublished.

di Giovanni, J., S. Kalemli-Özcan, M. Ulu, and Y. Baskaya (2022): "International Spillovers and Local Credit Cycles," *Review of Economic Studies*, 89, 733–773.

Engel, C. (2003): "Expenditure Switching and Exchange-Rate Policy," in *NBER Macroeconomics Annual 2002*, ed. by M. Gertler and K. Rogoff, MIT Press, vol. 17, chap. 5, 231–300.

Fama, E. (1984): "Forward and Spot Exchange Rates," *Journal of Monetary Economics*, 14, 319–338.

Fanelli, S. and L. Straub (2021): "A Theory of Foreign Exchange Interventions," *Review of Economic Studies*, 88, 2857–2885.

Farhi, E. and I. Werning (2012): "Dealing with the Trilemma: Optimal Capital Controls with Fixed Exchange Rates," NBER Working Papers 14533.

——— (2016): "A Theory of Macroprudential Policies in the Presence of Nominal Rigidities," *Econometrica*, 84, 1645–1704.

Faust, J. and J. Rogers (2003): "Monetary Policy's Role in Exchange Rate Behavior," *Journal of Monetary Economics*, 50, 1403–1424.

Flaccadoro, M. and V. Nispi Landi (2022): "Foreign Monetary Policy and Domestic Inflation in Emerging Markets," Bank of Italy Working Papers 1365.

Gabaix, X. and M. Maggiori (2015): "International Liquidity and Exchange Rate Dynamics," *Quarterly Journal of Economics*, 130, 1369–1420.

Georgiadis, G., G. Müller, and B. Schumann (2023): "Dollar Trinity and the Global Financial Cycle," CEPR Discussion Paper 18427.

——— (forthcoming): "Global Risk and the Dollar," *Journal of Monetary Economics*.

Gertler, M. and P. Karadi (2011): "A Model of Unconventional Monetary Policy," *Journal of Monetary Economics*, 58, 17–34.

——— (2015): "Monetary Policy Surprises, Credit Costs, and Economic Activity," *American Economic Journal: Macroeconomics*, 7, 44–76.

Gilchrist, S. and E. Zakrajsek (2012): "Credit Spreads and Business Cycle Fluctuations," *American Economic Review*, 102, 1692–1720.

Gopinath, G., E. Boz, C. Casas, F. Díez, P.-O. Gourinchas, and M. Plagborg-Møller (2020): "Dominant Currency Paradigm," *American Economic Review*, 110, 677–719.

Gopinath, G. and J. Stein (2018): "Banking, Trade, and the Making of a Dominant Currency," *Quarterly Journal of Economics*, 136, 783–830.

Gourinchas, P.-O., H. Rey, and N. Govillot (2010): "Exorbitant Privilege and Exorbitant Duty," IMES Discussion Paper 2010-E-20.

Han, X. and S. Wei (2018): "International Transmissions of Monetary Shocks: Between a Trilemma and a Dilemma," *Journal of International Economics*, 110, 205–219.

Ilzetzki, E. and K. Jin (2021): "The Puzzling Change in the International Transmission of U.S. Macroeconomic Policy Shocks," *Journal of International Economics*, 130, 103444.

Ilzetzki, E., C. Reinhart, and K. Rogoff (2019): "Exchange Rate Arrangements Entering the 21st Century: Which Anchor Will Hold?" *Quarterly Journal of Economics*, 134, 599–646.

Itskhoki, O. and D. Mukhin (2021): "Exchange Rate Disconnect in General Equilibrium," *Journal of Political Economy*, 129, 2183–2232.

Jarocinski, M. and P. Karadi (2020): "Deconstructing Monetary Policy Surprises—The Role of Information Shocks," *American Economic Journal: Macroeconomics*, 12, 1–43.

Jiang, Z., A. Krishnamurthy, and H. Lustig (2021): "Foreign Safe Asset Demand and the Dollar Exchange Rate," *Journal of Finance*, 76, 1049–1089.

Kekre, R. and M. Lenel (2024): "The Flight to Safety and International Risk Sharing," Unpublished.

Kim, S. (2001): "International Transmission of U.S. Monetary Policy Shocks: Evidence from VAR's," *Journal of Monetary Economics*, 48, 339–372.

Kollmann, R. (1996): "Incomplete Asset Markets and the Cross-Country Consumption Correlation Puzzle," *Journal of Economic Dynamics and Control*, 20, 945–961.

Krogstrup, S. and C. Tille (2018): "Foreign Currency Bank Funding and Global Factors," IMF Working Papers 2018/97.

Levine, P. and D. Lima (2015): "Policy Mandates for Macro-Prudential and Monetary Policies in a New Keynesian Framework," ECB Working Paper Series 1784.

Lubik, T. and F. Schorfheide (2007): "Do Central Banks Respond to Exchange Rate Movements? A Structural Investigation," *Journal of Monetary Economics*, 54, 1069–1087.

Miranda-Agrippino, S. and H. Rey (2020): "U.S. Monetary Policy and the Global Financial Cycle," *Review of Economic Studies*, 87, 2754–2776.

Monacelli, T. (2005): "Monetary Policy in a Low Pass-Through Environment," *Journal of Money Credit and Banking*, 37, 1047–1066.

Obstfeld, M., J. Ostry, and M. Qureshi (2019): "A Tie That Binds: Revisiting the Trilemma in Emerging Market Economies ," *Review of Economics and Statistics*, 101, 279–293.

Passari, E. and H. Rey (2016): "Financial Flows and the International Monetary System," *Economic Journal*, 125, 675–698.

Pesaran, M. H. and R. Smith (1995): "Estimating long-run relationships from dynamic heterogeneous panels," *Journal of Econometrics*, 68, 79–113.

Plagborg-Møller, M. and C. Wolf (2021): "Local Projections and VARs Estimate the Same Impulse Responses," *Econometrica*, 89, 955–980.

Rebucci, A. and C. Ma (2020): "Capital Controls: A Survey of the New Literature," in *Oxford Research Encyclopedia of Economics and Finance*, ed. by A. Dixit, S. Edwards, K. Judd, and K. Kletzer, Oxford University Press.

Rey, H. (2013): "Dilemma not Trilemma: The Global Cycle and Monetary Policy Independence," in *Proceedings - Economic Policy Symposium - Jackson Hole*, Federal Reserve of Kansas City Economic Symposium, 285–333.

——— (2016): "International Channels of Transmission of Monetary Policy and the Mundellian Trilemma," *IMF Economic Review*, 64, 6–35.

Schmitt-Grohé, S. and M. Uribe (2003): "Closing Small Open Economy Models," *Journal of International Economics*, 61, 163–185.

Schmitt-Grohé, S. and M. Uribe (2016): "Downward Nominal Wage Rigidity, Currency Pegs, and Involuntary Unemployment," *Journal of Political Economy*, 124, 1466–1514.

Smets, F. and R. Wouters (2007): "Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach," *American Economic Review*, 97, 586–606.

Taylor, J. (1993): "Discretion versus Policy Rules in Practice," *Carnegie-Rochester Conference Series on Public Policy*, 39, 195–214.

Appendix

A Data and Empirics

A.1 Data Sources

The larger sample includes 24 countries: Argentina, Australia, Brazil, Canada, Chile, Colombia, Germany, India, Indonesia, Israel, Japan, Korea, Mexico, New Zealand, Norway, Philippines, Poland, Russia, Singapore, South Africa, Sweden, Switzerland, Thailand, United Kingdom. The choice of countries, in this case, depends on data availability:

1. **Exchange rate regime**: Countries need to have a relatively flexible exchange rates (floats and managed floats). We ignore countries classified as '*Freely falling*' or '*Dual market in which parallel market data is missing*'

2. **Sample period**: Countries need to have a long enough sample period over which the exchange rate regime is classified as flexible.

3. **Size**: We ignore very small countries.

