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Capital flows and exchange rates: A quantitative assessment of the dilemma hypothesis

Ambrogio Cesa-Bianchi,[(1)] Andrea Ferrero[(2)] and Shangshang Li[(3)]

Abstract

In response to an unanticipated monetary policy tightening in the US, the demand/financial channel of the international transmission of the shock dominates over the expenditure-switching effect. For a typical small open economy with flexible exchange rates, credit spreads increase, while real GDP and exports fall despite a depreciation of the local currency. In an estimated two-country open economy model, financial and pricing frictions that assign a prominent role to the global reserve currency are key to account for the empirical evidence. Model-based counterfactual policy analysis suggests that, even in the presence of a global financial cycle, the exchange rate regime matters. The volatility of output and inflation is an increasing function of the weight associated to the stabilisation of the exchange rate in the monetary policy rule. The introduction of countercyclical policy instruments that target either domestic credit or capital flows dampens economic fluctuations. In a fixed exchange rate regime, either instrument can limit the negative spillovers of foreign monetary policy shocks on real economic activity, but not on inflation.

Key words: Exchange rates flexibility, currency invoicing, dilemma, expenditure-switching, foreign exchange liabilities, global financial cycle, trilemma.

JEL classification: E44, E58, F32, F42.

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1 Introduction

As central banks around the world managed the inflation surge that followed the Covid pandemic, the effects of the interest rate tightening cycle on exchange rate volatility and capital flows became once again front and center in the debate on the cross-country transmission of monetary policy.[1]

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.[2] A central bank can pursue inflation stability only if additional instruments, such as capital flows management and/or domestic macroprudential tools, are available.

In this paper, we offer a quantitative evaluation of the Dilemma hypothesis. Our analysis proceeds in three steps. First, we estimate a panel vector auto-regression (PVAR) and 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 the highest degree of exchange rate flexibility depreciates. Yet, exports and real GDP fall. The expenditure-switching channel does not fully offset the negative consequences of tighter financial conditions and lower global aggregate demand, in line with much of the evidence discussed in Engel (2003).

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. Three counterfactual experiments high-

[1] Kalemli-Özcan and Unsal (2023) put the recent tightening cycle in a historical perspective, arguing that better monetary policy and lower levels of dollar-denominated liabilities are the two key reasons why emerging markets have avoided adverse consequences this time around.

[2] In an application to Chile, Gourinchas (2018) discusses the policy tradeoffs associated with foreign monetary shocks for an intermediate level of financial spillovers.

light the crucial interplay between financial frictions and trade pricing frictions in accounting for the results. As in Akinci and Queralto (2024), financial frictions generate amplification of the shock on economic activity. The presence of imperfections in the banking sector of both regions explains the co-movement of credit spreads across countries. We complement this result by showing how trade pricing frictions allow the model to replicate the empirical response of exports and inflation. In order to match the response of exports with a reasonable degree of stickiness, the model needs a combination of local currency pricing for exporters in the country that receives the shock (Home) as well as importers that adjust infrequently their price in the country where the shock originates (Foreign). This finding is consistent with the result in Bodenstein et al. (2024) and Kekre and Lenel (2024a) that non-financial factors are important sources of volatility for international macroeconomic and financial variables. Conversely, price stickiness among Home importers is crucial to account for the response of inflation and the nominal interest rate. In this respect, our results offer an alternative explanation for the relative stability of inflation conditional on the GFC compared to Flaccadoro and Nispi Landi (2022), who instead emphasize the role of credibility in monetary policy.

Third, endowed with the estimated model, we perform a number of policy experiments. In our setup, as in Akinci and Queralto (2024), a central bank that aggressively targets the nominal exchange rate 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 financial markets imperfections, similar in spirit to those advocated by Rey (2013), 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. The introduction of one of these two instruments in a country that adopts a peg can substantially reduce the volatility of domestic output in response to a foreign monetary policy contraction as with more a flexible exchange rate regime. However, inflation volatility remains higher. Therefore, these instruments are not enough to fully compensate for the lack of exchange rate flexibility. Our conclusion is that, despite the GFC, the Trilemma is still the appropriate framework to think about the international transmission of monetary policy.

The seminal GFC literature (see Miranda-Agrippino and Rey, 2022, for a survey) has largely emphasized the empirical response of financial variables and capital flows to US monetary policy shocks.[3] Building on those contributions, Kalemli-Özcan (2019) highlights

[3]In turn, the empirical GFC literature is related to an earlier literature on the international transmission of monetary policy (see, for example, Kim, 2001; Faust and Rogers, 2003; Canova, 2005; and Ilzetzki and Jin, 2021).

the key role of changes in global investors' risk perception when the shock occurs. A number of recent papers, such as Dedola et al. (2017), Han and Wei (2018), Degasperi et al. (2020), Flaccadoro and Nispi Landi (2022), De Leo et al. (2023), and Fukui et al. (2025) have extended the focus on to macroeconomic outcomes, comparing the response of domestic variables across exchange rate regimes. 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.[4]

Our model is closely related to Dedola and Lombardo (2012), Aoki et al. (2020), and, especially, Akinci and Queralto (2024). 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 such a 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, also similar to the one arising in Gabaix and Maggiori (2015), albeit in a different setting.[5] An international interbank market links domestic and foreign financial intermediaries, thus amplifying the transmission of foreign monetary policy shocks. On the trade side, nominal rigidities among exporters and importers limit 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.[6] In addition, importers decouple the price at the dock from the retail price. The combination of these two forces allow the model to match the decline of exports despite the depreciation of the domestic currency. Nominal rigidities among importers also mute the effect of the exchange rate depreciation on domestic inflation, creating a law-of-one price gap (Monacelli, 2005). Overall, our framework thus features a dominant currency both in trade and finance, as in Gopinath and Stein (2018).[7]

[4]Georgiadis et al. (2024) 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).

[5]Valchev (2020) and Kalemli-Özcan and Varela (2023) document the evolution of the UIP premium at different horizons for advanced economies and emerging markets, respectively. Eichenbaum et al. (2021) and Itskhoki and Mukhin (2021) show that shocks to the UIP condition can rationalize several outstanding exchange rate puzzles.

[6]Georgiadis and Schumann (2021) find evidence in favor of the dominant currency pricing in a large sample of advanced and emerging market economies between 1995 and 2018.

[7]The dominance of the dollar in international finance markets is also the focus of a recent literature

In our estimated model, the volatility of output and inflation increases under a peg, while taxes on either foreign borrowing or domestic credit reduce macroeconomic volatility.[8] This result is consistent with the work of 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.[9] In our setting, we can design a countercyclical tax, either on domestic credit or foreign liabilities, that significantly reduces the volatility of output under a peg. These taxes alleviate the negative consequences of the peg on real activity by reducing financial frictions. Nonetheless, if the exchange rate cannot freely float, the domestic economy continues to experience deflationary pressures because the central bank must increase the nominal interest rate substantially, thus lowering domestic demand.

The recent paper by Camara et al. (2025) shares many similarities with our work and deserves a separate mention. Both contributions aim to shed light on the international transmission of US monetary policy shocks through a combination of empirical and theoretical work. Empirically, the key difference is that we focus on the response of exports of the country that receives the shock to highlight the lack of a strong expenditure-switching effect. On the theoretical front, our model fully endogeneizes the mechanism that explains the muted effect of a nominal exchange rate depreciation on exports via the joint effect of nominal rigidities among exporters that price in the currency of the market of destination and among importers that distribute goods produced abroad at the retail level.

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). The second iteration of this stream of work focuses on policy options. Chen et al. (2023) incorporate frictions that create a rationale for foreign exchange rate interventions when currency markets are not very deep, while Basu et al. (2023) compare the effect of different instruments (monetary policy, exchange rate interventions, capital controls and domestic macroprudential

that studies its insurance value (Gourinchas et al., 2010), liquidity characteristics (Bianchi et al., 2022), convenience yield (Kekre and Lenel, 2024b; Jiang et al., 2021), and collateral properties (Devereux et al., 2023).

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

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

instruments) for a small open economy. 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 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 Global Financial Cycle Evidence

In this section, we use a PVARX (a PVAR augmented with exogeous variables, as discussed in Pesaran, 2015) to estimate the effects of US monetary policy shocks on macroeconomic and financial variables for a sample of countries with high exchange rate flexibility.[10]

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) at the monthly frequency between 1997 and 2019. The countries in our sample feature the highest degree of exchange rate flexibility according to the classification in Ilzetzki et al. (2019).[11]

The empirical VARX specification for each country i is

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

where x_{it} is the vector of endogenous variables at time t, a_i is a vector of constants, each $F_{i\ell}$ is a matrix of coefficients, ϵ_{mt}^{US} is the US monetary policy shock, Φ_i is a vector of coefficients capturing the impact effect of the US monetary policy shock on the endogenous variables, and u_{it} is a vector of reduced form residuals with variance-covariance matrix Σ_{iu}.[12] The vector x_{it} includes three US-specific variables and six country-specific variables. The US-

[10] Paul (2020) employs a VARX methodology to estimate the response of macroeconomic and financial variables to a monetary policy shock in the US. Plagborg-Møller and Wolf (2021) demonstrate that, under fairly general assumptions, a VARX is equivalent to an instrumental-variable structural VAR (SVAR-IV).

[11] Appendix A assesses the robustness of our results to two modifications of the baseline sample. The first excludes emerging markets (Chile, Korea, Mexico, Singapore, South Africa, and Thailand) and includes ten euro area economies (Austria, Belgium, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain). The second expands the baseline set of small open economies by adding nine major emerging markets (Argentina, Brazil, Colombia, India, Indonesia, Israel, the Philippines, Poland, and Russia), which also feature a relatively high degree of exchange rate flexibility.

[12] Appendix A reports a robustness exercise without the time trend, which we include in the baseline PVARX specification.

specific variables are credit spreads, real GDP, and, as in Gertler and Karadi (2015), the yield on the one-year Treasury. The country-specific variables are real GDP, the CPI, exports in real terms, the policy rate (as suggested by De Leo et al., 2023), the nominal exchange rate, and credit spreads. GDP, exports, the CPI and the nominal exchange rate (units of domestic currency per US dollar) enter the VAR in logs while spreads and interest rates are in levels.[13] The US monetary policy shocks ϵ_{mt}^{US} are the high-frequency monetary policy surprises constructed by Jarocinski and Karadi (2020).[14]

For the estimation of the VAR and the construction of confidence intervals, we rely on the mean group estimator of Pesaran and Smith (1995), as pooled estimators are not consistent in dynamic panel data with heterogeneous slope coefficients (in our case, different across countries). The Bayesian Information Criterion suggests 3 lags for all countries. We thus set $L = 3$, but Appendix A shows that the results are robust to using a different lag length.

2.1 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 the US short-term interest rate (top-left panel), which roughly corresponds to a two-standard-deviation shock in Gertler and Karadi (2015). The solid line is the mean group estimator. The dark and light shaded areas represent the 68% and 95% confidence bands, respectively.

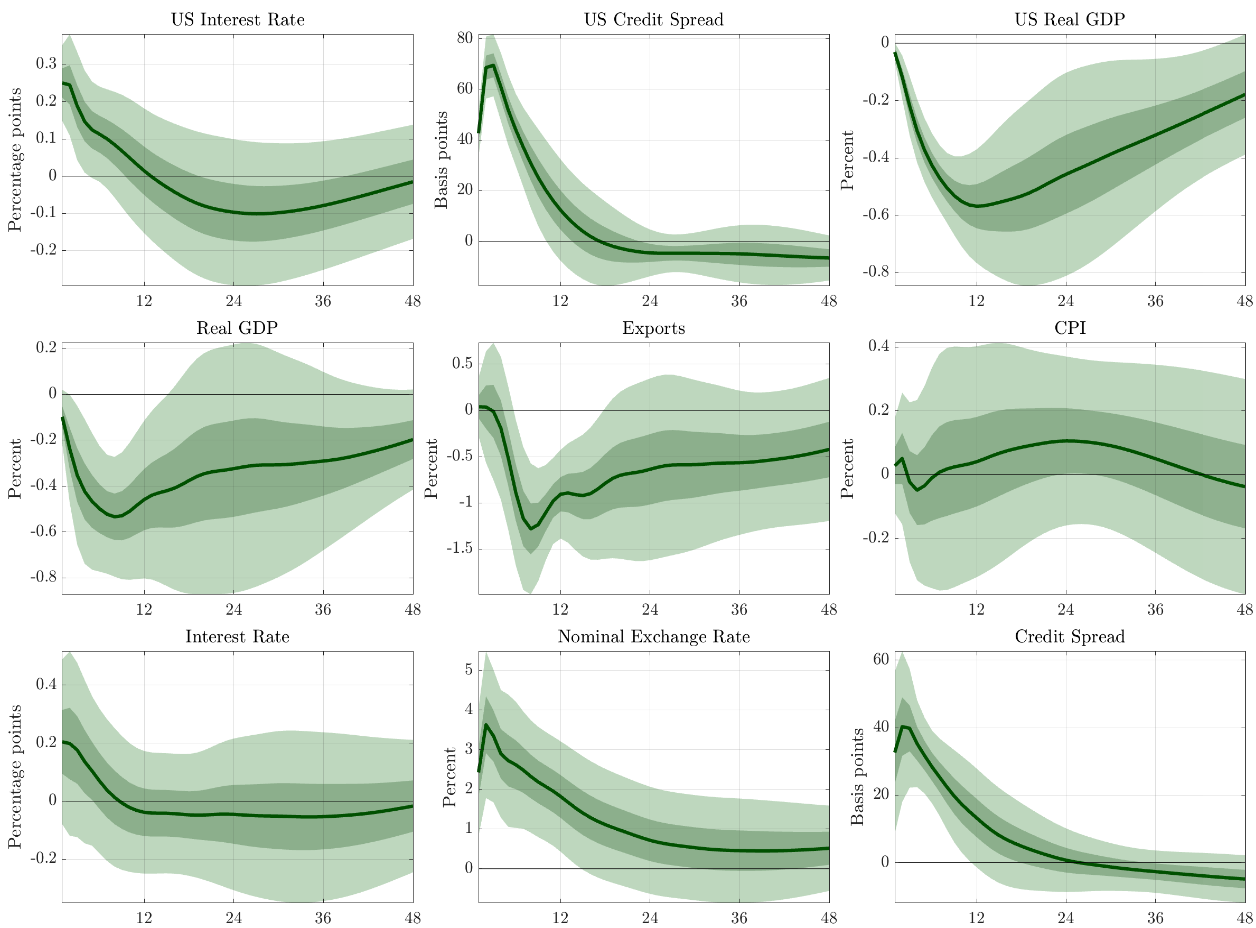
The shock leads to an increase of US credit spreads (top-middle panel) and a persistent and hump-shaped decline of US real GDP (top-right panel), as in the closed economy analysis of Gertler and Karadi (2015) and Caldara and Herbst (2019).

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 consistent with the idea of a global financial cycle, in the sense that domestic spreads closely co-move with those in the US. The persistent fall of real GDP (middle-left panel) and exports (middle-center panel) suggest that the global demand/financial channel of the transmission mechanism dominates over the expenditure-

[13] Following Miranda-Agrippino and Rey (2020), we interpolate macroeconomic quantities (real GDP and exports) from quarterly to monthly frequency. Credit spreads are from ICE Bank of America Merrill Lynch. Appendix A provides additional details on the definition and sources of the data.

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

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. The shock is normalized to generate a 25 basis points increase in the US short-term interest rate. Interest rates and credit spreads are reported in annualized terms.

switching effect. In a traditional 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 at work in partial equilibrium, the data highlight the strength of the transmission through global demand and 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 not statistically significant. The response of the CPI (middle-right) is also not significant and the mean group estimate remains close to zero over the entire horizon.[15] Appendix A shows that these results are robust to a number of variations.[16]

In short, our PVARX evidence is broadly aligned 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 global financial conditions and global demand leads to a fall in real GDP and exports, in spite of 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.

While our results for countries with the highest degree of exchange rate flexibility are in line with (and in fact, in our view, strengthen) the GFC evidence available for a broader set of countries, the empirical analysis alone cannot disentangle the relative contribution of financial market imperfections and other frictions in accounting for the international transmission of monetary policy shocks. In order to make further progress in this direction, the next section develops and estimates a two-country DSGE model with financial and trade frictions that allows us to highlight the importance of different channels.

3 A Model of the Global Financial Cycle

The model that we use is closely related to Akinci and Queralto (2024). 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 domestic financial intermediaries (banks). In both countries, banks raise deposits from domestic households, acquire securities issued by domestic intermediate good producers in exchange for loans to fund their capital stock, and can borrow and lend in the international interbank market. On the supply side, intermediate goods firms combine labor, capital, and imported intermediate goods to produce differentiated varieties. Retailers combine these varieties to produce a final good, which is partly sold domestically to consumers and firms and partly shipped to the other country. Importers distribute goods produced abroad to consumers.

[15] The non-significant response of inflation among countries with flexible exchange rates is in line with the evidence in Flaccadoro and Nispi Landi (2022).

[16] In addition to the robustness exercises already mentioned, the alternative specifications that we entertain include computing the mean group estimator using PPP–GDP weights, considering a longer sample period starting in 1985 (at the expenses of dropping credit spreads for the small open economies), substituting the policy rate with a measure of short-term market interest rates for the small open economies, and expanding the vector of endogenous variables (with either US CPI, the price of oil, or equity prices for the small open economies).

Capital producers transform the final consumption good into investment goods. In each country, a central bank sets monetary policy.

In both countries, prices and wages adjust infrequently. Foreign final goods producers price their goods in domestic currency independently of the market of destination, whereas Home final goods producers price their goods in the currency of the destination market. Banks are subject to an incentive compatibility constraint due a moral hazard friction, which for Home banks depends on the currency composition of their balance sheet. Finally, capital producers are subject to investment adjustment costs.

In what follows, we describe the model in detail 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 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

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

where $\bar{c}_{t-1}$ is a reference consumption level that the household takes as given, $\sigma > 0$ is the coefficient of relative risk aversion, $h \in (0,1)$ 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. Expenditure minimization implies that the consumer price 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

Home banks acquire financial securities z_t from domestic intermediate goods producers in exchange for loans, whose market price in real terms is q_t. In the mapping of the model to the data, we interpret the Home country as the typical small open economy in our sample and the Foreign country as the US. As a consequence, we follow Akinci and Queralto (2024) in assuming that Home banks are net borrowers in the international interbank market and that interbank loans are denominated in Foreign currency (denoted by b_t^* in real terms), that is, in US dollars. Therefore, the balance sheet of Home banks is

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

where $s_t \equiv \mathcal{E}_t P_t^*/P_t$ is the real exchange rate, $\mathcal{E}_t$ is the Home-country nominal exchange rate (units of Home currency per unit of Foreign currency), and n_t denotes net worth in real terms. 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 and deposits implies a reduction of the banks' net worth.[17]

Net worth is the difference between the realized gross return on assets and liabilities

$$n_t = r_{kt} q_{t-1} z_{t-1} - \frac{R_{t-1}}{\Pi_t} d_{t-1} - \frac{R^*_{bt-1}}{\Pi^*_t} s_t b^*_{t-1}, \tag{14}$$

where r_{kt} is the real return on capital, $\Pi_t \equiv P_t/P_{t-1}$ is the gross inflation rate, and R^*_{bt} is the gross nominal interest rate on interbank loans. Substituting out deposits from the balance sheet constraint, we can rewrite the law of motion of net worth as

$$n_t = \left(r_{kt} - \frac{R_{t-1}}{\Pi_t}\right) q_{t-1} z_{t-1} - \left(\frac{R_{t-1}}{\Pi_t} - \frac{R^*_{bt-1}}{\Pi^*_t}\frac{s_t}{s_{t-1}}\right) s_{t-1} b^*_{t-1} + \frac{R_{t-1}}{\Pi_t} n_{t-1}. \tag{15}$$

For given assets and liabilities, changes in returns (on deposits, loans, and interbank bor-

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

rowing) lead to fluctuations in banks' net worth.

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 (their initial net worth). Because banks are owned by households and eventually will exit the industry, their objective function is the expected value of terminal wealth, which we can write in recursive form as

$$V(n_t) = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1}[(1-\omega)n_{t+1} + \omega V(n_{t+1})] \right\}, \tag{16}$$

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

If a bank fails, a fraction of its assets gets lost in the bankruptcy process. Without any constraint, banks would seek to leverage as much as possible to minimize the bankruptcy costs born by equity. In order to provide the right incentives for banks to accumulate enough equity, its value must never be less than some fraction of the value of the assets lost in case of bankruptcy

$$V(n_t) \geq \Theta(x_t) q_t z_t, \tag{17}$$

where

$$\Theta(x_t) \equiv \theta \left(1 + \frac{\gamma}{2} x_t^2\right), \tag{18}$$

and $x_t \equiv s_t b_t^* / (q_t z_t)$, with θ and $\gamma > 0$. As in Akinci and Queralto (2024), 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. The parameter θ governs the tightness of the financial friction, while γ determines the sensitivity of the financial friction to the share of foreign currency liabilities.

The problem of Home banks consists of maximizing (16) subject to (15) and (17). In an equilibrium in which the incentive compatibility constraint is always binding, the solution can be written as

$$\lambda_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt} x_t)}, \tag{19}$$

where $\lambda_t \equiv q_t z_t / n_t$ is the optimal leverage ratio for Home banks.[18] The numerator of (19) is the expected discounted real return on deposits

$$\mu_{dt} = \mathbb{E}_t \left(\mathcal{M}_{t,t+1} \Omega_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right), \tag{20}$$

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

where $\Omega_{t,t+1} \equiv 1 - \omega + \omega\kappa_{t+1}$ is an additional discount factor that banks apply to future returns due to the probability of exiting, and $\kappa_t \equiv V(n_t)/n_t = \Theta(x_t)\lambda_t$ is the franchise value of the bank per unit of net worth.

The denominator of (19) is the difference between $\Theta(x_t)$ and two expected discounted excess returns, the second of which is multiplied by the share of foreign currency liabilities. In order to satisfy the incentive compatibility constraint (25), banks need to earn these excess returns in expectation. The first excess return concerns the spread that banks earn by lending to firms over remunerating deposits

$$\mu_{kt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1}\Omega_{t,t+1} \left(r_{kt+1} - \frac{R_t}{\Pi_{t+1}} \right) \right]. \tag{21}$$

As Gertler and Karadi (2011) stress, in the absence of financial frictions, μ_{kt} would be zero.

Home banks also arbitrage between domestic deposits and funds raised in foreign currency from the international interbank market. Financial frictions create an endogenous wedge between the returns on the two sources of funding

$$\mu_{bt} = \mathbb{E}_t \left[\mathcal{M}_{t,t+1}\Omega_{t,t+1} \left(\frac{R_t}{\Pi_{t+1}} - \frac{R^*_{bt}}{\Pi^*_{t+1}} \frac{s_{t+1}}{s_t} \right) \right]. \tag{22}$$

In equilibrium, such a wedge leads to a premium in the uncovered interest rate parity (UIP) condition, consistent with a large body of empirical evidence since Fama (1984). As Akinci and Queralto (2024) discuss, without financial frictions μ_{bt} would also be zero and the standard UIP condition would hold.

The optimal leverage ratio is increasing in μ_{dt}, μ_{kt} and μ_{bt}. Ceteris paribus, a higher deposit rate reduces banks' net worth, thus increasing the optimal leverage ratio. When the return on capital increases relative to the return on deposits (or when the cost of borrowing in foreign currency decreases relative to the cost of deposits) banks optimally increase leverage because lending to firms (or borrowing from Foreign banks) is particularly attractive.

Finally, given the functional form assumed for $\Theta(\cdot)$, we can solve for the optimal share of foreign currency debt, which can be written as

$$x_t = \frac{1}{\mu_t} \left(\sqrt{1 + \frac{2\mu_t^2}{\gamma}} - 1 \right), \tag{23}$$

where $\mu_t \equiv \mu_{bt}/\mu_{kt}$. Since interbank borrowing corresponds to the net external position of the Home country, equation (23) in steady state pins down net foreign liabilities.

Foreign banks are similar to Home banks, with two key simplifications. First, interbank loans are an asset for these institutions, so that their balance sheet is

$$q_t^* z_t^* + b_t^* = d_t^* + n_t^*. \tag{24}$$

Second, as equation (24) highlights, assets and liabilities are denominated in the same currency, thus avoiding any mismatch. As a consequence, the incentive compatibility constraint for Foreign banks does not depend on the currency composition of the balance sheet

$$V(n_t^*) \geq \theta^* \left(q_t^* z_t^* + b_t^*\right), \tag{25}$$

where $\theta^* > 0$.[19] The solution of the problem of Foreign banks also pins down the optimal leverage ratio for these institutions, which only depends on the expected discounted return on the deposits and the expected discounted excess return on capital

$$\lambda_t^* = \frac{\mu_{dt}^*}{\theta^* - \mu_{kt}^*}, \tag{26}$$

where $\lambda_t^* \equiv (q_t^* z_t^* + b_t^*)/n_t^*$.

3.3 Firms

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

The only difference between the structure of production in the Home and Foreign country is that Home final goods producers price their goods in the currency of the destination market ('local currency pricing' or LCP) while Foreign final goods producers price all their goods in domestic currency ('producer currency pricing' or PCP). In our two-country setting in which the Foreign country corresponds to the US, this assumption is consistent with the evidence on the US dollar as the dominant currency in international trade invoicing emphasized by Gopinath et al. (2020).

[19] Essentially, Foreign banks are identical to the ones in the closed economy model of Gertler and Karadi (2011), except for the presence of an additional asset (interbank loans). The resulting international financial structure in our model is thus is slightly different from Akinci and Queralto (2024), who abstract from banking frictions in the Foreign country. This different assumption has some consequences on the degree of amplification of financial frictions, which we discuss below.

3.3.1 Capital Producers

Capital producers transform final goods into capital to be used as input in the production of intermediates. Their activity is subject to an adjustment cost, which we assume to be quadratic in the growth rate of investment. Thus, the problem for capital producers is to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \mathcal{M}_{t,t+j} \left[q_{t+j} - 1 - \frac{\varphi_i}{2} \left(\frac{i_{t+j}}{i_{t+j-1}} - 1 \right)^2 \right] i_{t+j}, \tag{27}$$

where $\varphi_i > 0$ measures the sensitivity of the price of capital to changes in investment.

3.3.2 Intermediate Goods Producers

Competitive intermediate goods producers have access to a CES technology that combines capital (k_t), labor, and imported inputs (x_t) according to

$$y_t = A_t \left[(1-\varpi)^{\frac{1}{\vartheta}} \left(k_{t-1}^{\alpha} \ell_t^{1-\alpha} \right)^{\frac{\vartheta-1}{\vartheta}} + \varpi^{\frac{1}{\vartheta}} x_t^{\frac{\vartheta-1}{\vartheta}} \right]^{\frac{\vartheta}{\vartheta-1}}, \tag{28}$$

where A_t is a productivity shock, $\varpi \in (0,1)$ is the share of intermediate inputs, $\vartheta > 0$ is the elasticity of substitution between intermediate inputs and other inputs, and $\alpha \in (0,1)$ 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

$$q_t z_t = q_t k_t, \tag{29}$$

and their profits are

$$\mathcal{P}_t = p_{mt} y_t - w_t \ell_t - r_{kt} q_{t-1} z_{t-1} + (1-\delta) q_t k_{t-1} - p_{Ft} x_t, \tag{30}$$

where p_{mt} is the relative price of intermediate goods, $w_t \equiv W_t/P_t$ is the real wage, and $p_{Ft} = P_{Ft}/P_t$ is the relative price of imported intermediate inputs.

The first order conditions for the three inputs of production are standard (see Appendix B for details) and equalize their price to the respective marginal products. Since intermediate goods producers are perfectly competitive, the zero-profit condition pins down the relative price of intermediate inputs as a combination of the real wage, the real return on capital, and the relative price of imported inputs. The problem of Foreign intermediate goods producers is symmetric.

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 $\xi_p \in (0,1)$. With LCP, the profit maximization problem for a firm that can change prices at time t is

$$\max_{\widetilde{P}_t(h),\widetilde{P}_t^{im*}(h)} \mathbb{E}_t \sum_{j=0}^{\infty} \xi_p^j \mathcal{M}_{t,t+j} \left\{ \left[\frac{\widetilde{P}_t(h)}{P_{t+j}} - p_{mt+j} \right] y_{t,t+j}(h) + \left[\frac{\mathcal{E}_{t+j}\widetilde{P}_t^{im*}(h)}{P_{t+j}} - p_{mt+j} \right] y^*_{t,t+j}(h) \right\}, \tag{31}$$

subject to

$$y_{t,t+j}(h) = \left[\frac{\widetilde{P}_t(h)}{P_{Ht+j}} \right]^{-\varrho} y_{Ht+j} \qquad \text{and} \qquad y^*_{t,t+j}(h) = \frac{1-n}{n} \left[\frac{\widetilde{P}_t^{im*}(h)}{P_{t+j}^{im*}} \right]^{-\varrho} y^*_{Ht+j}. \tag{32}$$

The first equation in (32) corresponds to the demand for Home final goods by Home households, which is standard. The second equation is the demand for Home final goods by Foreign importers. Since importers purchase goods produced abroad on behalf of consumers and firms in their country, their demand takes the same form as final demand. As we further discuss in the next section, these firms distribute the imported goods to final consumers setting their prices on a staggered basis. We denote with P_t^{im*} the price index associated with their demand. Domestically, Home goods are only used for consumption and investment (including adjustment costs)

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

Conversely, Foreign demand for Home goods also includes imported inputs

$$y^*_{Ht} = a^* \left(\frac{P^*_{Ht}}{P^*_t} \right)^{-\epsilon} \left[c^*_t + i^*_t + \frac{\varphi_i}{2} \left(\frac{i^*_t}{i^*_{t-1}} - 1 \right)^2 i^*_t \right] + x^*_t.$$

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

The problem for final goods producers in the Foreign country is similar, except that those firms operate under PCP and thus only set one price independently of the market of destination for their product. As a consequence, the solution of the pricing problem with PCP gives rise to only one Phillips curve.

3.3.4 Importers

The presence of importers distinguishes the production side of our framework from Akinci and Queralto (2024). Following Monacelli (2005), we assume that importers adjust their price in domestic currency infrequently. For the Home country, this friction introduces imperfect exchange rate pass-through, which turns out to be a key ingredient for matching the empirical response of inflation to a Foreign monetary policy shocks. Importantly, the disconnect between prices at the dock and at the consumer level in the Foreign country also plays a crucial role in accounting for the response exports, above and beyond LCP. We discuss these two channels extensively in Section 4.

In the Home country, 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, the retailers that distribute imported goods to households and intermediate goods producers change their prices only with probability $\xi_{im} \in (0,1)$ in each period. Thus, their problem is to choose the price $\widetilde{P}_t(f)$ to maximize

$$\mathbb{E}_t \sum_{j=0}^{\infty} \xi_{im}^j \mathcal{M}_{t,t+j} \left[\frac{\widetilde{P}_t(f)}{P_{t+j}} - \frac{P_{t+j}^{im}(f)}{P_{t+j}} \right] y_{t,t+j}(f), \tag{33}$$

where

$$y_{t,t+j}(f) = \frac{n}{1-n} \left[\frac{\widetilde{P}_t(f)}{P_{Ft+j}} \right]^{-\varrho} y_{Ft+j},$$

and

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

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 ratio between the price of imports in Foreign currency times the nominal exchange rate and the price of imports in domestic currency.

Importers in the Foreign country solve a similar problem, with the key difference that for Home exports the law of one price typically does not hold even at the dock because of LCP.

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)

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\Pi_t^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_y} \left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)^{\phi_\mathcal{E}}\right]^{1-\rho_R}, \tag{34}$$

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 and 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

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

$$ca_t \equiv -s_t(b^*_t - b^*_{t-1}).$$

Finally, in equilibrium, the reference level of consumption corresponds to aggregate consumption ($\bar{c}_t = c_t$).

4 Estimation and Counterfactuals

Our quantitative assessment of the model relies on a mix of calibrated and estimated parameters. Table 1 reports the list of calibrated parameters. For the Foreign country, the parameters unrelated to the financial frictions are consistent with standard values in literature (see, for example, Smets and Wouters, 2007), and whenever possible we maintain

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
ζ	Inverse Frisch elasticity	1	1
ϱ	Elasticity of substitution among goods varieties	6	6
a	Home bias in consumption	0.66	0.95
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
ϖ	Intermediate input share	0.1	0.1
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 table reports the calibrated parameters (first column), their description (second column), and their values for the Home and Foreign country (third and fourth column, respectively). The missing parameters for the Home country are estimated.

symmetry across countries. The relative size of the Home country is equal to 0.1, which corresponds to the average size of the small open economies in our sample relative to the US. Given the values of the 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 parameters imply that the export share of GDP is about 35% for the Home country, in line with the average in our sample, and 15% for the Foreign country, as in US data. The choice of parameters for 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 VAR presented in section 2 for the typical small open economy (the mean group

Table 2: Estimated parameters.

Parameter	Prior			Posterior			
	Distribution	Mean	SD	Mode	Median	5%	95%
h	Beta	0.650	0.1	0.711	0.705	0.567	0.838
σ	Gamma	1	0.375	1.001	1.217	0.757	1.830
λ	Gamma	5	1	4.858	5.115	3.710	6.946
x	Beta	0.240	0.15	0.020	0.053	0.001	0.134
φ_i	Gamma	2.850	2	0.680	0.784	0.179	1.625
ξ_p	Beta	0.660	0.1	0.689	0.702	0.536	0.869
ξ_{im}	Beta	0.660	0.1	0.718	0.676	0.533	0.814
ξ_{im}^*	Beta	0.660	0.1	0.731	0.715	0.551	0.877
ϑ	Gamma	1.5	1	0.920	1.382	0.142	2.992
ϑ^*	Gamma	1.5	1	0.618	1.068	0.089	2.342
ρ_R	Beta	0.750	0.1	0.802	0.787	0.621	0.936
ϕ_π	Gamma	1.500	0.25	1.569	1.592	1.243	1.944
ϕ_y	Gamma	0.125	0.05	0.116	0.130	0.054	0.220
$\phi_{\mathcal{E}}$	Gamma	0.100	0.05	0.062	0.083	0.024	0.158
ρ_R^*	Beta	0.750	0.1	0.821	0.782	0.689	0.867
ϕ_π^*	Gamma	1.500	0.25	1.437	1.481	1.140	1.868
ϕ_y^*	Gamma	0.125	0.05	0.105	0.116	0.046	0.196

NOTE: The table reports the estimated parameters (first column), the distribution, mean and standard deviation of the priors (second to fourth columns), and the mode, median, 5^{th} and 95^{th} percentile of the posteriors (fifth to eighth column).

estimates).[20] 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 VAR, $\Psi(\eta)$ is the vector containing of impulse responses from the DSGE model and $\widehat{W}$ is a diagonal matrix collecting the estimated variances of each impulse response from the VAR (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

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

(first column), the shape, mean and standard deviation of their prior distributions (second to fourth columns), and the mode, median, 5^{th} and 95^{th} percentile of their posteriors (fifth to eighth 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 0.49 (very close to the assumed value for θ^*), a degree of Home bias for bank funding γ equal to 16.90, and a bank transfer rate ξ_b equal to 0.001, 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.[21] The average frequency of price changes for final goods producers and importers implied by the estimated degree of price stickiness at the posterior mode is between three and four quarters. The degree of interest rate inertia and the coefficients on inflation and output growth in the interest rate rule are very close across countries. Most importantly, 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 very small.