Data sources:

- **GDP** (real index): OECD, IMF IFS, Bloomberg. The quarterly level data are interpolated using a shape-preserving piecewise cubic interpolation (MatLab command: `y1 = interp1(t0,y0,t1,'pchip')`.

- **Consumer prices** (CPI): OECD, IMF IFS, Bloomberg.

- **Nominal interest rates (policy rates)**: OECD, National Central Banks.

- **Nominal exchange rate** (units of local currency per US dollar, so that an increase corresponds to a depreciation of the local currency): Datastream.

- **Exports** (exports of goods and services, by expenditure in constant prices): OECD. The quarterly level data are interpolated using a shape-preserving piecewise cubic interpolation (MatLab command: `y1 = interp1(t0,y0,t1,'pchip')`.

- **Credit spreads** (average of the option-adjusted spreads across non-financial firms in a country): ICE Bank of America Merrill Lynch Global Index.

A.2 Panel VAR

Figure A.1 reports the impulse responses obtained when we estimate our VAR on the larger sample of 24 small open economies, as outlined in Appendix A. The results are very similar to our baseline.

Figure ?? and A.3 report the impulse responses obtained when we estimate our VAR with 3 lags (as suggested by the Bayesian information criterion) and without a deterministic trend. The results are very similar to our baseline, with slightly more persistent effects in the specification with no trend.

Figure A.4 reports the impulse responses obtained when we estimate our VAR on a sample starting in 1985 (instead of 1997). As credit spreads are only available from 1997, in this specification with drop credit spreads from the vector of endogenous variables. The results are very similar to our baseline.

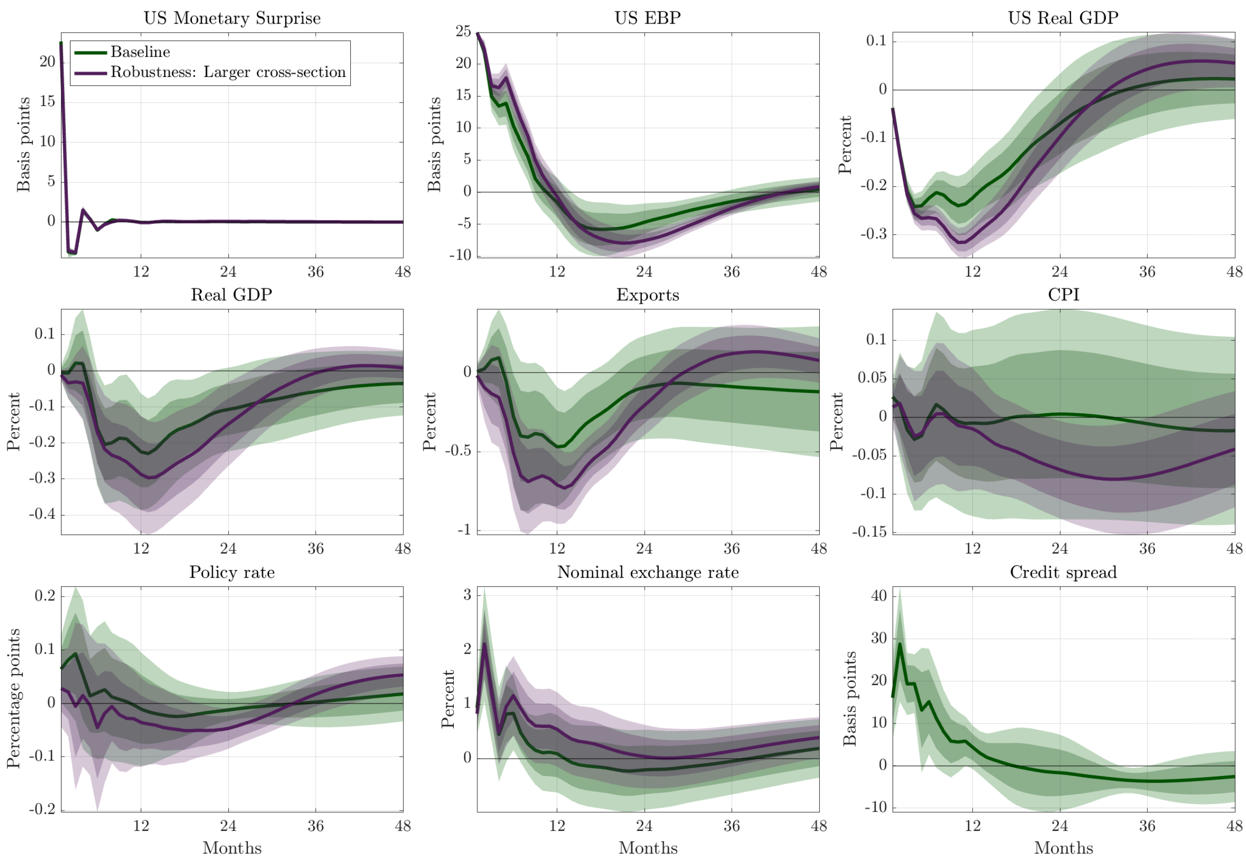
Figure A.5 reports the impulse responses obtained when we estimate our VAR with a measure of short-term market interest rates instead of policy interest rates, to address concerns that our results may be affected by the little variability of policy rates over the zero lowe bound period. The results are very similar to our baseline.

Figure A.6 reports the impulse responses obtained when we estimate our VAR on an extended vector of endogenous variables that includes US CPI. In line with the evidence in Jarocinski and Karadi (2020) we find that a contractionary US monetary policy shock reduces US consumer prices. The responses of the small open economy are not affected by the introduction of US CPI in the vector of endogenous variables.

Figure A.7 reports the impulse responses obtained when we estimate our VAR on an extended vector of endogenous variables that includes an equity price index for the small open economy. We find that a contractionary US monetary policy shock reduces equity prices in the small open economy, and that the responses of other variables are not affected.

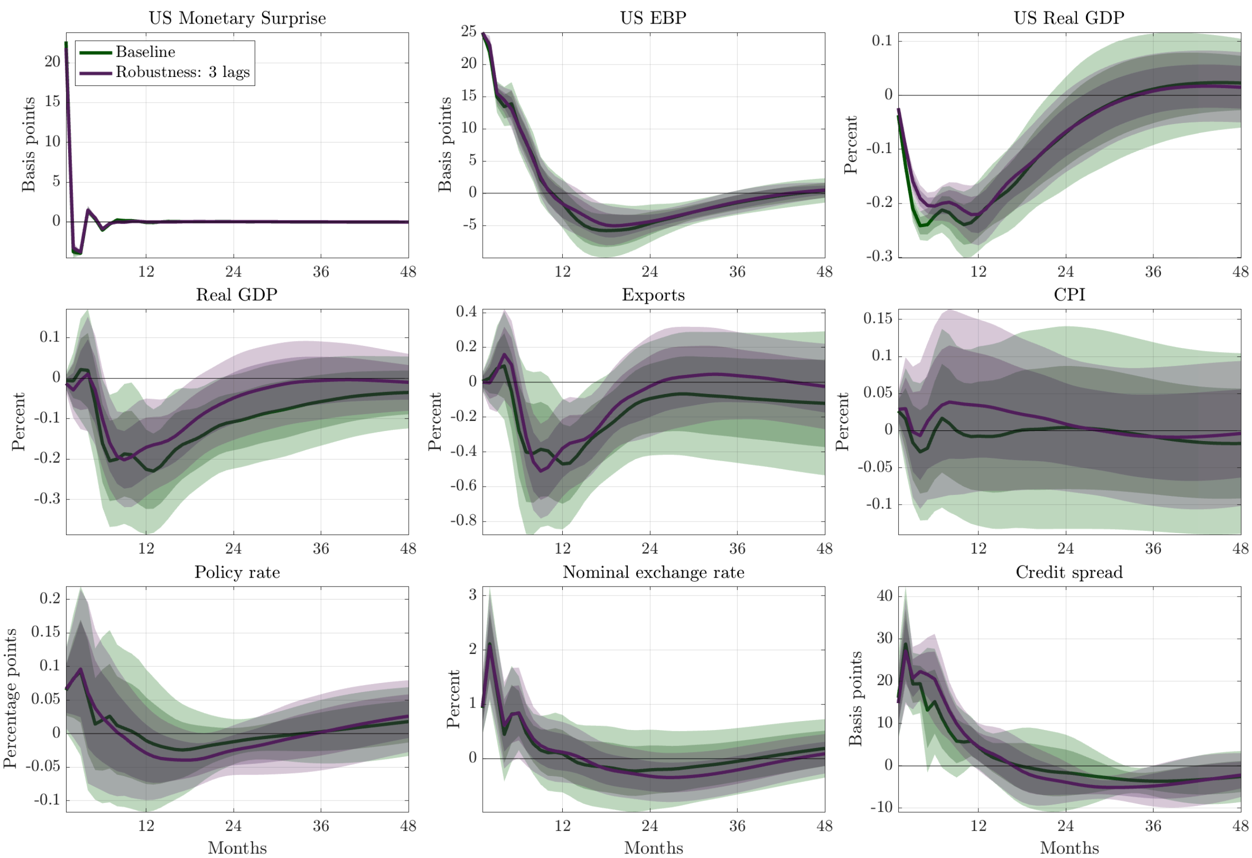
Figure A.8 reports the impulse responses obtained when we estimate our VAR on an extended vector of endogenous variables that includes oil prices. We find that a contractionary US monetary policy shock reduces oil prices, and that the responses of other variables are not affected.

Figure A.1: Robustness: Larger Sample of Countries



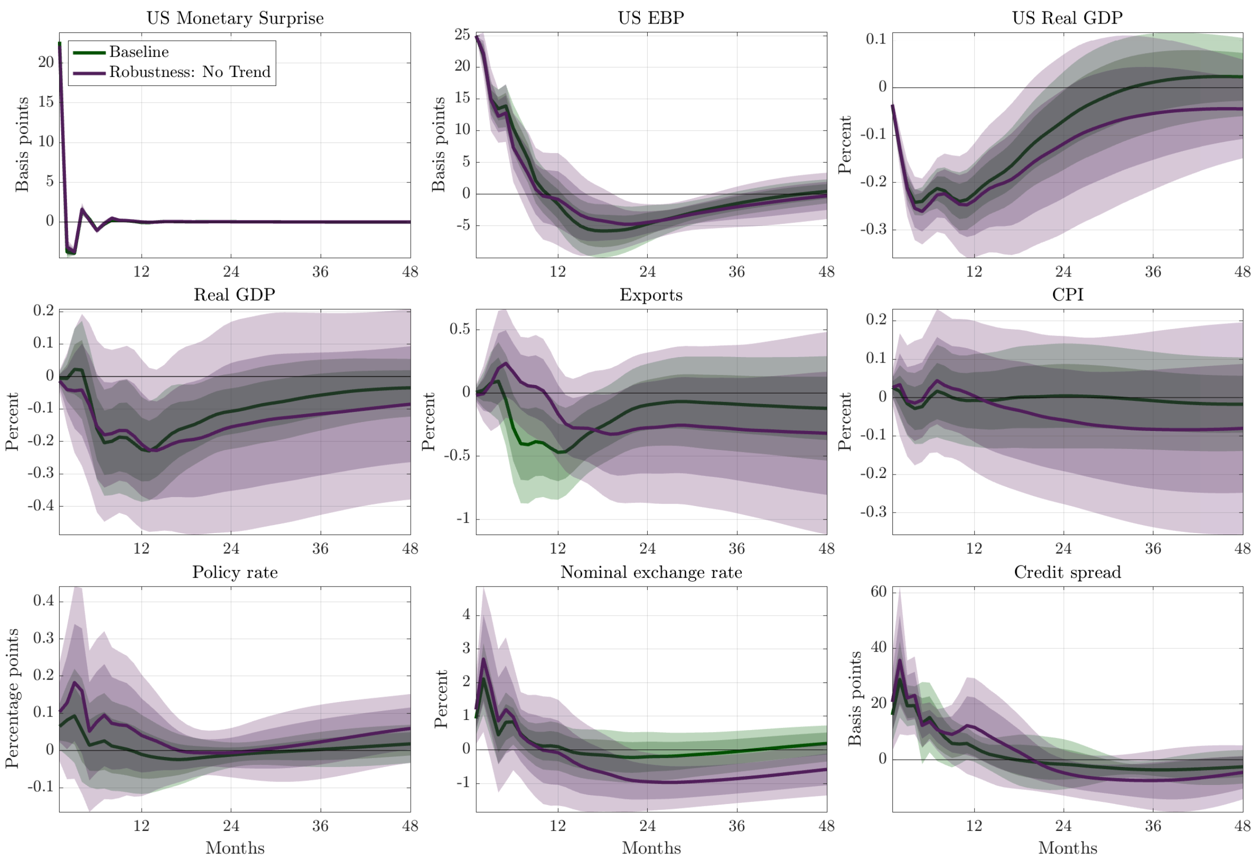
NOTE: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

Figure A.2: Robustness: 3 lags



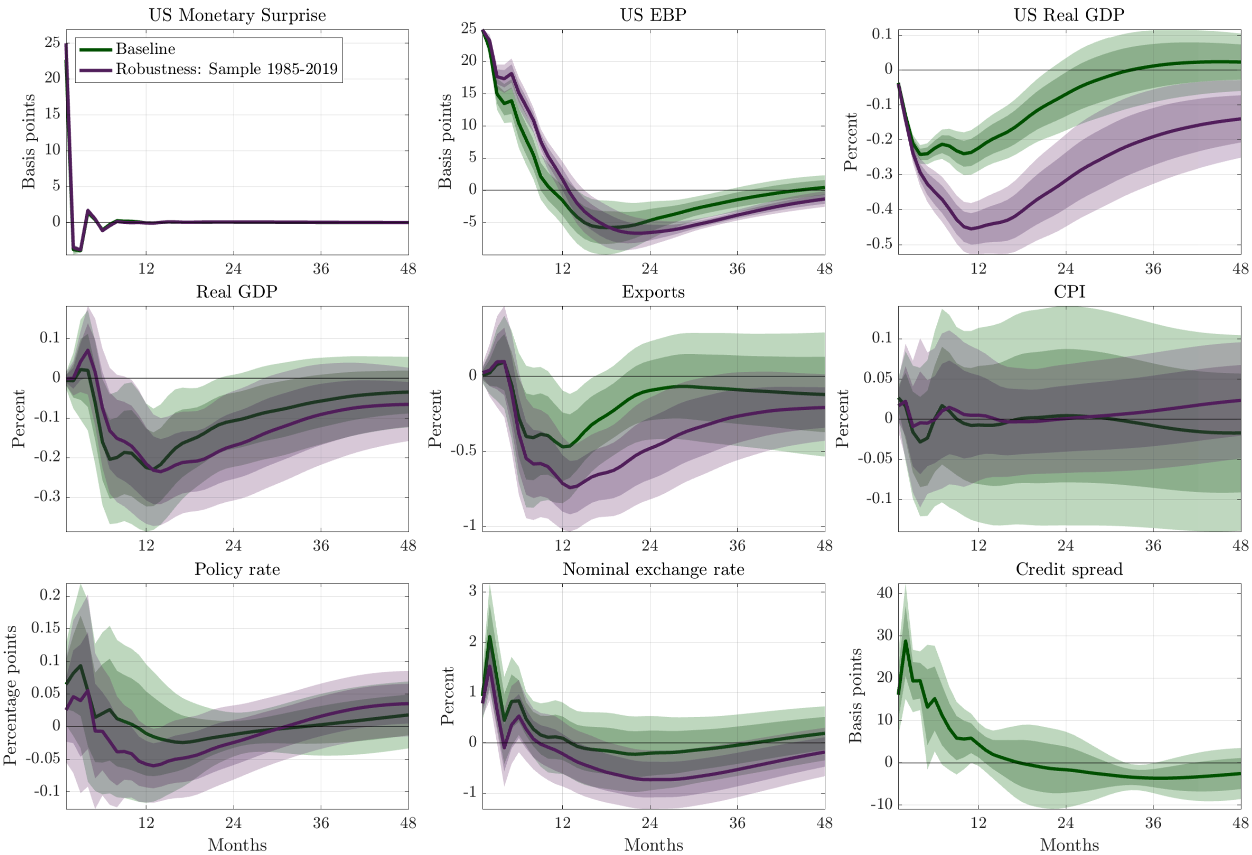
Note: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