Figure 2 presents the mean group estimate of the impulse responses for the typical small open economy to a contractionary 25 basis points US monetary policy shock aggregated at 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 magnitude for the same variables in the model at the posterior mode. Overall, the model fits the response of macro and financial variables very well. For all the variables that we target, the quantitative differences between empirical and theoretical impulese responses are minimal and well within the confidence bands.

Figure 3 compares the response of the UIP wedge in the data and the model. In the data, we construct the UIP wedge as the difference between the response of the policy rate differential across countries and the expected depreciation of the nominal exchange rate. The corresponding concept in the model is

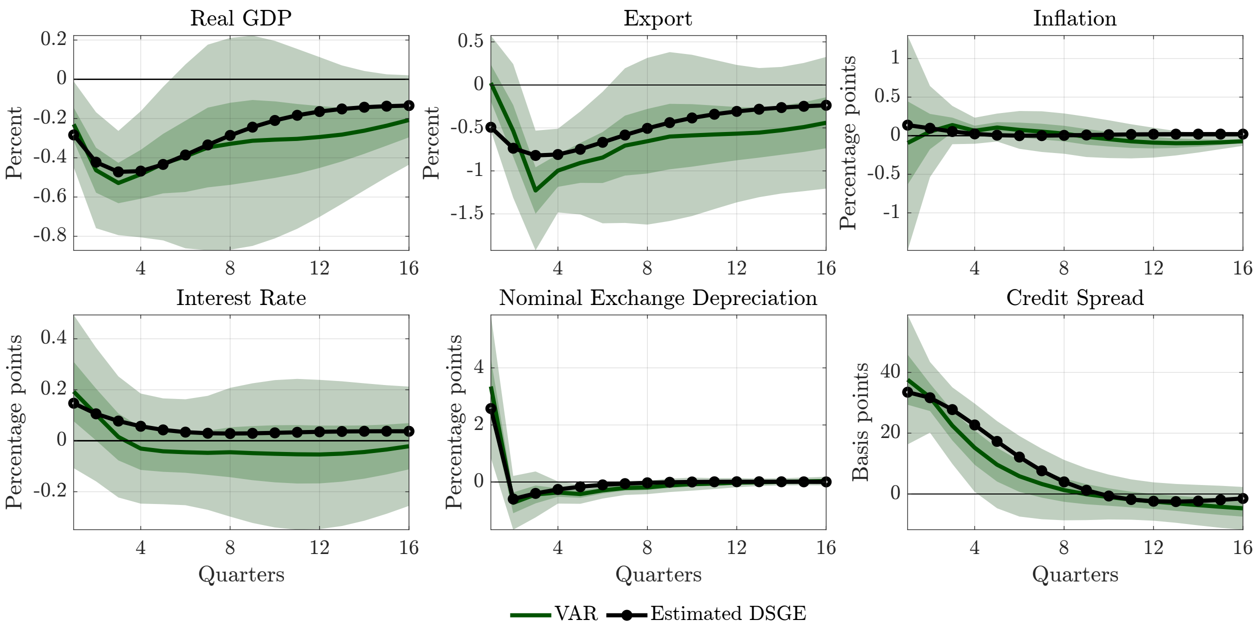
$$\mu_t^{\text{UIP}} = \hat{R}_t - \hat{R}_t^* - \mathbb{E}_t \Delta \widehat{\mathcal{E}}_{t+1}, \tag{35}$$

where a hat denotes the log-deviations from steady state.[22] Importantly, we do not target

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

[22] While related, μ_t^{UIP} is not a first-order approximation of μ_{bt}, as the latter is expressed in real terms and involves the cost of borrowing in Foreign currency for Home banks R_{bt}^* rather than the Foreign policy rate R_t^*.

Figure 2: Impulse response matching.



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

explicitly the UIP wedge in the estimation exercise. Yet, the model can explain about two-third of the impact effect of this variable and fits well its dynamics over the entire simulation horizon. This result provides further validation for the empirical performance of the model, with particular reference to the recent debate on the 'exchange rate disconnect' (Itskhoki and Mukhin, 2021).

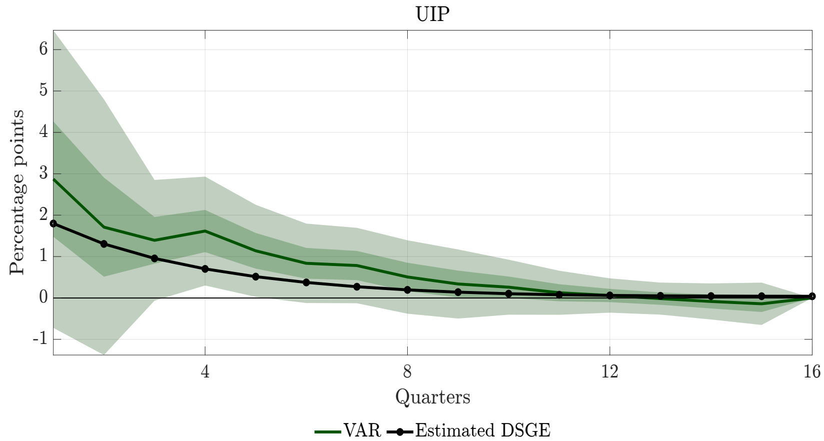
The model, therefore, is able to replicate the dominant role of the global demand/financial channel in propagating Foreign monetary policy shocks to the domestic economy that we have highlighted in section 2.[23] In the next sections, we investigate the key ingredients of the transmission mechanism by way of three counterfactual exercises.

4.1 Financial Frictions and Amplification

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

[23] As Appendix B.12 shows, the model is also consistent with the GFC evidence conditional on Foreign credit supply shocks.

Figure 3: The UIP wedge.



Note: The figure displays the impulse responses of the UIP wedge in a typical small open economy to a US contractionary monetary policy shock, in the VAR (solid green line) and in the estimated DSGE model (solid black line with markers). The light and dark grey shaded areas are the VAR 68% and 90% confidence intervals from the VAR, respectively.

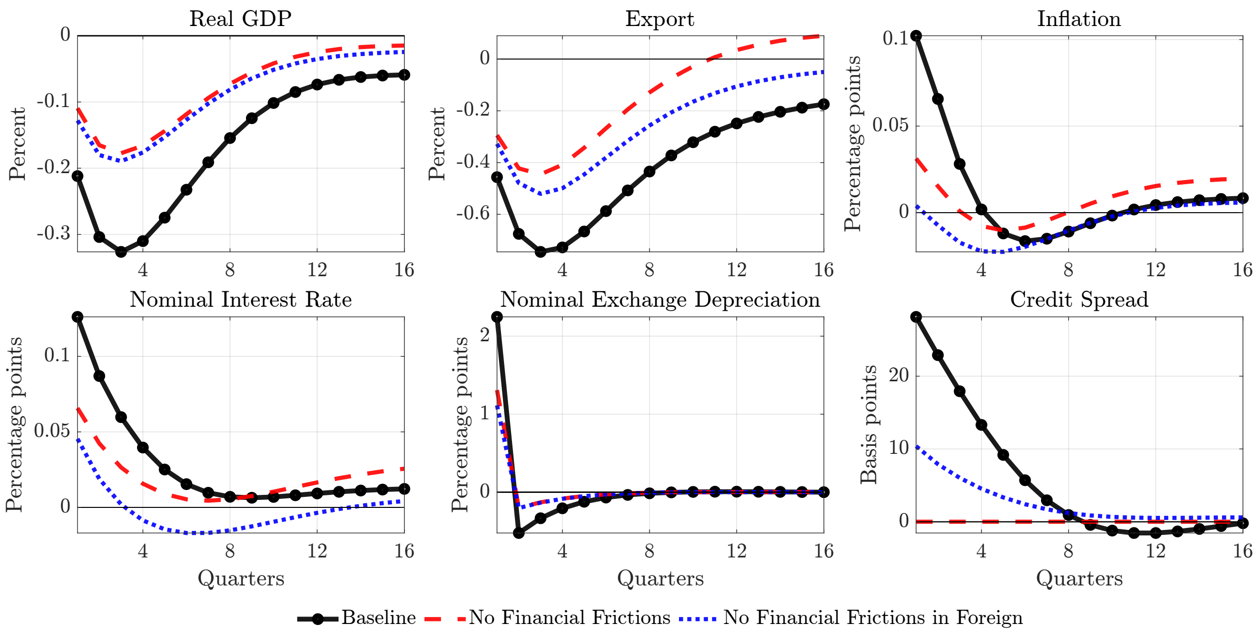
bonds. Bonds denominated in Foreign currency are internationally traded, whereas bonds denominated in Home currency only circulate domestically and are in zero net supply. These assumptions preserve the dominance of the Foreign currency (in practice the US dollar) in international financial markets even in the absence of global banks.[24] 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, as pioneered by Baxter and Crucini (1995) and Kollmann (1996), with the addition of nominal rigidities. Without financial frictions only in the Foreign country, the structure of international financial markets replicates Akinci and Queralto (2024). We perform this experiment to isolate the quantitative contribution of introducing financial frictions in both economies.

Figure 4 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 shock 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 slightly less than 0.2% at the trough, compared to more than 0.3% in the baseline. The absence of an endogenous UIP

[24] 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.

Figure 4: The role of financial frictions.

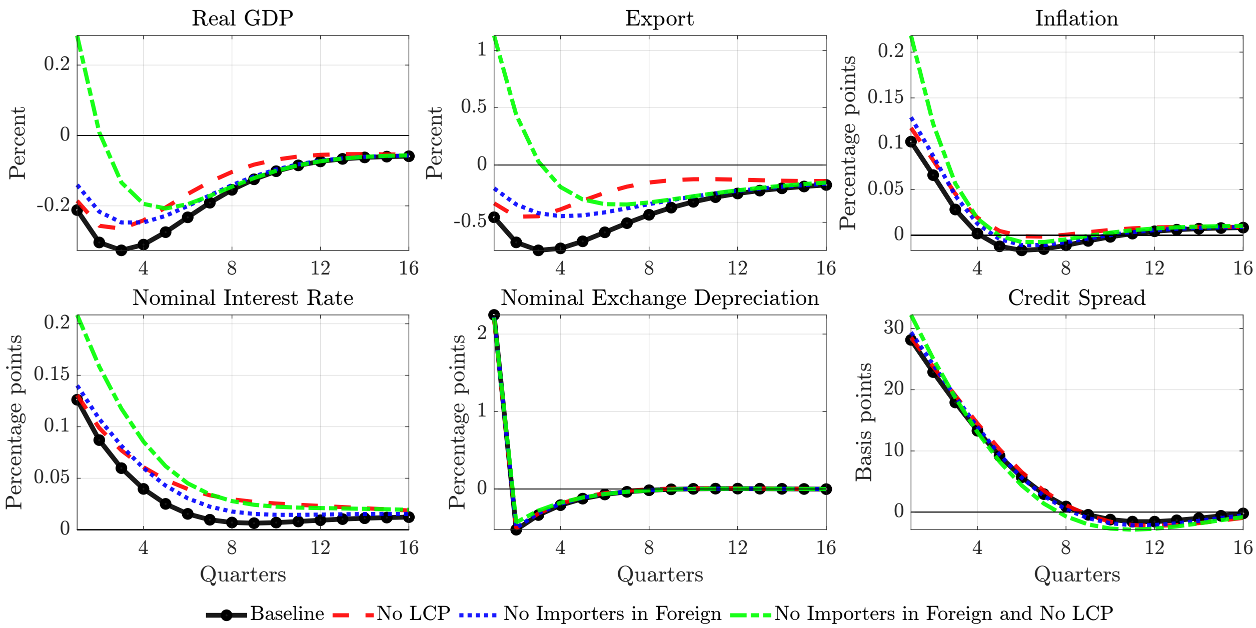


NOTE: The figure displays the impulse responses of real GDP, exports, CPI inflation, nominal interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country without financial frictions in both countries (dashed 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 reported in annualized terms.

wedge almost halves the depreciation of the Home currency on impact. This second effect (smaller depreciation) quantitatively dominates over the first (smaller recession), implying less inflation than in the baseline. As a consequence, the central bank increases the nominal interest rate less. Financial frictions also significantly amplify the response of exports. In the frictionless model, the negative response is somewhat smaller on impact and less persistent than in the baseline case, turning positive after two and a half years.

With no financial frictions in the Foreign country only, domestic spreads increase on impact by 10 basis points compared to about 30 in the baseline. Thus, the combination of Home and Foreign financial frictions is important to fully account for the cross-country co-movement of credit spreads. The financial channel partly offsets the relatively higher Foreign demand. Quantitatively, however, the effect on macroeconomic activity is very small. This result suggests that domestic financial frictions drive the amplification effects of Foreign monetary policy shocks on Home GDP. The key reason is that the estimated fraction of liabilities denominated in Foreign currency is extremely small (the posterior mean of x is 2% and the posterior median is 6%). Another quantitative difference with the case of no financial frictions in both countries concerns the persistence of the response of exports, which falls in between the baseline and the case of no financial frictions in both countries. The key reason

Figure 5: The role of LCP and Foreign importers for Home exports.



NOTE: The figure displays the impulse responses of real GDP, exports, CPI inflation, nominal interest rate, nominal exchange rate depreciation and credit spreads in the Home country to a contractionary monetary policy shock in the Foreign country with no LCP in the Home country (dashed red line), no importers in the Foreign country (dotted blue line) and neither of those two frictions (dashed-dotted green line) against the baseline (solid black line). Inflation, the nominal interest rate and spreads are reported in annualized terms.

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.

4.2 Pricing Frictions in Trade and the Response of Exports

The key elements of the model that explain the sign of the impact response of exports and, consequently, of GDP are the pricing frictions in international trade. Under our baseline assumptions, Home country firms price their exports in the currency of the destination market (LCP), which mimicks the dominance of the US dollar in goods price invoicing around the world. In addition, the firms that deliver imported Home goods to Foreign consumers and firms (i.e., the importers) adjust their price infrequently, thus introducing a wedge between the price at the dock and at the retail level. The combination of these two pricing frictions mutes the expenditure-switching effect. Following a monetary policy contraction in the Foreign country, Home exports fall because Foreign demand is lower and the exchange rate depreciation that the Home country experiences does not boost the international competitiveness of its goods.

Figure 5 illustrates the quantitative importance of these two pricing frictions in international trade. The figure compares the baseline impulse response functions (solid black line) with three counterfactual cases: (i) when Home final goods producers do not price to market (dashed red line), (ii) when the price at the dock of Home exports is the same to the price faced by Foreign consumers and firms (dotted blue line), and (iii) when both frictions are absent (dashed-dotted green line).

With neither LCP in the Home country nor importers setting prices on a staggered basis in the Foreign country, the law of one price for Home exports holds, both at the dock and at the retail level. In this case, the nominal exchange rate depreciation that the Home country experiences significantly reduces the Foreign price of its exports, which become more competitive. The expenditure-switching effect boosts exports by about 1%, pushing real GDP in positive territory, at least temporarily. Exports remain above steady state for about one year, while the positive response of overall activity lasts for two quarters. Furthermore, in this counterfactual, the response of inflation is also somewhat larger, and remains positive almost throughout the simulation horizon despite tighter domestic monetary policy. Differently from the baseline, the Home central bank does not face a short-run tradeoff between stabilizing inflation and output in response to the foreign monetary policy shock.

Without importers, LCP introduces a wedge between the real marginal cost that Home final goods producers face and the Foreign retail price. Up to a first-order approximation, the Phillips curve for Home exports is

$$\pi^*_{Ht} = \iota_p(\hat{p}_{mt} - \hat{s}_t - \hat{p}^*_{Ht}) + \beta \mathbb{E}_t \pi^*_{Ht+1}, \tag{36}$$

where $\iota_p \equiv (1-\xi_p)(1-\beta\xi_p)/\xi_p$ and π^*_{Ht} is the inflation rate of Home exports.[25] Conversely, without LCP, the presence of importers introduces a wedge between the price of Home exports at the dock and at the retail level

$$\pi^*_{Ht} = \iota^*_{im}(\hat{p}_{Ht} - \hat{s}_t - \hat{p}^*_{Ht}) + \beta^* \mathbb{E}_t \pi^*_{Ht+1}, \tag{37}$$

where $\iota^*_{im} \equiv (1-\xi^*_{im})(1-\beta^*\xi^*_{im})/\xi^*_{im}$. If Home final goods producers set domestic prices flexibly ($\hat{p}_{mt} = \hat{p}_{Ht}$), the differences between the two frictions would boil down to values

[25] Similarly, the Phillips curve for Home goods sold domestically introduces a wedge between the real marginal cost and the Home retail price

$$\pi_{Ht} = \iota_p(\hat{p}_{mt} - \hat{p}_{Ht}) + \beta \mathbb{E}_t \pi_{Ht+1}.$$

of the parameters (ξ_p versus ξ^*_{im} and β versus β^*), which we estimate to be very small. With sticky prices, the differences are slightly more pronounced. Nevertheless, the two trade pricing frictions play a similar qualitative and quantitative role. Both limit the pass-through of the nominal exchange rate depreciation on Home exports, thus affecting the strength of the expenditure-switching effect. However, quantitatively, neither is per sé sufficient to fully account for the negative response of exports in the baseline. When we estimate the model with only one of the two frictions, we obtain an implausibly high degree of stickiness (a probability of not being able to reset prices well above 0.9) and a worse fit of the data.