Figure A.3: Robustness: No Trend



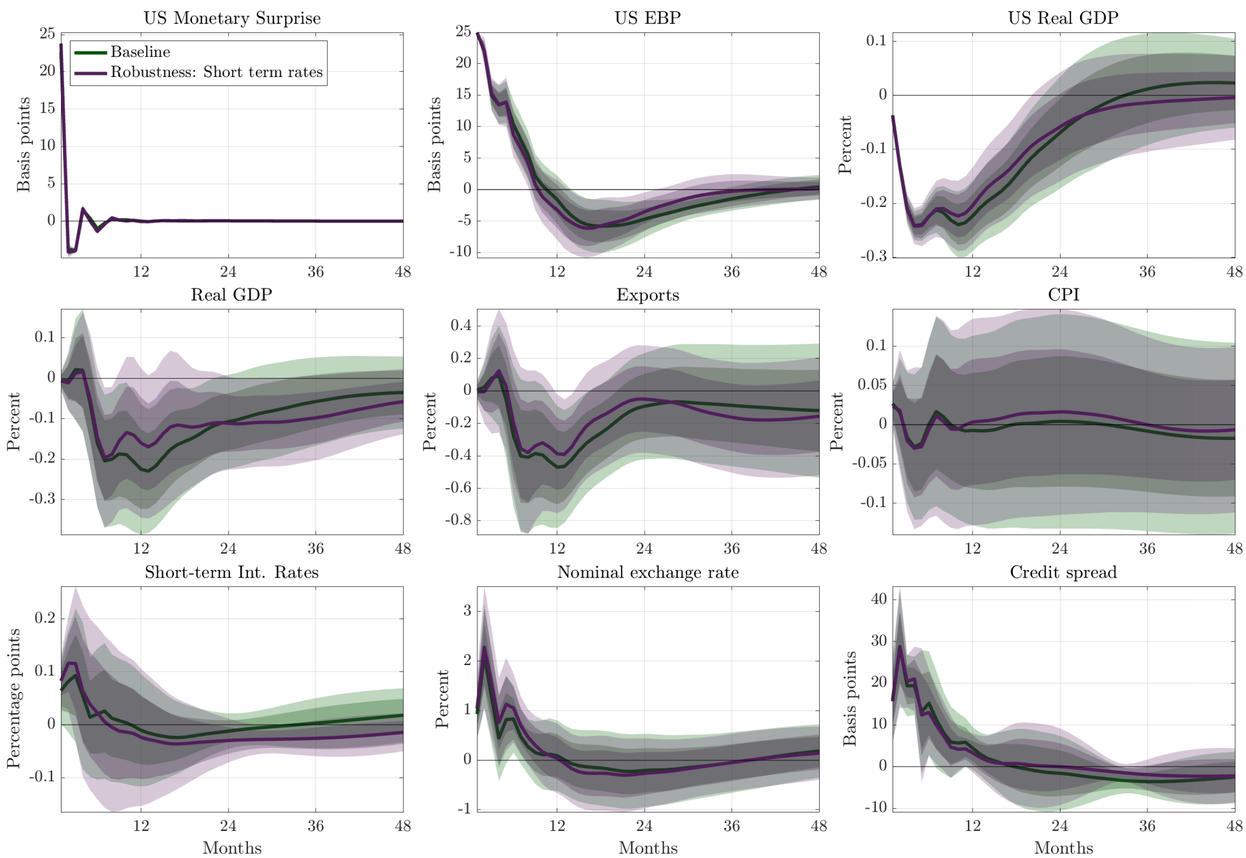
Note: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

Figure A.4: Robustness: Sample 1985 to 2019



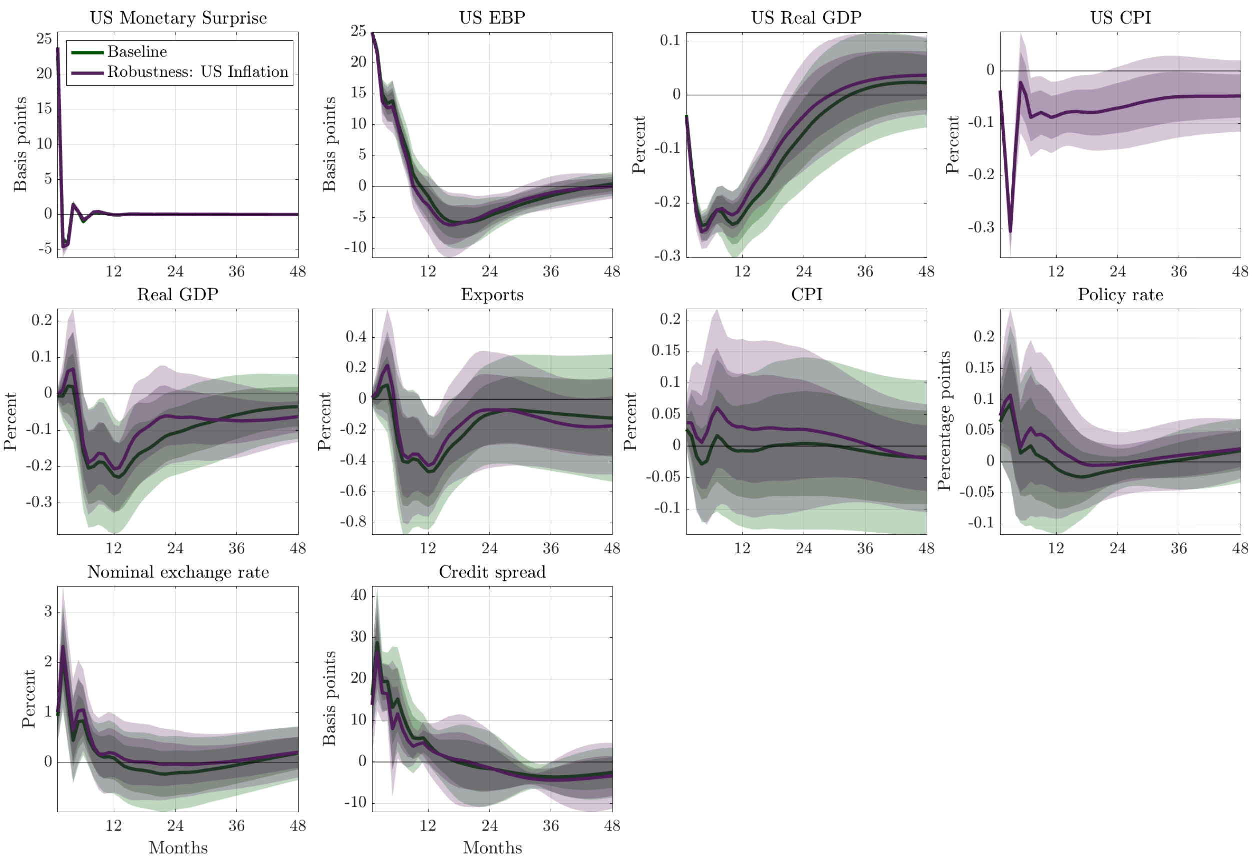
NOTE: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