Figure 5 also highlights that the effects of the two frictions are not simply additive. Either friction dampens the expenditure-switching effect more by itself than in combination with the other. Without Foreign importers, LCP has a strong effect because Home producers know that their pricing decisions directly affect the final demand for their products. Thus, compared to the case of PCP, Home producers reduce their price by much less, which in turn mutes the positive impact of the exchange rate depreciation on the demand for Home exports. When we add Foreign importers, the effect of LCP is smaller because the demand for Home goods is not very elastic to their own pricing decisions (and instead responds to Foreign importers' pricing decisions). In this case, LCP simply affects the price at the dock, which is only partially reflected in the retail price. Hence, the pure effect of LCP conditional on Foreign importers being present is relatively small.

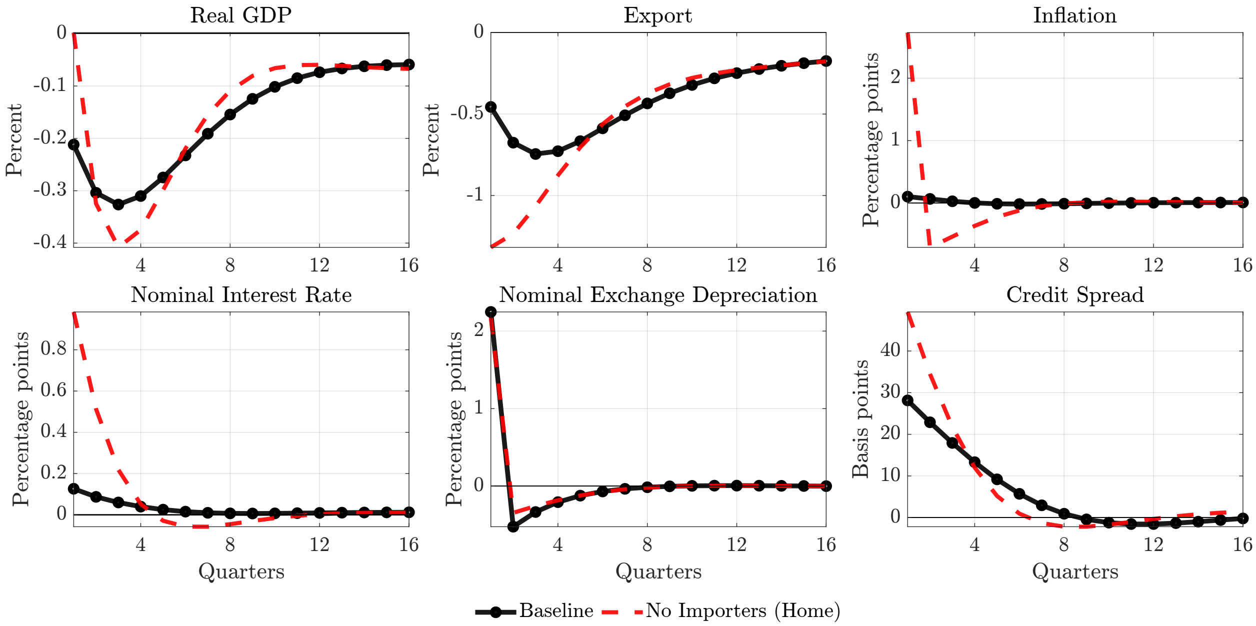
Conversely, without LCP at Home, a moderate degree of price stickiness among Foreign importers can significantly reduce the degree of pass-through (a point that we further stress in the next section with reference to Home inflation). Even though the exchange rate depreciation significantly reduces the Foreign price of Home goods at the dock, the price of imports faced by Foreign consumers and firms only reflects a small fraction of such a lower price. Adding LCP mutes the pass-through of the exchange rate depreciation onto the dock price. In this case, the additional effect of Foreign importers is that the (the minority of) firms that update their price do not cut their prices much. Thus, the pure effect of US importers conditional on LCP being present is also relatively small.

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 Imperfect Pass-Through and the Response of Inflation

From the perspective of monetary policy stabilization, the response of 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,

Figure 6: The role of imperfect pass-through in the Home country.



NOTE: The figure displays the impulse responses of real GDP, exports, CPI inflation, nominal 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 reported in annualized terms.

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. Yet, the dynamics of inflation have received relatively little attention in the literature.

Our evidence suggests that the response of inflation to a contractionary foreign monetary policy shock is very muted and not statistically significant in small open economies with the highest degree of exchange rate flexibility. This result is consistent with the 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.[26]

Figure 6 shows that imperfect pass-through in the Home country, due to the presence of infrequent price adjustment among Home importers, plays a key role in aligning the model with the evidence for the response of inflation, above and beyond the contribution of the 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

[26] 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.

the law of one price holds at the retail level in the Home country. In this variant of the model, Home importers are perfectly competitive firms that deliver foreign goods to final consumers and firms 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 200 basis points in annualized terms, compared to 10 in the baseline. Without pricing frictions on importers, the exchange rate pass-through on impact is full, compared to less than 5% in the baseline.[27] In the counterfactual, the inflation increase forces the central bank to raise the nominal interest rate by a factor of five compared to the baseline formulation of the model.

Without imperfect pass-through, the Foreign monetary policy contraction has no impact effect on GDP, a more negative effect on exports, and causes a larger increase in spreads. Because of the domestic currency depreciation, Foreign goods become significantly more expensive. Therefore, Home consumers and producers cut their demand for imports, which leads to a temporary improvement in GDP relative to the baseline. At the same time, the spike of Home prices depreciates the real exchange rate less than in the baseline case, thus worsening the response of exports. Over time, the tighter monetary policy stance, which is necessary to stabilize inflation, eventually creates an even worse recession than in the baseline, and also explains the additional spreads increase. 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 severe than in the baseline.

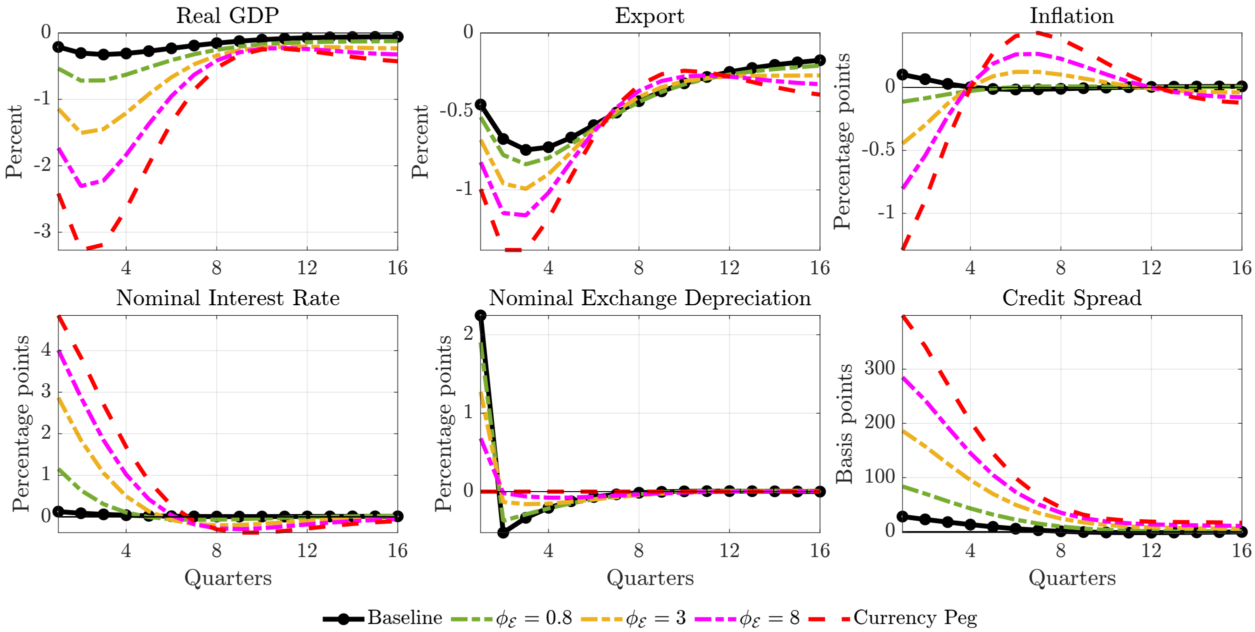
5 Policy Analysis

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 domestic credit or foreign borrowing) affects the volatility of macroeconomic and financial variables induced by foreign monetary policy shocks.[28]

[27] Focusing on the beer market, Goldberg and Hellerstein (2013) find a low degree of exchange rate pass-through, between 5 and 10%, even in the long run.

[28] 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.

Figure 7: Comparing different degrees of exchange rate flexibility.



NOTE: The figure compares the impulse responses of real GDP, exports, CPI inflation, nominal 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 reported in annualized terms.

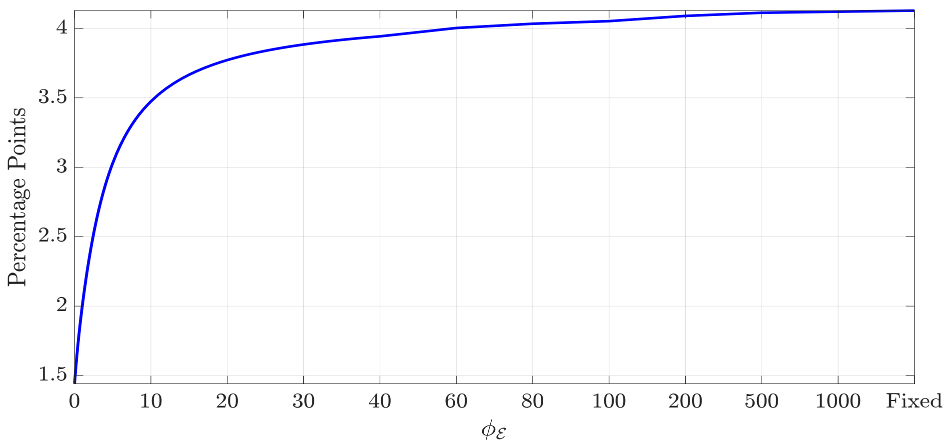
5.1 The Benefits of a Flexible Exchange Rate

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 exacerbating the negative impact of the shock.

Even without full insulation, Figure 7 shows that a flexible exchange rate nevertheless limits macroeconomic volatility compared to a managed float or a peg.[29] 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 7), the central bank of the Home country must increase the nominal interest

[29] 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 ($\phi_{\mathcal{E}} = 0.062$).

Figure 8: Exchange rate flexibility and the UIP wedge.



NOTE: The figure plots the impact response of the UIP wedge in the model as a function of the degree of exchange rate flexibility in the Home country, measured by the size of the coefficient $\phi_{\mathcal{E}}$ in the monetary policy rule (34).

rate to track the monetary policy tightening abroad.

Interestingly, in the model, the Home nominal interest rate increases is much larger than the one in the Foreign country because the response of the UIP wedge is decreasing in the degree of exchange rate flexibility (Figure 8). When the exchange rate does not depreciate, the Home interest rate must increase substantially to make banks indifferent between raising funds via domestic deposits or international interbank markets without violating their incentive compatibility constraint. As a result, domestic financial conditions significantly worsen, with spreads increasing more than tenfold compared to the baseline. Real GDP falls by about 3 percentage points at the trough, compared to about 0.3 percentage points under the baseline regime, in which the exchange rate is nearly fully flexible. The Home country also experiences a decline of inflation (by more than one percentage point), and a larger and more persistent fall in exports compared with the baseline.

Table 3 reports the volatility of real GDP and inflation (in percent) across different exchange regimes and with additional policy instruments (discussed in the next section). The volatility of real GDP and inflation under a peg is much higher than in the baseline.[30]

The impact response of real GDP, the nominal interest rate and credit spreads increases monotonically (in absolute value) with the coefficient on exchange rate depreciation in the monetary policy rule (dashed-dotted magenta, yellow and green lines). If the central bank

[30] Interestingly, the volatility of real GDP and inflation is slightly higher under a fully flexible exchange rate than in the baseline regime. While our analysis has a positive flavor, this result hints at the fact that the optimal non-cooperative monetary policy arrangement may involve some degree of exchange rate targeting. We leave a full exploration of the welfare properties of the model for future research.

Table 3: Exchange rate regimes, policy rules and macroeconomic volatility.

	Policy rules coefficients		Standard deviations	
Regime (additional instrument)	$\phi_{\mathcal{E}}$	ϕ_k or ϕ_b	Real GDP	Inflation
Fully flexible exchange rate	0	0	1.22	0.07
Baseline	0.062	0	1.58	0.05
Baseline + tax on domestic credit (τ_k^{flex})	0.062	-0.05	0.95	0.07
Baseline + tax on foreign borrowing (τ_b^{flex})	0.062	-0.15	0.60	0.32
Peg	∞	0	109.66	8.79
Peg + tax on domestic credit (τ_k^{peg})	∞	-0.05	21.88	5.66
Peg + tax on foreign borrowing (τ_b^{peg})	∞	-0.35	22.46	4.77

NOTE: The table reports the coefficient on the exchange rate depreciation in the Home monetary policy rule (34) (second column), the coefficient in the tax rules (39) or (40) (third column), and the standard deviations of real GDP (fourth column) and inflation (fifth column) expressed in percent, across different exchange rate regimes (first column).

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 displays a smaller response on impact when monetary policy tries to actively stabilize the nominal exchange rate. In the short run, the nominal exchange rate effect dominates over the fall in the Home CPI so that the real exchange rate depreciates less, which explains the further decline in exports relative to the baseline.

Overall, the results in our model are consistent with those in Akinci and Queralto (2024) and 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.[31]

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

[31] Appendix B.11 studies the sensitivity of the results in this section to the share of foreign currency liabilities. With such a high share, macroeconomic volatility increases under the baseline exchange rate regime. Aggressive exchange rate targeting still increases volatility, but the gap between flexible and fixed exchange rates is smaller.

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. A tax on domestic credit, which we denote with τ_t^k, reduces the effective return on loans that accrues to Home banks. A tax on borrowing in foreign currency, which we denote with τ_t^b, increases the cost that banks pay on foreign loans. We focus on the consequences of the introduction of these taxes on Home banks. As a result, their net worth 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 the tax on domestic credit in response to deviations of the credit spread from its steady state value

$$\tau_t^k = \left[\frac{\mathbb{E}_t\left(r_{kt+1} - R_t/\Pi_{t+1}\right)}{r_k - R}\right]^{\phi_k} - 1, \tag{39}$$

and the tax on borrowing in foreign currency in response to deviations of the UIP wedge from its steady state value

$$\tau_t^b = \left[\frac{\mathbb{E}_t(R_t - R_{bt}^* \mathcal{E}_{t+1}/\mathcal{E}_t)}{R - R_b^*}\right]^{\phi_b} - 1, \tag{40}$$

where $\phi_j < 0$ for $j = \{k, b\}$. With this formulation, the additional policy instrument directly targets the potential inefficiencies associated with fluctuations in the value of credit, in the spirit of Borio and Lowe (2002).[32] In the exercises of the next two sections, we assume that the government rebates the tax proceedings lump-sum to households and we choose the coefficient ϕ_j to maximize utility of the Home representative household.[33]

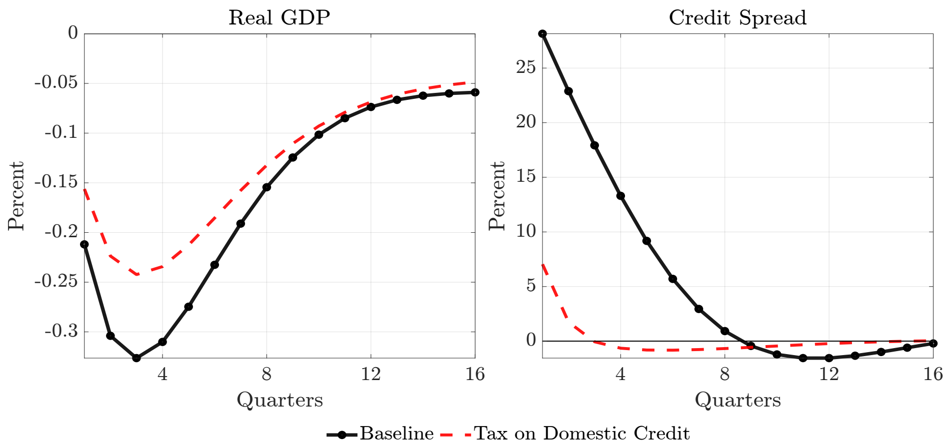
5.2.1 The Effects of a Tax on Domestic Credit

Figure 9 compares the effects of a tax on domestic credit (dashed red line) against the baseline (solid black line). The impulse responses show that the policy is effective in reducing the impact of the Foreign monetary tightening on real GDP. As we can see in Table 3 (row 'Baseline + tax on domestic credit'), the presence of the tax reduces the volatility of real

[32] Appendix C.1 shows that the results in this section are robust to specifying the tax rule in response to deviations of credit from steady state.

[33] 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. The third column of Table 3 reports the value of the coefficients ϕ_j in each case.

Figure 9: The effects of a tax on domestic credit.



NOTE: The figure displays the impulse responses of real GDP 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). Spreads are reported in annualized terms.

GDP by more than 0.6 percentage points, at the expense of a tiny increase in inflation volatility.[34]

The tax on domestic credit directly affects credit spreads

$$\mu_{kt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[(1 - \tau_t^k) r_{kt+1} - \frac{R_t}{\Pi_{t+1}} \right] \right\}. \tag{41}$$

Through this channel, the introduction of this additional instrument mitigates the adverse consequences of financial frictions on economic activity. Since the Foreign monetary policy shock has the effect of contracting domestic credit, the government actually subsidizes domestic banks, compressing spreads by two-third compared to the baseline. As a consequence, real GDP declines less. The presence of this additional policy instrument tilts the monetary policy tradeoff against inflation. Consequently, the policy rate needs to be slightly higher than in the baseline to contain the inflationary consequences of the shock and the tax response.