Figure A.5: Robustness: Short-term Market Interest Rates



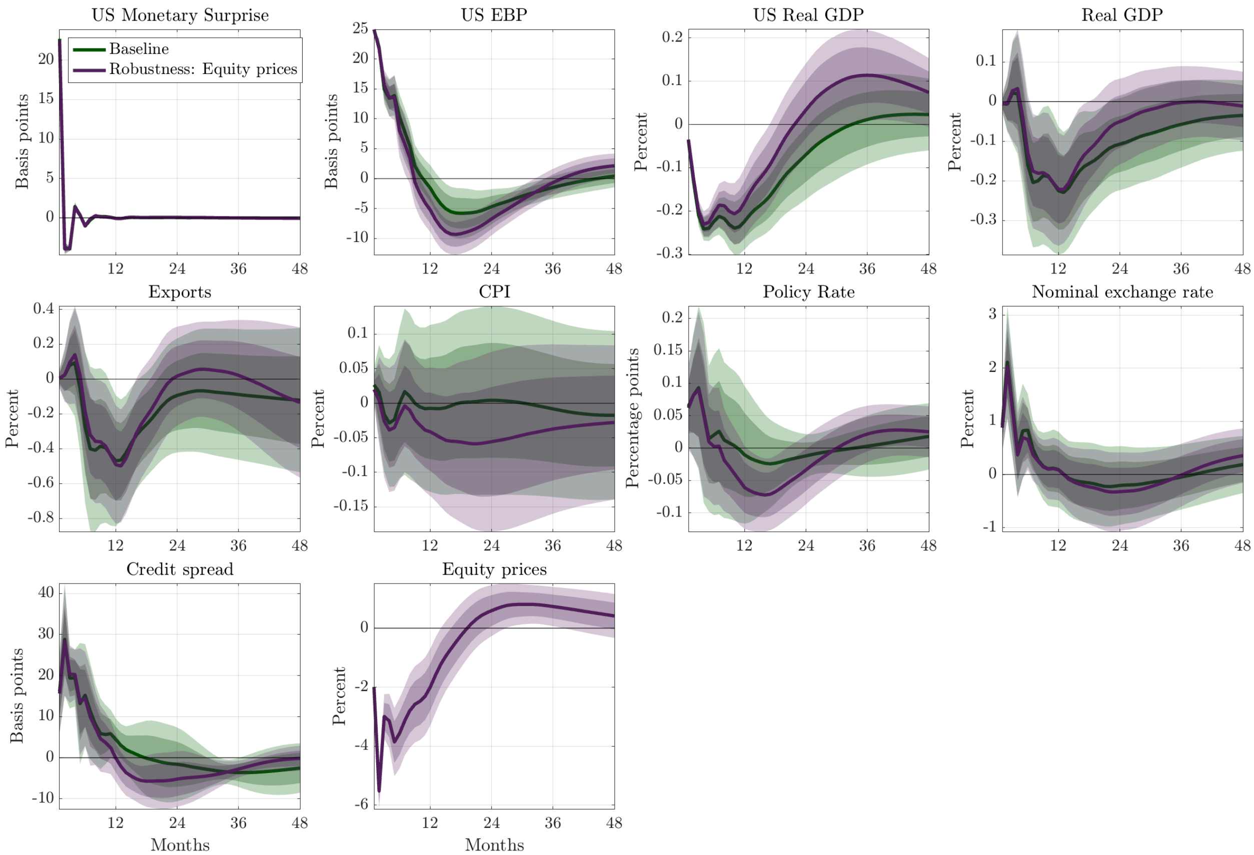
NOTE: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

Figure A.6: Robustness: Adding US CPI



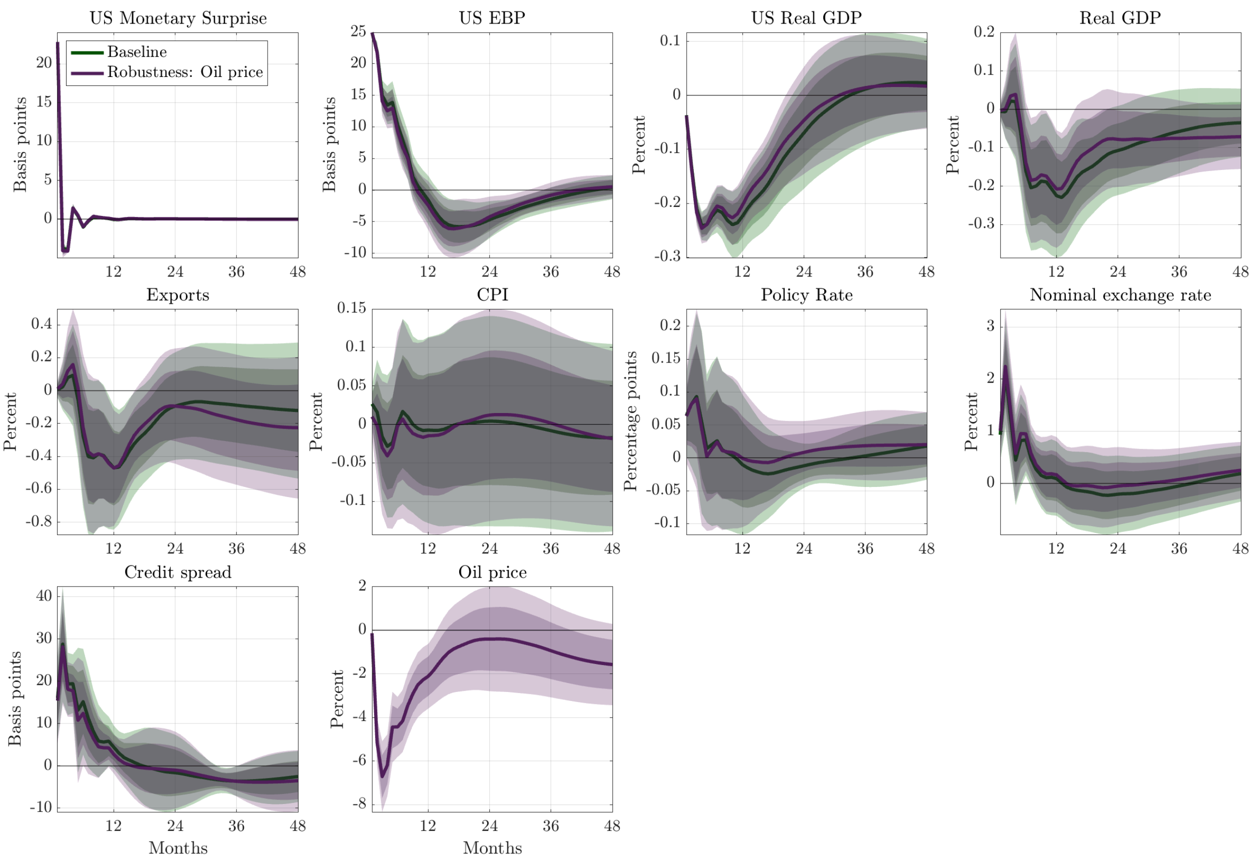
Note: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