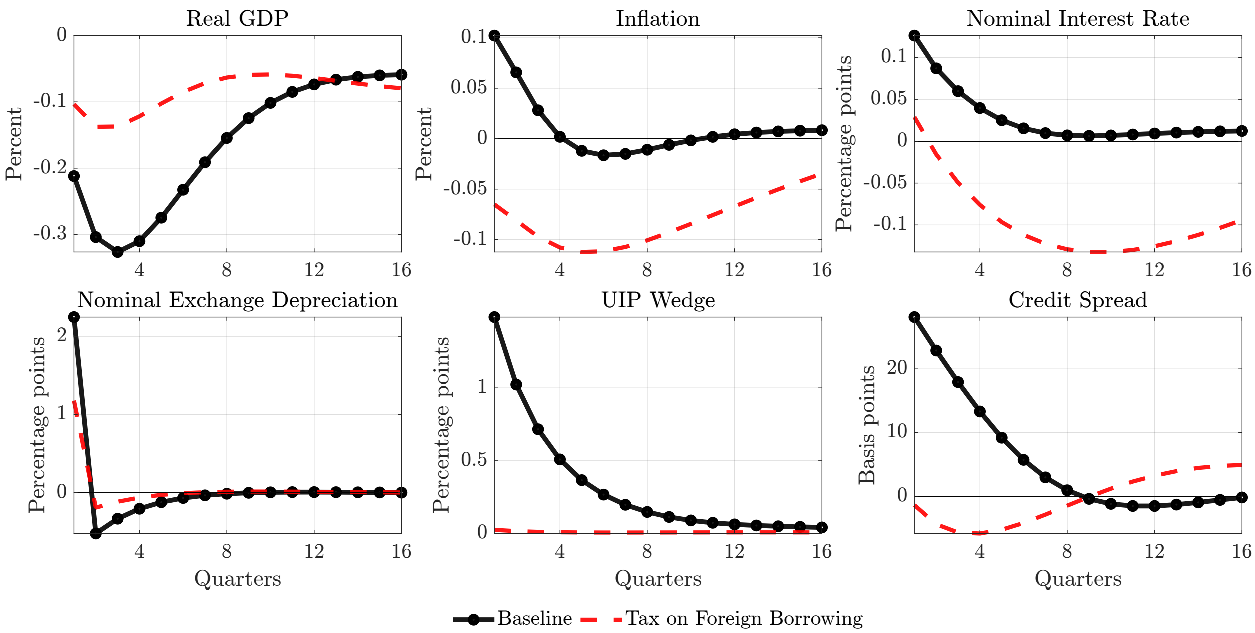
5.2.2 The Effects of a Tax on Foreign Borrowing

Figure 10 compares the effects of a tax on foreign borrowing (dashed red line) against the baseline (solid black line).[35] This instrument is more effective than the tax on domestic

[34] As for inflation, the difference in the impulse responses of exports, interest rates, and the nominal exchange rate across the two policy regimes is negligible. Figure C.1 in Appendix C reports the full set of results.

[35] In this case, we report the response of the UIP wedge (bottom-middle panel), which is central to the transmission mechanism of the policy, instead of exports, which are not significantly different from the

Figure 10: The effects of a tax on foreign borrowing.



NOTE: The figure displays the impulse responses of real GDP, CPI inflation, nominal interest rate, nominal exchange rate depreciation, UIP wedge 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 reported in annualized terms.

credit in reducing the impact of the Foreign monetary policy shock on Home real GDP. Row 'Baseline + tax on foreign borrowing' in Table 3 shows that the volatility of real GDP declines by more than a half compared to the baseline. However, as in the previous case, the volatility of inflation increases, in fact even more substantially.

The tax on foreign borrowing also reduces domestic spreads, albeit indirectly, since this instrument operates by reducing the UIP wedge, which becomes

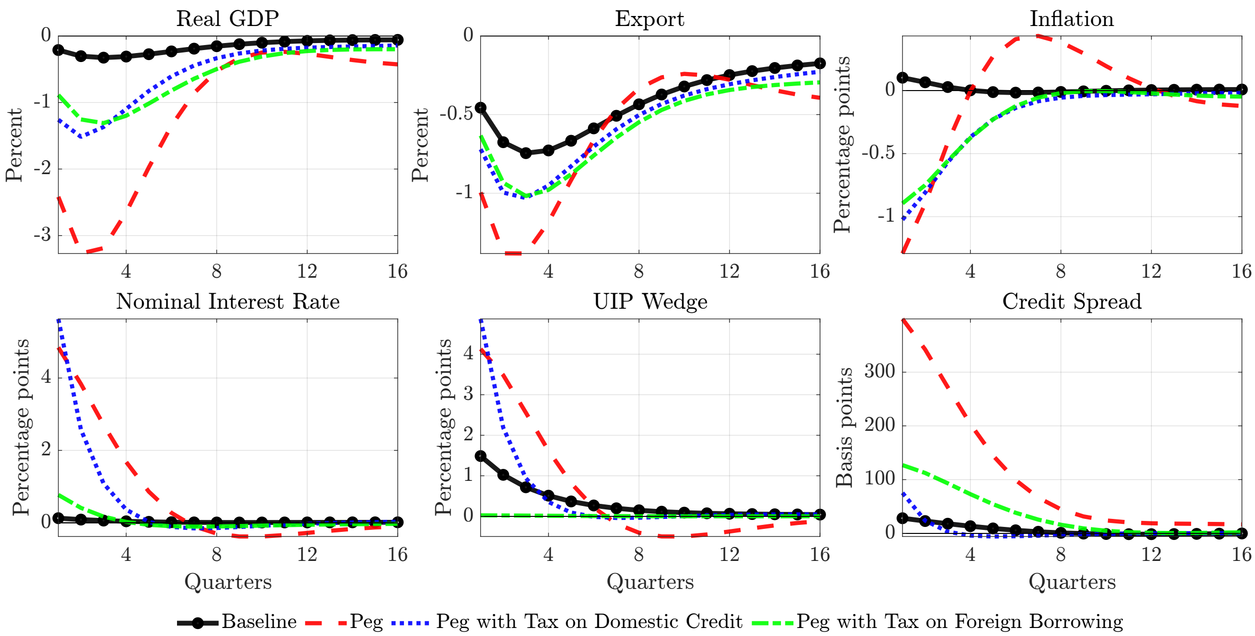
$$\mu_{bt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[\frac{R_{t+1}}{\Pi_{t+1}} - (1 + \tau_t^b) \frac{R_{bt}^*}{\Pi_{t+1}^*} \frac{s_{t+1}}{s_t} \right] \right\}. \tag{42}$$

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. In our quantitative experiment, the subsidy fully closes the UIP wedge, which in turn limits the impact of the shock on the leverage ratio of financial intermediaries (see equation 19) 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 (by about 50%). As a consequence, inflation falls, instead of rising

baseline.

Figure 11: The effects of a tax on domestic credit/foreign borrowing with a peg.



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

as in the baseline, and remains persistently below target. Therefore, the introduction of a tax on foreign borrowing eliminates the tradeoff between inflation and GDP. As inflation declines, the central bank cuts the policy rate, which remains below its steady state value throughout the simulation horizon.

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 11 shows the results. The introduction of a tax on domestic credit (dotted blue line) reduces the volatility of real GDP relative to a peg without the additional instrument by a factor of five (line 'Peg + tax on domestic credit'). The government subsidizes credit so that, on impact, domestic spreads increase by much less and not as persistently.

Despite the gains on the real side, the Home nominal interest rate remains elevated in order to track its Foreign counterpart and a sizable UIP wedge, while inflation is well below target throughout the simulation horizon. As a result, inflation volatility is still high, although less so than under a peg without the additional policy instrument.

Like for the case of the tax on domestic credit, the introduction of a tax on foreign borrowing (dashed-dotted green line in Figure 11) significantly reduces macroeconomic volatility relative to the pure peg. The effects on real GDP, exports and inflation are very similar to the case of a tax on domestic credit, suggesting that the two instruments are close substitutes in this respect. The mechanism of transmission, however, operates through a different channel. By subsidizing foreign borrowing, the government induces financial intermediaries to take advantage of cheaper funding from abroad. As with flexible exchange rates, the tax on foreign borrowing closes the UIP wedge. Domestic spreads increase much less than under a peg alone, although more than with a tax on domestic credit that directly impacts that variable. While the tax effectively restores the UIP condition, the peg implies that the Home interest rate must nonetheless increase together with the Foreign rate. As a result, inflation remains persistently below target and its volatility is only slightly smaller than under a peg with a tax on domestic credit.

6 Conclusions

Monetary policy shocks originating in large financial centers like the US 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 pricing frictions in international trade. 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 bring the response of economic activity close to the case of flexible exchange rates. However, even 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 long as the world remains as financially interconnected as today, the results in this paper should be informative for the design of appropriate policy frameworks that address the international transmission of monetary 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 2020/122.

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

AKINCI, O. AND A. QUERALTO (2024): "Exchange Rate Dynamics and Monetary Spillovers with Imperfect Financial Markets," *Review of Financial Studies*, 37, 309–355.

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 2020/121.

——— (2023): "Integrated Monetary and Financial Policies for Small Open Economies," IMF Working Papers 2023/161.

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.

BODENSTEIN, M., P. CUBA-BORDA, N. GOERNEMANN, AND I. PRESNO (2024): "Exchange Rate Disconnect and the Trade Balance," International Finance Discussion Papers 1391.

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.

CAMARA, S., L. CHRISTIANO, AND H. DALGIC (2025): "The International Monetary Transmission Mechanism," in *NBER Macroeconomics Annual 2024*, ed. by M. Eichenbaum, J. Leahy, and V. Ramey, University of Chicago Press, vol. 39, chap. 2, 65–140.

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

Cesa-Bianchi, A., A. Ferrero, and A. Rebucci (2018): "International Credit Supply Shocks," *Journal of International Economics*, 112, 219–237.

Chen, K., M. Kolasa, J. Lindé, H. Wang, P. Zabczyk, and J. Zhou (2023): "An Estimated DSGE Model for Integrated Policy Analysis," IMF Working Papers 2023/135, International Monetary Fund.

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.

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.

Eichenbaum, M., B. Johannsen, and S. Rebelo (2021): "Monetary Policy and the Predictability of Nominal Exchange Rates," *Review of Economic Studies*, 88, 192–228.

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.

Fukui, M., E. Nakamura, and J. Steinsson (2025): “The Macroeconomic Consequences of Exchange Rate Depreciations,” NBER Working Paper 31279.

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.

——— (2024): “Global Risk and the Dollar,” *Journal of Monetary Economics*, 144, 103549.

Georgiadis, G. and B. Schumann (2021): “Dominant-Currency Pricing and the Global Output Spillovers from US Dollar Appreciation,” *Journal of International Economics*, 133, 103537.

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.

Goldberg, P. and R. Hellerstein (2013): “A Structural Approach to Identifying the Sources of Local Currency Price Stability,” *Review of Economic Studies*, 80, 175–210.

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. (2018): "Monetary Policy Transmission in Emerging Markets: An Application to Chile," in *Monetary Policy and Global Spillovers: Mechanisms, Effects and Policy Measures*, ed. by E. Mendoza, E. Pasten, and D. Saravia, Central Bank of Chile, vol. XXV, 279–324.

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.

Kalemli-Özcan, S. (2019): "U.S. Monetary Policy and International Risk Spillover," in *Proceedings of the Jackson Hole Economic Policy Symposium*, Federal Reserve of Kansas City, 95–191.

Kalemli-Özcan, S. and F. Unsal (2023): "Global Transmission of Fed Hikes: The Role of Policy Credibility and Balance Sheets," *Brookings Papers on Economic Activity*, Fall, 169–235.

Kalemli-Özcan, S. and L. Varela (2023): "Five Facts about the UIP Premium," NBER Working Paper 28923.

Kekre, R. and M. Lenel (2024a): "Exchange Rates, Natural Rates, and the Price of Risk," NBER Working Papers 32976.

——— (2024b): "The Flight to Safety and International Risk Sharing," *American Economic Review*, 114, 1650–1691.

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.

Miranda-Agrippino, S. and H. Rey (2022): "The Global Financial Cycle," in *Handbook of Internatioal Economics*, ed. by G. Gopinath, E. Helpman, and K. Rogoff, North Holland, vol. 6, chap. 1, 1–43.

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.

Paul, P. (2020): "The Time-Varying Effect of Monetary Policy on Asset Prices," *Review of Economics and Statistics*, 102, 690–704.

Pesaran, H. (2015): *Time Series and Panel Data Econometrics*, Oxford University Press.

Pesaran, 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 of the Jackson Hole Economic Policy Symposium*, Federal Reserve Bank of Kansas City, 285–333.

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

Rogers, J., B. Sun, and W. Wu (2025): "Drivers of the Global Financial Cycle," *Journal of International Economics*, forthcoming.

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.

Valchev, R. (2020): "Bond Convenience Yields and Exchange Rate Dynamics," *American Economic Journal: Macroeconomics*, 12, 124–166.

Appendix

A Data and Empirics

A.1 Sample and Data Sources

We consider two alternative country samples to assess robustness.

First, we construct a version of the baseline sample that excludes emerging markets (Chile, Korea, Mexico, Singapore, South Africa, and Thailand) and instead includes ten euro area economies (Austria, Belgium, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain).

Second, we expand the baseline set of small open economies by adding nine major emerging markets (Argentina, Brazil, Colombia, India, Indonesia, Israel, the Philippines, Poland, and Russia), which also feature a high degree of exchange rate flexibility. The inclusion of these countries is based on the following criteria:

1. **Exchange rate regime**: Countries must have relatively flexible exchange rates (classified as floats' or managed floats' in Ilzetzki et al. (2019)). We exclude countries classified as *Freely falling*' or *Dual market in which parallel market data is missing*'.

2. **Sample period**: Countries must have a sufficiently long sample period during which the exchange rate regime is classified as flexible (i.e., the average value in the fine classification of Ilzetzki et al. (2019) over 1997–2019 must exceed 8).

3. **Size**: We exclude very small countries (e.g., Vanuatu has an average value of 10 in the Ilzetzki et al. (2019) classification but is not included in our sample).

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')`, following Miranda-Agrippino and Rey (2020).

- **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')`, following Miranda-Agrippino and Rey (2020).

- **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 VARX

Figures A.1 and A.2 show the impulse responses obtained from estimating our VAR on two alternative samples. The first expands the baseline group of 15 small open economies by adding nine major emerging markets (Argentina, Brazil, Colombia, India, Indonesia, Israel, the Philippines, Poland, and Russia), yielding a total of 24 countries. The second modifies the baseline sample by excluding emerging markets (Chile, Korea, Mexico, Singapore, South Africa, and Thailand) and adding ten Euro Area economies (Austria, Belgium, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain). In both cases, the results are very similar to our baseline.

Figure A.3 reports the impulse responses obtained when we compute the mean group estimator using weighted averages (based on PPP–GDP weights) instead of simple averages. The results are almost identical to our baseline.

Figure A.4 reports the impulse responses obtained when we estimate the VAR with no trend. The results are somewhat more persistent, but remain similar to our baseline.

Figure A.5 reports the impulse responses obtained when we estimate our VAR using a measure of short-term market interest rates instead of the policy rate. The results are very similar to our baseline.

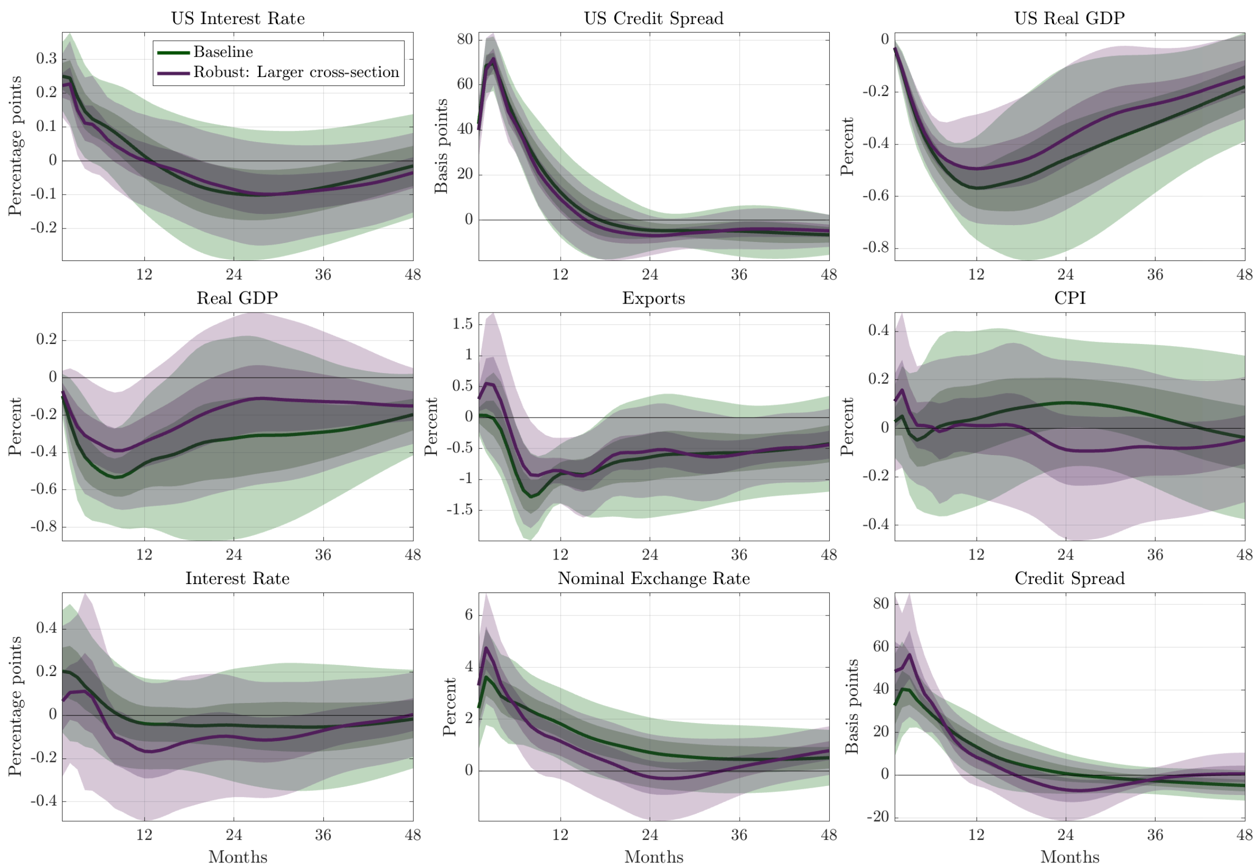
Figure A.6 reports the impulse responses obtained when we estimate our VAR on an extended vector of endogenous variables that includes US CPI. In line with the evidence in Jarocinski and Karadi (2020), we find that a contractionary US monetary policy shock reduces US consumer prices. The responses of the small open economy are essentially unchanged.