Figure A.7: Robustness: Controlling for Equity Prices



Note: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

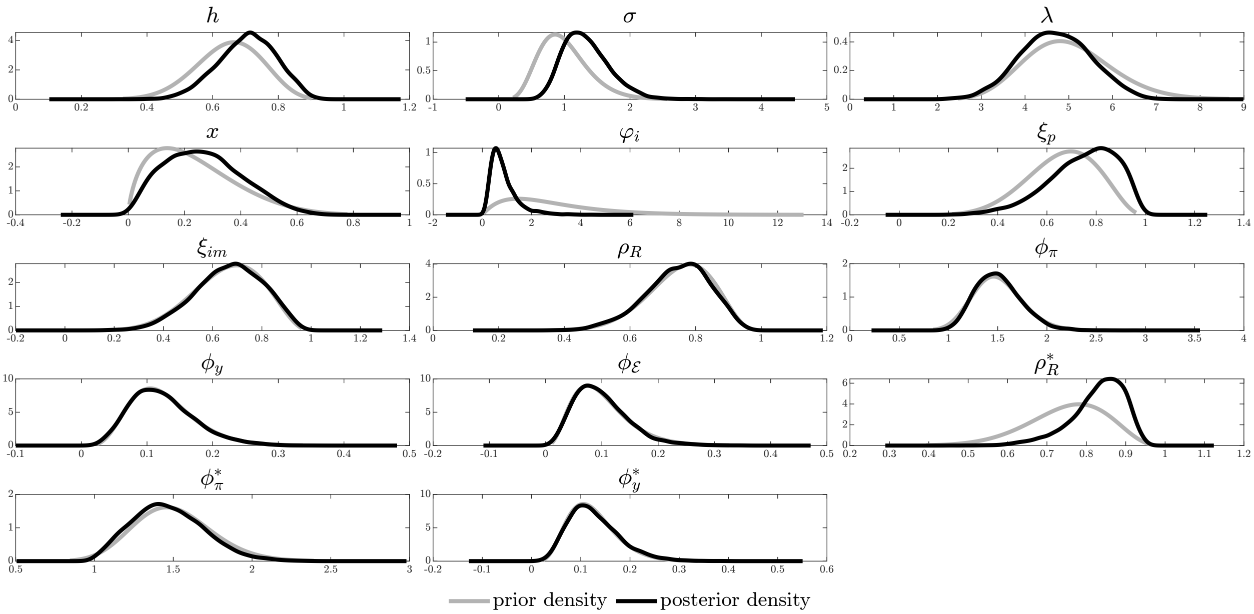
Figure A.8: Robustness: Controlling for Oil Prices



Note: The figure displays the impulse responses of the EBP and real GDP in the US, and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The solid green line and shaded areas report the mean group estimate in our baseline. The solid purple line and shaded areas report the mean group estimate in our robustness exercise. The nominal interest rate and spreads are in annualized terms. The shock is normalized to generate a 25 basis points increase in the EBP.

A.3 Prior and Posterior Densities

Figure A.9: Prior and posterior densities for impulse response matching exercise



Note: The figure displays the prior (light grey) and posterior (black) densities for the impulse response matching exercise for the habit parameter (h), the coefficient of relative risk aversion (σ), the leverage ratio (λ), the ratio of foreign-currency liabilities (x), the investment adjustment cost parameter (φ_i), the domestic price stickiness parameter (ξ_p), the import price stickiness parameter (ξ_{im}), and the parameters in the monetary policy rules of both countries (ρ_R, ϕ_π, ϕ_y, $\phi_\mathcal{E}$, and their Foreign counterparts).

Figure A.9 reports the prior and posterior densities of the estimation exercise.

B Model Derivations

In this section, we report the first-order conditions for households, financial intermediaries, and firms, and characterize the steady state of the model.

B.1 Households

The first-order conditions for the Home household are

$$\Lambda_t = \frac{1}{c_t - h\bar{c}_{t-1}} \tag{A1}$$

$$\Lambda_t = \beta \mathbb{E}_t \left(\Lambda_{t+1} \frac{R_t}{\Pi_{t+1}} \right). \tag{A2}$$

The optimal wage-setting condition is

$$\widetilde{w}_t^{1+\nu\zeta} = \frac{\chi\nu}{\nu - 1} \frac{F_{1t}^W}{F_{2t}^W} \tag{A3}$$

where $\widetilde{w}_t$ is the optimal real wage, and

$$F_{1t}^W = \ell_t^{1+\zeta} w_t^{\nu\zeta} + \beta\xi_w \mathbb{E}_t \left[\left(\frac{w_{t+1}}{w_t} \right)^{\nu} \Pi_{t+1}^{\nu(1+\zeta)} F_{1t+1}^W \right] \tag{A4}$$

$$F_{2t}^W = \Lambda_t \ell_t + \beta\xi_w \mathbb{E}_t \left[\left(\frac{w_{t+1}}{w_t} \right)^{\nu} \Pi_{t+1}^{\nu-1} F_{2t+1}^W \right]. \tag{A5}$$

The aggregate nominal wage level evolves according to

$$W_t = [(1-\xi_w)\widetilde{W}_t^{1-\nu} + \xi_w W_{t-1}^{1-\nu}]^{\frac{1}{1-\nu}}, \tag{A6}$$

which we can rewrite in real terms as

$$w_t = \left[(1-\xi_w)\widetilde{w}_t^{1-\nu} + \xi_w \left(\frac{w_{t-1}}{\Pi_t} \right)^{1-\nu} \right]^{\frac{1}{1-\nu}}. \tag{A7}$$

The first-order conditions for the Foreign representative household are symmetric.

B.2 Financial Intermediation

We define the leverage ratio of a typical bank in the Foreign country as $\lambda_t^* = (q_t^* z_t^* + b_t^*)/n_t^*$, where $b_t^* = B_t^*/P_t^*$ is the amount of lending to Home banks in real terms. The bank chooses an optimal leverage ratio to maximize the expected value of terminal wealth $V(n_t^*)$, subject to the balance sheet constraint and the incentive compatibility constraint. The fact that the bank can arbitrage between lending to firms and lending to Foreign banks implies the first order condition

$$\mathbb{E}_t(\mathcal{M}^*_{t,t+1}\Omega^*_{t,t+1}r^*_{kt+1}) = \mathbb{E}_t\left(\mathcal{M}^*_{t,t+1}\Omega^*_{t,t+1}\frac{R^*_{bt}}{\Pi^*_{t+1}}\right), \tag{A8}$$

where

$$\Omega^*_{t,t+1} = \mathbb{E}_t(1-\omega+\omega\kappa^*_{t+1}) \tag{A9}$$

and

$$\kappa^*_t = \frac{V(n^*_t)}{n^*_t}. \tag{A10}$$

In an equilibrium in which the incentive compatibility constraint binds, we have

$$\kappa^*_t = \theta^*\lambda^*_t, \tag{A11}$$

which implies

$$\lambda^*_t = \frac{\mu^*_{1t}}{\theta^* - \mu^*_{0t}} \tag{A12}$$

where

$$\mu^*_{kt} = \mathbb{E}_t\left[\mathcal{M}^*_{t,t+1}\Omega^*_{t,t+1}\left(r^*_{kt+1} - \frac{R^*_t}{\Pi^*_{t+1}}\right)\right] \tag{A13}$$

and

$$\mu^*_{dt} = \mathbb{E}_t\left(\mathcal{M}^*_{t,t+1}\Omega^*_{t,t+1}\frac{R^*_t}{\Pi^*_{t+1}}\right). \tag{A14}$$

The aggregate balance sheet of the banking sector is

$$q^*_t z^*_t + b^*_t = d^*_t + n^*_t. \tag{A15}$$

The aggregate banking sector net worth evolves such that

$$n^*_t = (\omega+\xi^*_b)\left(r^*_{kt}q^*_{t-1}z^*_{t-1} + \frac{R^*_{bt-1}b^*_{t-1}}{\Pi^*_t}\right) - \omega\frac{R^*_{t-1}d^*_{t-1}}{\Pi^*_t} \tag{A16}$$

where ξ^*_b is the proportion of total assets that the household transfers to new bankers.