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. US interest rates remain above their long-run value and US GDP falls by less. The responses of the 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 after the first period, and that the responses of other variables are not affected.

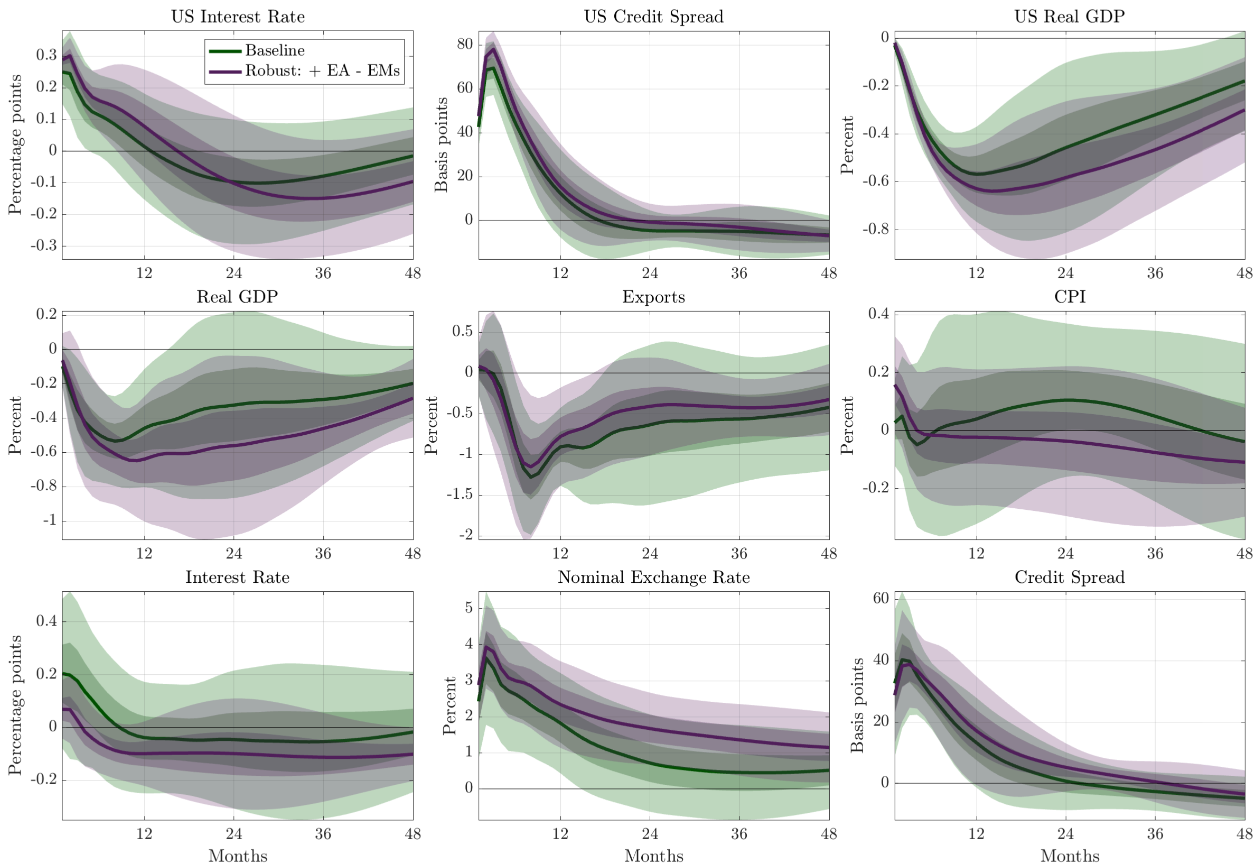
Figure A.9 reports impulse responses from estimating our VAR on a longer sample starting in 1985 (instead of 1997). Since credit spreads outside the US are only available from 1997 onward, we exclude that variable from the vector of endogenous variables. The results remain very similar to our baseline. In this longer sample, we can also assess the robustness of our findings to a richer lag structure. Figure A.10 shows impulse responses from a specification with six lags. The US experiences a slightly larger fall in real GDP, while small open economies see a somewhat milder contraction and smaller depreciation. The responses of the other variables remain very similar to the baseline.

Figure A.1: Robustness with a larger sample of EMs.



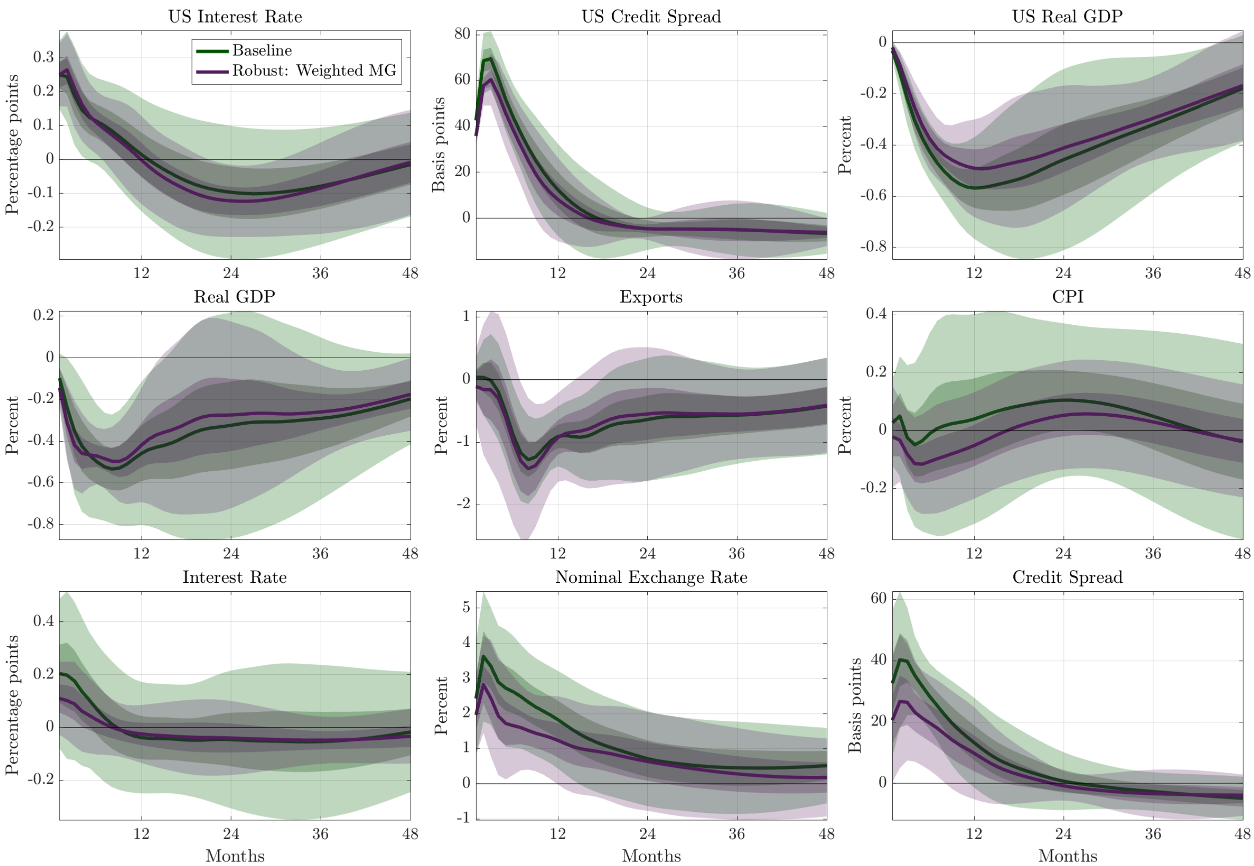
NOTE: The figure displays the impulse responses of the interest rate, credit spreads, and real GDP in the US; and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.2: Robustness excluding EMs and adding Euro Area countries.



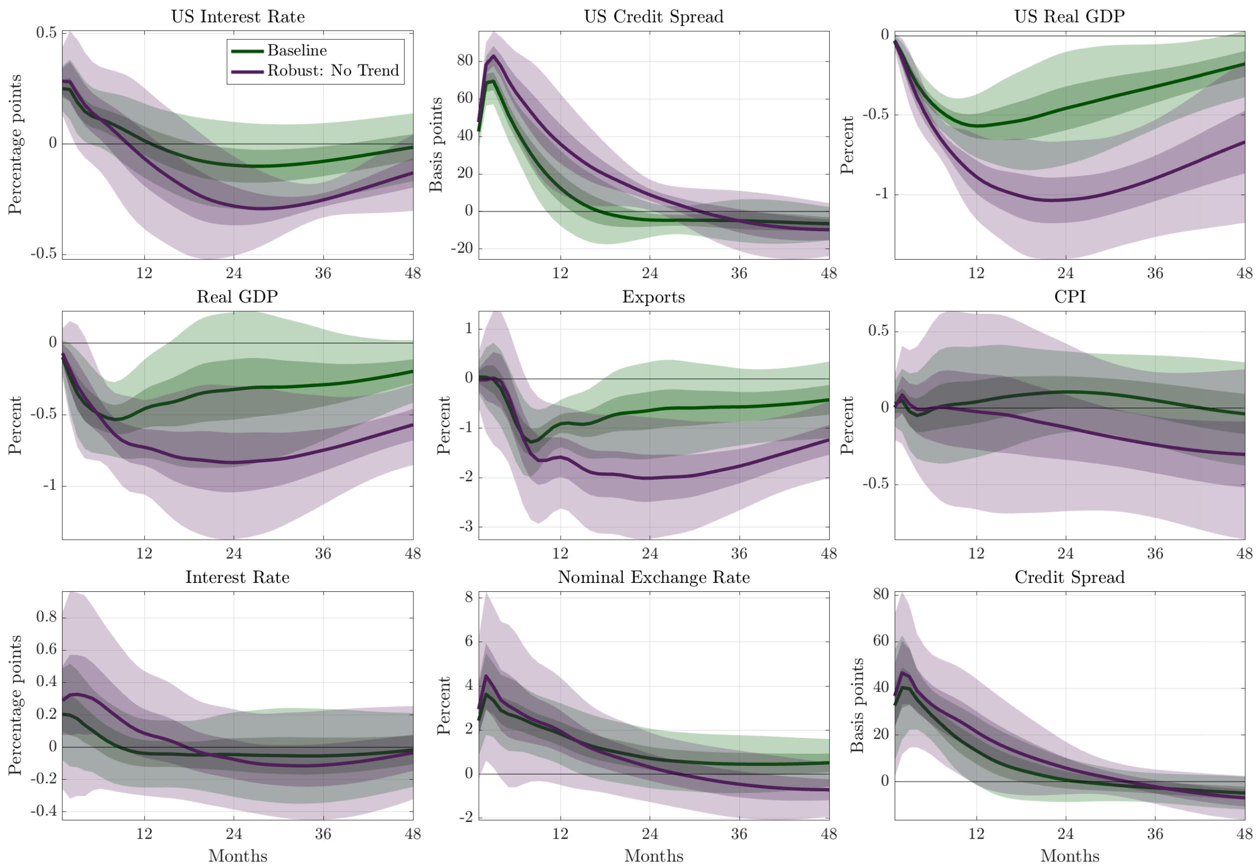
NOTE: The figure displays the impulse responses of the interest rate, credit spreads, and real GDP in the US; and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.3: Robustness with weighted mean group estimator.



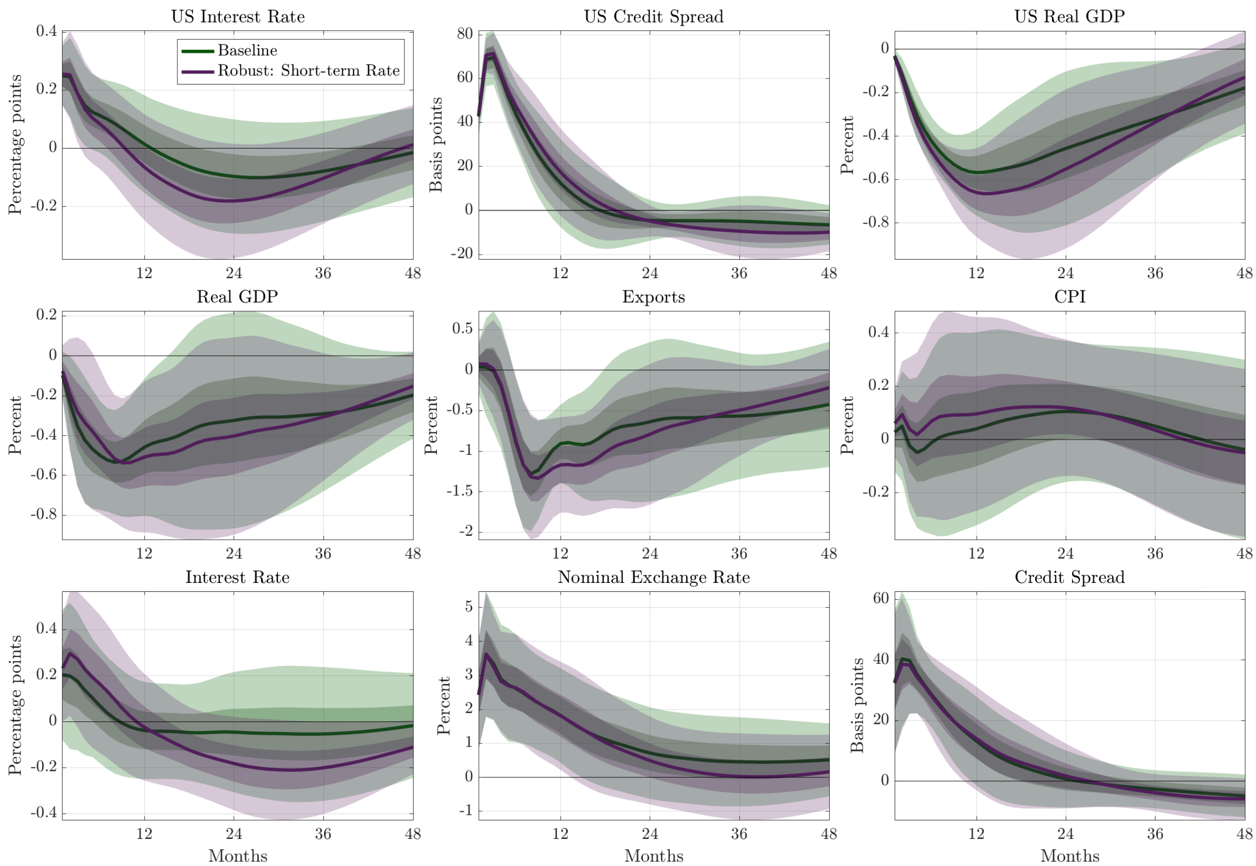
NOTE: The figure displays the impulse responses of the interest rate, credit spreads, and real GDP in the US; and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.4: Robustness with no time trend.