The optimality conditions for Home banks are similar. The leverage ratio is $\lambda_t = q_t z_t/n_t$ and is determined by

$$\kappa_t = \underbrace{\theta\left(1+\frac{\gamma}{2}x_t^2\right)}_{\equiv\Theta(x_t)}\lambda_t, \tag{A17}$$

where $x_t = s_t b^*_t/(q_t z_t)$, which implies

$$\lambda_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt}x_t)} \tag{A18}$$

where

$$\mu_{bt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t,t+1} \left(\frac{R_t}{\Pi_{t+1}} - \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right) \right] \tag{A19}$$

$$\mu_{kt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t,t+1} \left(r_{kt+1} - \frac{R_t}{\Pi_{t+1}} \right) \right] \tag{A20}$$

$$\mu_{dt} = \mathbb{E}_t \left(\mathcal{M}_{t,t+1} \Omega_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right) \tag{A21}$$

$$\Omega_{t,t+1} = \mathbb{E}_t (1 - \omega + \omega \kappa_{t+1}) \tag{A22}$$

$$\kappa_t = \frac{V(n_t)}{n_t}. \tag{A23}$$

The optimal proportion of foreign currency debt is given by

$$x_t = \frac{\sqrt{1 + \frac{2\mu_t^2}{\gamma}} - 1}{\mu_t}, \tag{A24}$$

where $\mu_t = \mu_{bt}/\mu_{kt}$.

The aggregate balance sheet is

$$q_t z_t = d_t + s_t b^*_t + n_t, \tag{A25}$$

while net worth evolves according to

$$n_t = (\omega + \xi_b) r_{kt} q_{t-1} z_{t-1} - \omega \left(\frac{R_{t-1} d_{t-1}}{\Pi_t} + \frac{s_t R^*_{bt-1} b^*_{t-1}}{\Pi^*_t} \right). \tag{A26}$$

B.3 Intermediate Goods Producers

The balance sheet of intermediate goods producer in the Home country is

$$q_t z_t = q_t k_t. \tag{A27}$$

Profit maximization yields the first-order conditions with respect to ℓ_t and k_{t-1}, which are

$$w_t = (1 - \alpha) p_{mt} k^{\alpha}_{t-1} \ell_t^{-\alpha} \tag{A28}$$

and

$$r_{kt} = \frac{\alpha p_{mt} k^{\alpha-1}_{t-1} \ell_t^{1-\alpha} + (1 - \delta) q_t}{q_{t-1}}. \tag{A29}$$

The zero-profit condition implies that the price for intermediate goods is

$$p_{mt} = \frac{[r_{kt} q_{t-1} - (1 - \delta) q_t]^{\alpha} w_t^{1-\alpha}}{A_t \alpha^{\alpha} (1 - \alpha)^{1-\alpha}}, \tag{A30}$$

where $a_t \equiv \ln(A_t/A)$ follows an exogenous first-order autoregressive process

$$a_t = \rho_a a_{t-1} + e_{at}, \tag{A31}$$

with $\rho_a \in [0,1]$ and $e_{at} \sim \mathcal{N}(0, \sigma_a^2)$. The problem for Foreign intermediate goods producers and the resulting first-order conditions are symmetric.

B.4 Capital Producers

The first-order condition for capital producers in the Home country is

$$q_t = 1 + \frac{\varphi_i}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 + \varphi_i\left(\frac{i_t}{i_{t-1}} - 1\right)\frac{i_t}{i_{t-1}} - \varphi_i \mathbb{E}_t\left[\mathcal{M}_{t,t+1}\left(\frac{i_{t+1}}{i_t} - 1\right)\frac{i_{t+1}^2}{i_t^2}\right], \tag{A32}$$

and the capital accumulatation equation is

$$k_t = i_t + (1-\delta)k_{t-1}. \tag{A33}$$

The problem for capital producers in the Foreign country yields similar first-order conditions.

B.5 Final Goods Producers

Home final goods producers that serve the domestic market and can reset their price at time t choose

$$\frac{\widetilde{P}_t(h)}{P_{Ht}} = \frac{\varrho}{\varrho - 1}\frac{\mathcal{H}_{1t}}{\mathcal{H}_{2t}} \tag{A34}$$

where

$$\mathcal{H}_{1t} = \Lambda_t p_{mt} y_{Ht} + \beta\xi_H \mathbb{E}_t(\Pi_{Ht+1}^{\varrho}\mathcal{H}_{1t+1}) \tag{A35}$$

$$\mathcal{H}_{2t} = \Lambda_t p_{Ht} y_{Ht} + \beta\xi_H \mathbb{E}_t(\Pi_{Ht+1}^{\varrho-1}\mathcal{H}_{2t+1}), \tag{A36}$$

with $p_{Ht} \equiv P_{Ht}/P_t$ and

$$y_{Ht} = a p_{Ht}^{-\epsilon}\left[c_t + i_t + \frac{\varphi_i}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2 i_t\right].$$

The link between the optimal reset price and inflation is

$$\xi_H \Pi_{Ht}^{\varrho-1} + (1-\xi_H)\left[\frac{\widetilde{P}_t(h)}{P_{Ht}}\right]^{1-\varrho} = 1. \tag{A37}$$

A similar set of conditions applies to all Foreign final goods producers.

Home final goods producers that serve the Foreign market and can reset their price at time t

choose

$$\frac{S_t\widetilde{P}_t^*(h)}{P_{Ht}^*} = \frac{\varrho}{\varrho-1}\frac{\mathcal{F}_{1t}}{\mathcal{F}_{2t}}, \tag{A38}$$

where

$$\mathcal{F}_{1t} = \left(\frac{1-n}{n}\right)\Lambda_t p_{mt} y_{Ht}^* + \beta\xi_H \mathbb{E}_t[(\Pi_{Ht+1}^*)^{\varrho}\mathcal{F}_{1t+1}] \tag{A39}$$

$$\mathcal{F}_{2t} = \left(\frac{1-n}{n}\right)\Lambda_t p_{Ht}^* y_{Ht}^* + \beta\xi_H \mathbb{E}_t\left[\frac{S_{t+1}}{S_t}(\Pi_{Ht+1}^*)^{\varrho-1}\mathcal{F}_{2t+1}\right], \tag{A40}$$

with

$$y_{Ht}^* = a^*(p_{Ht}^*)^{-\epsilon}\left[c_t^* + i_t^* + \frac{\varphi_i}{2}\left(\frac{i_t^*}{i_{t-1}^*}-1\right)^2 i_t^*\right].$$

In this case, the link between the optimal reset price and inflation is

$$\xi_H(\Pi_{Ht}^*)^{\varrho-1} + (1-\xi_H)\left[\frac{\widetilde{P}_t^*(h)}{P_{Ht}^*}\right]^{1-\varrho} = 1. \tag{A41}$$

B.5.1 Importers

Importers who adjust their price at time t set

$$\frac{\widetilde{P}_t(f)}{P_{Ft}} = \frac{\varrho}{\varrho-1}\frac{\mathcal{I}_{1t}}{\mathcal{I}_{2t}}, \tag{A42}$$

where

$$\mathcal{I}_{1t} = \left(\frac{1-n}{n}\right)\Lambda_t p_t^{im} y_{Ft} + \beta\xi\mathbb{E}_t(\Pi_{Ft+1}^{\varrho}\mathcal{I}_{1t+1}) \tag{A43}$$

$$\mathcal{I}_{2Ft} = \left(\frac{1-n}{n}\right)\Lambda_t p_{Ft} y_{Ft} + \beta\xi\mathbb{E}_t(\Pi_{Ft+1}^{\varrho-1}\mathcal{I}_{2t+1}), \tag{A44}$$

with

$$y_{Ft} = (1-a)p_{Ft}^{-\epsilon}\left[c_t + i_t + \frac{\varphi_i}{2}\left(\frac{i_t}{i_{t-1}}-1\right)^2 i_t\right].$$

The link between the optimal reset price of Foreign goods and inflation is

$$\xi_F\Pi_{Ft}^{\varrho-1} + (1-\xi_F)\left[\frac{\widetilde{P}_t(f)}{P_{Ft}}\right]^{1-\varrho} = 1. \tag{A45}$$

B.6 Relative Prices and Inflation

From the definition of the CPI index (8), we can link the relative price of Home goods p_{Ht} to the terms of trade according to

$$p_{Ht}^{\epsilon-1} = a + (1-a)\mathcal{T}_t^{1-\epsilon}, \tag{A46}$$

where $\mathcal{T}_t = P_{Ft}/P_{Ht}$.

Similarly, for the relative price of Foreign goods, we have

$$(p_{Ft}^*)^{\epsilon-1} = a^* \left(\frac{\psi_t}{\psi_t^* \mathcal{T}_t}\right)^{1-\epsilon} + (1-a^*), \tag{A47}$$

where $\psi_t = \mathcal{E}_t P_{Ht}^*/P_{Ht}$ and $\psi_t^* = \mathcal{E}_t P_{Ft}^*/P_{Ft}$ are the law-of-one-price gaps for Home and Foreign goods, respectively (the measure of price pass-through for tradable goods).

The link between the relative prices of the two goods in the Home country is

$$a p_{Ht}^{1-\epsilon} + (1-a) p_{Ft}^{1-\epsilon} = 1, \tag{A48}$$

while the link between CPI inflation and domestic inflation is

$$\frac{\Pi_{Ht}}{\Pi_t} = \frac{p_{Ht}}{p_{Ht-1}}. \tag{A49}$$

The last two equations have identical counterparts for the Foreign country.

Finally, the link between the terms of trade $\mathcal{T}_t$ and the real exchange rate is

$$S_t^{1-\epsilon} = \frac{a^* \psi_t^{1-\epsilon} + (1-a^*)(\psi_t^* \mathcal{T}_t)^{1-\epsilon}}{a + (1-a)\mathcal{T}_t^{1-\epsilon}}. \tag{A50}$$

B.7 Monetary Policy

The central bank in the Home country follows the interest rate rule

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\Pi_t^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_y} \left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)^{\phi_\mathcal{E}}\right]^{1-\rho_R}. \tag{A51}$$

In the baseline analysis, we set $\phi_\mathcal{E} = 0$, which instead we allow to be positive in some of the counterfactual experiments.

The interest rate rule in the Foreign country is

$$\frac{R_t^*}{R^*} = \left(\frac{R_{t-1}^*}{R^*}\right)^{\rho_R} \left[(\Pi_t^*)^{\phi_\pi} \left(\frac{y_t^*}{y_{t-1}^*}\right)^{\phi_y}\right]^{1-\rho_R} e^{\epsilon_{Rt}^*}, \tag{A52}$$

where $\epsilon_{Rt}^* \sim \mathcal{N}(0, \sigma_{R^*}^2)$ is a monetary policy shock.

B.8 Market Clearing

In the Home country, the market clearing condition for intermediate goods requires

$$y_t = \Delta_{Ht} y_{Ht} + \left(\frac{1-n}{n}\right) \Delta^*_{Ht} y^*_{Ht}, \tag{A53}$$

where Δ_{Ht} and Δ^*_{Ht} are indexes of price dispersion defined as

$$\Delta_{Ht} \equiv \int_0^n \left[\frac{\widetilde{P}_t(h)}{P_{Ht}}\right]^{-\varrho} dh \qquad\qquad \Delta^*_{Ht} \equiv \int_n^1 \left[\frac{\widetilde{P}^*_t(h)}{P^*_{Ht}}\right]^{-\varrho} dh.$$

From the expression of the domestic price index, we can derive the law of motion of the two price dispersion variables as

$$\Delta_{Ht} = \xi_H \Pi^{\varrho}_{Ht} \Delta_{Ht-1} + (1-\xi_H) \left[\frac{\widetilde{P}_t(h)}{P_{Ht}}\right]^{-\varrho}$$

and

$$\Delta^*_{Ht} = \xi_H (\Pi^*_{Ht})^{\varrho} \Delta^*_{Ht-1} + (1-\xi_H) \left[\frac{\widetilde{P}^*_t(h)}{P^*_{Ht}}\right]^{-\varrho}.$$

The market clearing condition for the Foreign country is

$$y^*_t = \Delta^*_{Ft} \left(y^*_{Ft} + \frac{n}{1-n} y_{Ft}\right)$$

where

$$\Delta^*_{Ft} = \int_n^1 \left[\frac{\widetilde{P}^*_t(f)}{P^*_{Ft}}\right]^{-\varrho} df,$$

and the index of price dispersion evolves according to

$$\Delta^*_{Ft} = \xi^*_F (\Pi^*_{Ft})^{\varrho} \Delta^*_{Ft-1} + (1-\xi^*_F) \left[\frac{\widetilde{P}^*_t(f)}{P^*_{Ft}}\right]^{-\varrho}.$$

Lastly, the law of motion of net foreign debt for the Home country is

$$b^*_t = \frac{R^*_{bt-1} b^*_{t-1}}{\Pi^*_t} + p^*_{Ft} y_{Ft} - \left(\frac{1-n}{n}\right) p^*_{Ht} y^*_{Ht}. \tag{A54}$$

C Steady State

We approximate the model around a non-stochastic steady state with zero inflation in both countries and relative prices normalized to one. As a consequence, also steady state price dispersion is equal to one.

In each country, the steady state real interest rate is equal to the inverse of the individual discount factor. We choose χ so that steady state hours ℓ are equal to one-third. Zero steady state investment adjustment costs imply that the relative price of capital q is equal to one. Moreover, since in steady state all firms can adjust their price, the relative price of intermediate goods is equal to the inverse of the steady state markup ($p_m = (\varrho - 1)/\varrho$). Given this value, the first order conditions for intermediate goods producers pin down w, r_k and k. In turn, from the production function, we obtain y, and from the law of motion of capital we can derive i.

In equilibrium, the quantity of securities that banks hold z corresponds to the capital stock k. Given the leverage ratio λ and the ratio of foreign currency liabilities x, banks' net worth of banks is $n = k/\lambda$ and the stock of foreign liabilities is $b^* = xk$.[28] The aggregate balance sheet of banks residually determines deposits ($d = (1 - 1/\lambda - x)k$). With these expressions, we can derive $V(n)$ and κ, which, together with the returns on deposits and capital, pin down μ_d, μ_k, and μ_b.

Finally, the demand equations and the market clearing conditions determine the quantities c_h, c_h^*, c_f, c_f^*, y_h, y_h^*, y_f, y_f^*, c and c^*.

[28]Our choice to directly estimating λ and x corresponds to choosing values for the parameters γ and θ consistent with the moral hazard constraint at equality and the first order condition for the optimal portfolio choice.

D Banks' Problem with Taxes

This section specifies the solution of Home banks' problem if we introduce countercyclical taxes as in section 5.2. In each period, Home banks maximise the expected net worth (22) subject to the balance sheet constraint (18), the incentive compatibility constraint (20), and the evolution of net worth with taxes as defined by (38).

Similar to the optimality condition to the banks' problem without taxes, the leverage ratio is

$$\lambda_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt} x_t)}. \tag{D1}$$

However, μ_{bt} in this case becomes

$$\mu_{bt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t,t+1} \left(\frac{R_t}{\Pi_{t+1}} - \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} (1 + \tau^b_t) \right) \right], \tag{D2}$$

and μ_{kt} becomes

$$\mu_{kt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \Omega_{t,t+1} \left(r_{kt+1} (1 - \tau^k_t) - \frac{R_t}{\Pi_{t+1}} \right) \right]. \tag{D3}$$

The equations for μ_{dt} and x_t are identical to those for banks without the taxes, which are described by (24) and (27), respectively.

Finally, the aggregate net worth evolves according to

$$n_t = (\omega + \xi_b) r_{kt} q_{t-1} z_{t-1} - \omega \tau^k_{t-1} r_{kt} q_{t-1} z_{t-1} - \omega \left(\frac{R_{t-1} d_{t-1}}{\Pi_t} + \frac{(1 + \tau^b_{t-1}) R^*_{bt-1} s_t b^*_{t-1}}{\Pi^*_t} \right). \tag{D4}$$