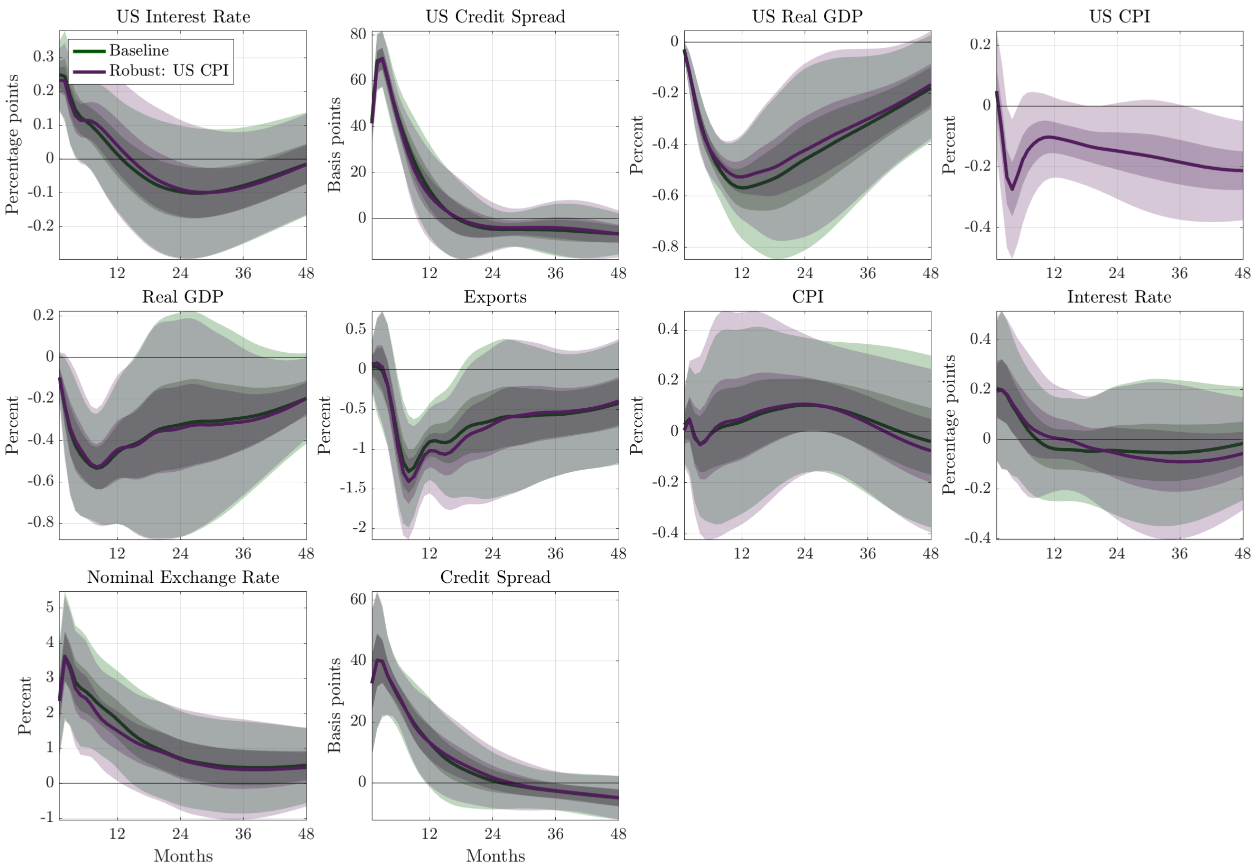
Note: The figure displays the impulse responses of the interest rate, credit spreads, and real GDP in the US; and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.5: Robustness using short-term rates for the small open economies.



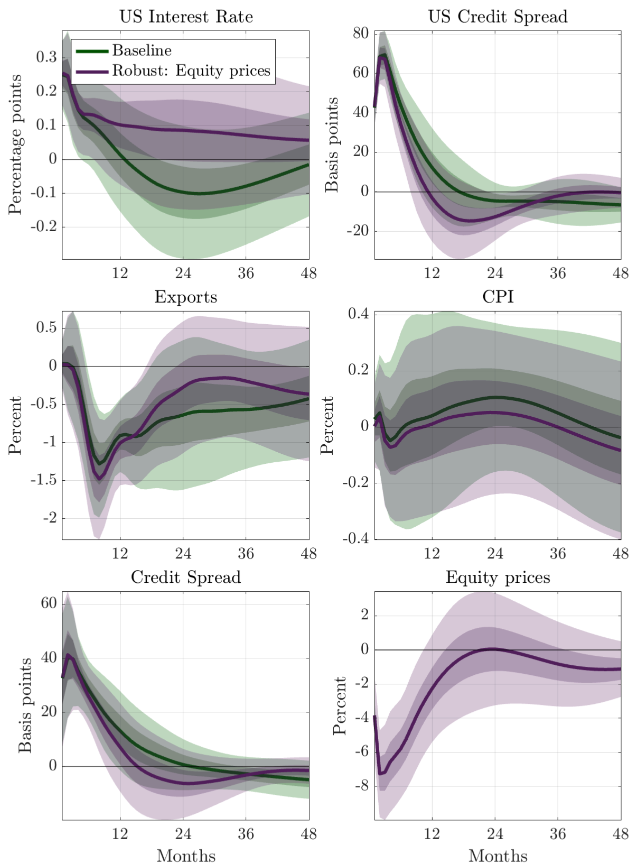
Note: The figure displays the impulse responses of the interest rate, credit spreads, and real GDP in the US; and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.6: Robustness adding US CPI.



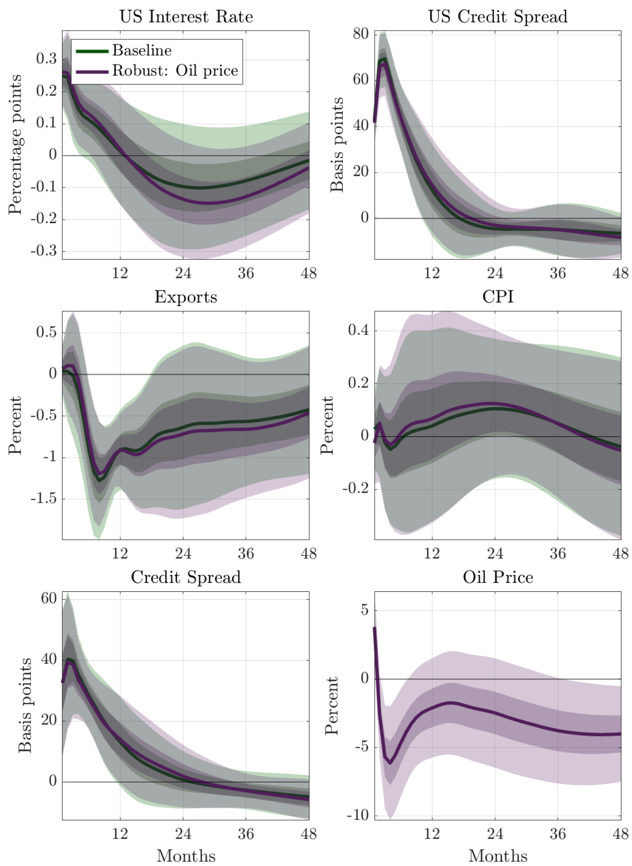
Note: The figure displays the impulse responses of the interest rate, credit spreads, real GDP, and CPI in the US; and of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.7: Robustness controlling for equity prices in the small open economies.



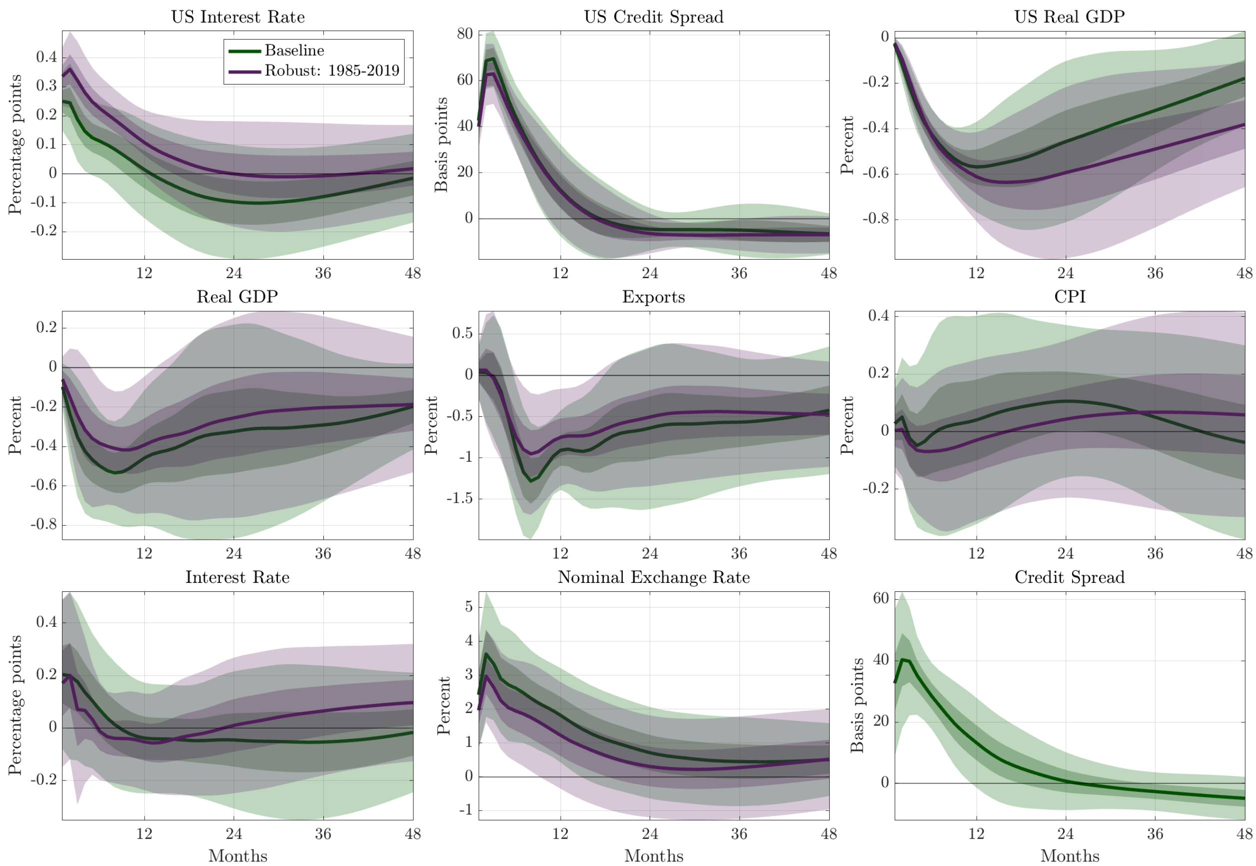
NOTE: The figure displays the impulse responses of the interest rate, credit spreads, and real GDP in the US; and of real GDP, CPI, exports, interest rate, nominal exchange rate, credit spreads, and equity prices in a typical small open economy with a flexible exchange rate regime to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.8: Robustness controlling for oil prices.



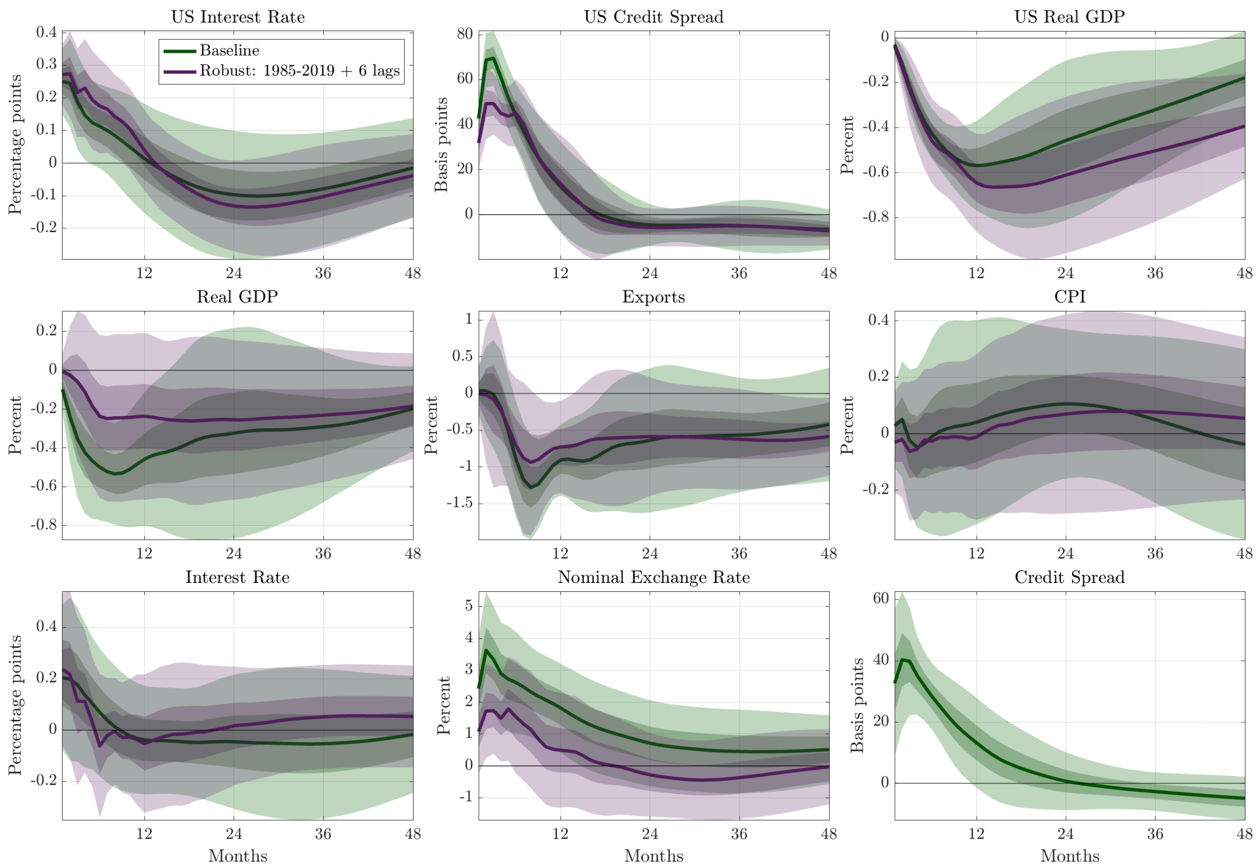
NOTE: The figure displays the impulse responses of the interest rate, credit spreads, and real GDP in the US; of real GDP, CPI, exports, interest rate, nominal exchange rate, and credit spreads in a typical small open economy with a flexible exchange rate regime; and oil prices to a contractionary monetary policy shock in the US. The shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.9: Robustness with longer sample (1985 to 2019) and no credit spreads outside the US.



Note: The figure displays the impulse responses of the interest rate, credit spreads, 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 shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

Figure A.10: Robustness with longer sample (1985 to 2019), 6 lags in the VAR, and no credit spreads outside the US.



NOTE: The figure displays the impulse responses of the interest rate, credit spreads, 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 shock is normalized to generate a 25 basis points increase in the US interest rate. 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 the robustness exercise. The nominal interest rate and spreads are reported in annualized terms.

B Model Derivations

In this section, we report the first-order conditions for households, financial intermediaries, and firms, characterize the steady state of the model, display the prior and posterior densities for the parameter estimation exercise, and show a number of additional quantitative exercises.

B.1 Households

The Euler equation for the Home household is

$$1 = \mathbb{E}_t \left(\mathcal{M}_{t,t+1} \frac{R_t}{\Pi_{t+1}} \right), \tag{A1}$$

where the stochastic discount factor between period t and $t+j$ is

$$\mathcal{M}_{t,t+j} = \beta^j \frac{c_{t+j} - h\bar{c}_{t+j-1}}{c_t - h\bar{c}_{t-1}}.$$

The optimal wage-setting condition is

$$\widetilde{w}_t^{1+\nu\zeta} = \frac{\chi\nu}{\nu-1} \frac{F_{1t}^W}{F_{2t}^W}, \tag{A2}$$

where $\widetilde{w}_t$ is the optimal real wage, which depends on

$$F_{1t}^W = \ell_t^{1+\zeta} w_t^{\nu\zeta} + \beta\xi_w \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \left(\frac{w_{t+1}}{w_t} \right)^{\nu} \Pi_{t+1}^{\nu(1+\zeta)} F_{1t+1}^W \right] \tag{A3}$$

and

$$F_{2t}^W = \ell_t + \beta\xi_w \mathbb{E}_t \left[\mathcal{M}_{t,t+1} \left(\frac{w_{t+1}}{w_t} \right)^{\nu} \Pi_{t+1}^{\nu-1} F_{2t+1}^W \right]. \tag{A4}$$

The aggregate nominal wage level evolves according to

$$W_t = [(1-\xi_w)\widetilde{W}_t^{1-\nu} + \xi_w W_{t-1}^{1-\nu}]^{\frac{1}{1-\nu}}, \tag{A5}$$

which we can rewrite in real terms as

$$w_t = \left[(1-\xi_w)\widetilde{w}_t^{1-\nu} + \xi_w \left(\frac{w_{t-1}}{\Pi_t} \right)^{1-\nu} \right]^{\frac{1}{1-\nu}}. \tag{A6}$$

Alternatively, we can write the wage index to link the optimal reset wage to wage inflation as

$$(1-\xi_w) \left(\frac{\widetilde{W}_t}{W_t} \right)^{1-\nu} + \xi_w \left(\Pi_t^W \right)^{\nu-1} = 1. \tag{A7}$$

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 Home country as $\lambda_t = q_t z_t / n_t$. 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.

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

$$\frac{V(n_t)}{n_t} \equiv \kappa_t = \underbrace{\theta\left(1+\frac{\gamma}{2}x_t^2\right)}_{\equiv\Theta(x_t)}\lambda_t, \tag{A8}$$

where $x_t = s_t b_t^* / (q_t z_t)$. The optimal leverage rate is

$$\lambda_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt} x_t)} \tag{A9}$$

where

$$\mu_{dt} = \mathbb{E}_t\left(\mathcal{M}_{t,t+1}\Omega_{t,t+1}\frac{R_t}{\Pi_{t+1}}\right) \tag{A10}$$

$$\mu_{kt} = \mathbb{E}_t\left[\mathcal{M}_{t,t+1}\Omega_{t,t+1}\left(r_{kt+1} - \frac{R_t}{\Pi_{t+1}}\right)\right] \tag{A11}$$

$$\mu_{bt} = \mathbb{E}_t\left[\mathcal{M}_{t,t+1}\Omega_{t,t+1}\left(\frac{R_t}{\Pi_{t+1}} - \frac{R_{bt}^*}{\Pi_{t+1}^*}\frac{s_{t+1}}{s_t}\right)\right], \tag{A12}$$

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

The optimal proportion of foreign currency debt is given by

$$x_t = \frac{1}{\mu_t}\left(\sqrt{1+\frac{2\mu_t^2}{\gamma}} - 1\right), \tag{A13}$$

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

The aggregate balance sheet is

$$q_t z_t = d_t + s_t b_t^* + n_t, \tag{A14}$$

while aggregate net worth evolves according to

$$n_t = (\omega + \xi_b) r_{kt} q_{t-1} z_{t-1} - \omega\left(\frac{R_{t-1}d_{t-1}}{\Pi_t} + \frac{s_t R_{bt-1}^* b_{t-1}^*}{\Pi_t^*}\right), \tag{A15}$$

where ξ_b is the proportion of total assets that the household transfers to new bankers.

The solution for Foreign banks is similar. In this case, the leverage ratio of a typical Foreign bank is $\lambda_t^* = (q_t^* z_t^* + b_t^*)/n_t^*$, 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

$$\mathbb{E}_t(\mathcal{M}_{t,t+1}^* \Omega_{t,t+1}^* r_{kt+1}^*) = \mathbb{E}_t \left(\mathcal{M}_{t,t+1}^* \Omega_{t,t+1}^* \frac{R_{bt}^*}{\Pi_{t+1}^*} \right), \tag{A16}$$

where

$$\Omega_{t,t+1}^* = \mathbb{E}_t(1 - \omega + \omega \kappa_{t+1}^*) \tag{A17}$$

and

$$\kappa_t^* = \frac{V(n_t^*)}{n_t^*}. \tag{A18}$$

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

$$\kappa_t^* = \theta^* \lambda_t^*, \tag{A19}$$

which implies

$$\lambda_t^* = \frac{\mu_{dt}^*}{\theta^* - \mu_{kt}^*} \tag{A20}$$

where

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

and

$$\mu_{kt}^* = \mathbb{E}_t \left[\mathcal{M}_{t,t+1}^* \Omega_{t,t+1}^* \left(r_{kt+1}^* - \frac{R_t^*}{\Pi_{t+1}^*} \right) \right] \tag{A22}$$

The aggregate balance sheet of the Foreign banking sector is

$$q_t^* z_t^* + b_t^* = d_t^* + n_t^*, \tag{A23}$$

while aggregate net worth evolves such that

$$n_t^* = (\omega + \xi_b^*) \left(r_{kt}^* q_{t-1}^* z_{t-1}^* + \frac{R_{bt-1}^* b_{t-1}^*}{\Pi_t^*} \right) - \omega \frac{R_{t-1}^* d_{t-1}^*}{\Pi_t^*}. \tag{A24}$$

B.3 Intermediate Goods Producers

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

$$q_t z_t = q_t k_t. \tag{A25}$$

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

$$w_t = (1-\alpha)(1-\varpi)^{1/\vartheta}\frac{A_t p_{mt}}{\ell_t}\left(\frac{y_t}{A_t}\right)^{1/\vartheta}(k_{t-1}^{\alpha}\ell_t^{1-\alpha})^{\frac{\vartheta-1}{\vartheta}}, \tag{A26}$$

$$r_{kt} = \frac{\alpha(1-\varpi)^{1/\vartheta}\frac{A_t p_{mt}}{k_{t-1}}(\frac{y_t}{A_t})^{1/\vartheta}(k_{t-1}^{\alpha}\ell_t^{1-\alpha})^{\frac{\vartheta-1}{\vartheta}} + (1-\delta)q_t}{q_{t-1}}, \tag{A27}$$

and

$$p_{Ft} = \varpi^{1/\vartheta}A_t p_{mt}\left(\frac{y_t}{A_t}\right)^{1/\vartheta}x_t^{-\frac{1}{\vartheta}}. \tag{A28}$$

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

$$p_{mt} = \left\{(1-\varpi)\left[\frac{[q_{t-1}r_{kt}-(1-\delta)q_t]^{\alpha}\, w_t^{1-\alpha}}{A_t\alpha^{\alpha}(1-\alpha)^{1-\alpha}}\right]^{1-\vartheta} + \varpi\left(\frac{p_{Ft}}{A_t}\right)^{1-\vartheta}\right\}^{\frac{1}{1-\vartheta}}. \tag{A29}$$

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

$$q_t = 1 + \frac{\varphi_i}{2}\left(\frac{i_t}{i_{t-1}}-1\right)^2 + \varphi_i\left(\frac{i_t}{i_{t-1}}-1\right)\frac{i_t}{i_{t-1}} - \varphi_i\mathbb{E}_t\left[\mathcal{M}_{t,t+1}\left(\frac{i_{t+1}}{i_t}-1\right)\frac{i_{t+1}^2}{i_t^2}\right], \tag{A30}$$

and the capital accumulatation equation is

$$k_t = i_t + (1-\delta)k_{t-1}. \tag{A31}$$

The problem for capital producers in the Foreign country yields a similar first-order condition for the price of capital.

B.5 Final Goods Producers

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

$$\frac{\widetilde{P}_t(h)}{P_{Ht}} = \frac{\mathcal{H}_{1t}}{\mathcal{H}_{2t}} \tag{A32}$$

where

$$\mathcal{H}_{1t} = \left(\frac{\varrho}{\varrho - 1}\right) p_{mt} y_{Ht} + \beta \xi_p \mathbb{E}_t (\mathcal{M}_{t,t+1} \Pi_{Ht+1}^{\varrho} \mathcal{H}_{1t+1}) \tag{A33}$$

$$\mathcal{H}_{2t} = p_{Ht} y_{Ht} + \beta \xi_p \mathbb{E}_t (\mathcal{M}_{t,t+1} \Pi_{Ht+1}^{\varrho} \mathcal{H}_{2t+1}), \tag{A34}$$

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 domestic inflation is

$$\xi_p \Pi_{Ht}^{\varrho - 1} + (1 - \xi_p) \left[\frac{\widetilde{P}_t(h)}{P_{Ht}} \right]^{1-\varrho} = 1. \tag{A35}$$

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

$$\frac{\widetilde{P}_t^{im*}(h)}{P_t^{im*}} = \frac{\mathcal{F}_{1t}}{\mathcal{F}_{2t}}, \tag{A36}$$

where

$$\mathcal{F}_{1t} = \left(\frac{1-n}{n}\right) \left(\frac{\varrho}{\varrho - 1}\right) p_{mt} y_{Ht}^* + \beta \xi_p \mathbb{E}_t [\mathcal{M}_{t,t+1} (\Pi_{t+1}^{im*})^{\varrho} \mathcal{F}_{1t+1}] \tag{A37}$$

$$\mathcal{F}_{2t} = \left(\frac{1-n}{n}\right) s_t p_t^{im*} y_{Ht}^* + \beta \xi_p \mathbb{E}_t \left[\mathcal{M}_{t,t+1} (\Pi_{t+1}^{im*})^{\varrho - 1} \mathcal{F}_{2t+1} \right], \tag{A38}$$

with

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

In this case, the link between the optimal reset price and the inflation rate that Foreign importers face is

$$\xi_p \left(\Pi_t^{im*} \right)^{\varrho - 1} + (1 - \xi_p) \left[\frac{\widetilde{P}_t^{im*}(h)}{P_t^{im*}} \right]^{1-\varrho} = 1. \tag{A39}$$

The last equation implies that the relative price of imports for Foreign importers obeys

$$(p_t^{im*})^{1-\varrho} = \xi_p \left[\frac{p_{t-1}^{im*}}{\Pi_t^*} \right]^{1-\varrho} + (1 - \xi_p) \left[\frac{\widetilde{P}_t^{im*}(h)}{P_t^*} \right]^{1-\varrho}. \tag{A40}$$

Foreign final goods producers do not discriminate depending on the market of destination. Thus, the firms that reset their price at time t only choose $\widetilde{P}_t^*(f)$.

B.5.1 Importers

Importers who adjust their price at time t set

$$\frac{\widetilde{P}_t(f)}{P_{Ft}} = \frac{\mathcal{I}_{1t}}{\mathcal{I}_{2t}}, \tag{A41}$$

where

$$\mathcal{I}_{1t} = \left(\frac{1-n}{n}\right)\left(\frac{\varrho}{\varrho-1}\right) p_t^{im} y_{Ft} + \beta\xi_{im}\mathbb{E}_t(\mathcal{M}_{t,t+1}\Pi_{Ft+1}^{\varrho}\mathcal{I}_{1t+1}) \tag{A42}$$

$$\mathcal{I}_{2Ft} = \left(\frac{1-n}{n}\right) p_{Ft} y_{Ft} + \beta\xi_{im}\mathbb{E}_t(\mathcal{M}_{t,t+1}\Pi_{Ft+1}^{\varrho}\mathcal{I}_{2t+1}), \tag{A43}$$

with

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

The link between the optimal reset price of Foreign goods and the inflation rate that Home consumers and firms face is

$$\xi_{im}\Pi_{Ft}^{\varrho-1} + (1-\xi_{im})\left[\frac{\widetilde{P}_t(f)}{P_{Ft}}\right]^{1-\varrho} = 1. \tag{A44}$$

A similar set of conditions apply to Foreign importers.

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

$$p_{Ht}^{\epsilon-1} = a + (1-a)\mathcal{T}_t^{1-\epsilon}, \tag{A45}$$

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

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

$$(p_{Ft}^*)^{\epsilon-1} = a^*\left(\frac{\psi_t}{\psi_t^*\mathcal{T}_t}\right)^{1-\epsilon} + (1-a^*), \tag{A46}$$

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

$$a p_{Ht}^{1-\epsilon} + (1-a)p_{Ft}^{1-\epsilon} = 1, \tag{A47}$$

while the link between CPI inflation and domestic inflation is

$$\frac{\Pi_{Ht}}{\Pi_t} = \frac{p_{Ht}}{p_{Ht-1}}. \tag{A48}$$

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

$$s_t^{1-\epsilon} = \frac{a^* \psi_t^{1-\epsilon} + (1-a^*)(\psi_t^* \mathcal{T}_t)^{1-\epsilon}}{a + (1-a)\mathcal{T}_t^{1-\epsilon}}. \tag{A49}$$

B.7 Monetary Policy

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

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_R} \left[\Pi_t^{\phi_\pi} \left(\frac{y_t}{y_{t-1}}\right)^{\phi_y} \left(\frac{\mathcal{E}_t}{\mathcal{E}_{t-1}}\right)^{\phi_\mathcal{E}}\right]^{1-\rho_R}. \tag{A50}$$

In the baseline analysis, we estimate $\phi_\mathcal{E}$. We change the value of $\phi_\mathcal{E}$ in some of the counterfactual experiments.

The interest rate rule in the Foreign country is

$$\frac{R_t^*}{R^*} = \left(\frac{R_{t-1}^*}{R^*}\right)^{\rho_R} \left[(\Pi_t^*)^{\phi_\pi} \left(\frac{y_t^*}{y_{t-1}^*}\right)^{\phi_y}\right]^{1-\rho_R} e^{\epsilon_{Rt}^*}, \tag{A51}$$

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

$$y_t = \Delta_{Ht} y_{Ht} + \left(\frac{1-n}{n}\right) \Delta_{Ht}^* y_{Ht}^*, \tag{A52}$$

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

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

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

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

and

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

The market clearing condition for the Foreign country is

$$y^*_t = \Delta^*_{Ft}y^*_{Ft} + \Delta_{Ft}\frac{n}{1-n}y_{Ft}$$

where

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

and the indices of price dispersion evolve according to

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

and

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

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

$$b^*_t = \frac{R^*_{bt-1}b^*_{t-1}}{\Pi^*_t} + p^*_{Ft}y_{Ft} - \left(\frac{1-n}{n}\right)p^*_{Ht}y^*_{Ht}. \tag{A53}$$

B.9 Steady State

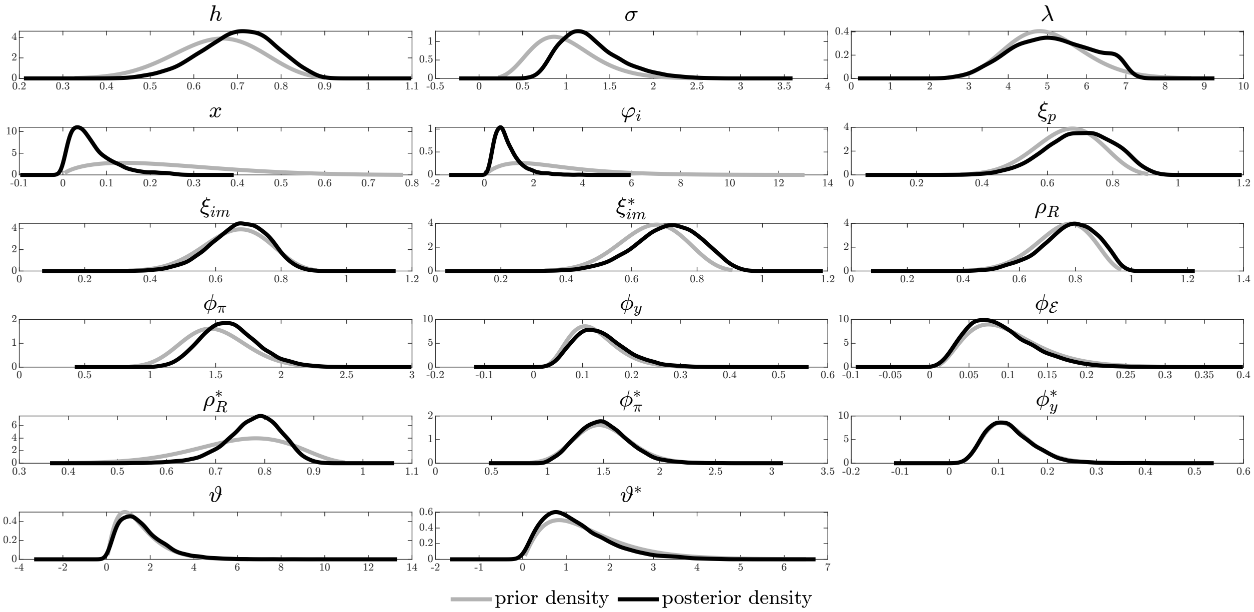
We approximate the model around a non-stochastic steady state with zero inflation in both countries and relative prices normalized to one. As a consequence, also steady state price dispersion is equal to one.

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 $b^* = xk$.[36] The aggregate balance sheet of banks

[36] 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

Figure B.1: 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 parameters in both countries (ξ_{im} and ξ^*_{im}), the parameters in the monetary policy rules of both countries (ρ_R, ϕ_π, ϕ_y, $\phi_{\mathcal{E}}$, and their Foreign counterparts except for $\phi^*_{\mathcal{E}}$ which we assume to be equal to zero), and the elasticities of substitution between intermediate inputs and other inputs (ϑ and ϑ^*).

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.

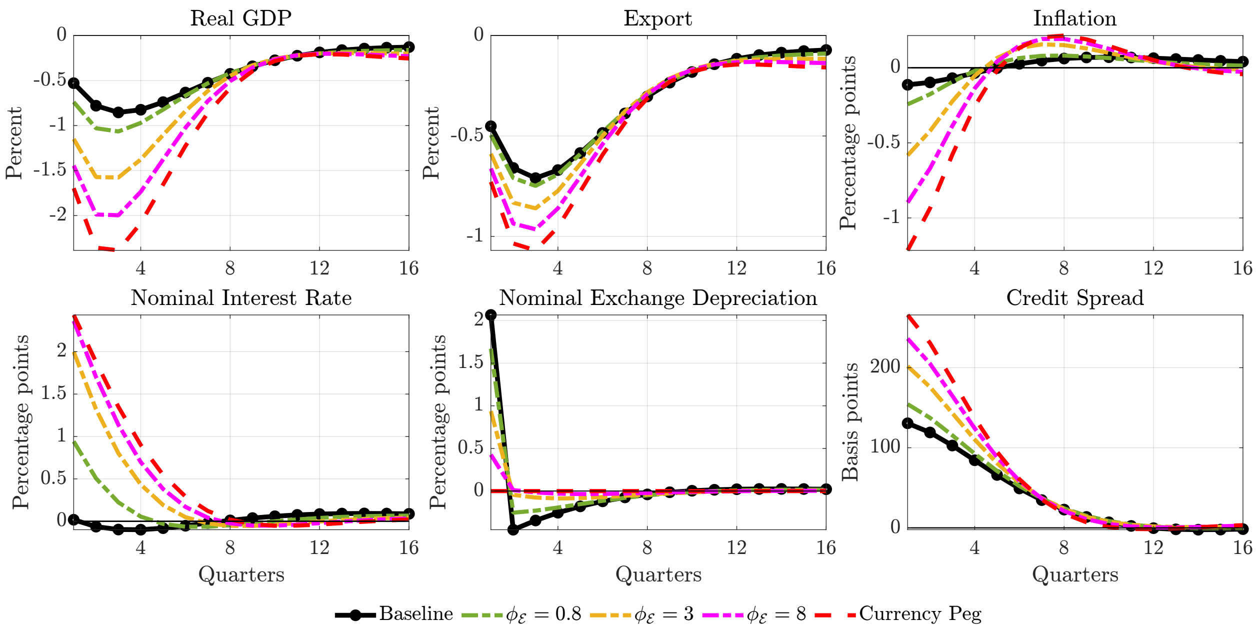
Finally, the demand equations and the market clearing conditions determine the quantities c_h, c^*_h, c_f, c^*_f, y_h, y^*_h, y_f, y^*_f, c and c^*.

B.10 Prior and Posterior Densities

We estimate some of the model's parameters by minimizing the distance between the model-implied impulse responses to a Foreign monetary policy shock and the impulse responses of the VAR presented in section 2 for the typical small open economy (the mean group estimates). Figure B.1 reports the prior and posterior densities of the estimation exercise.

choice.

Figure B.2: Managed nominal exchange rate with high share of FX liabilities.



NOTE: The figure compares the impulse responses of real GDP, exports, CPI inflation, nominal interest rate, nominal exchange rate depreciation and credit spreads in the Home country with a high share of foreign currency liabilities 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 reported in annualized terms.

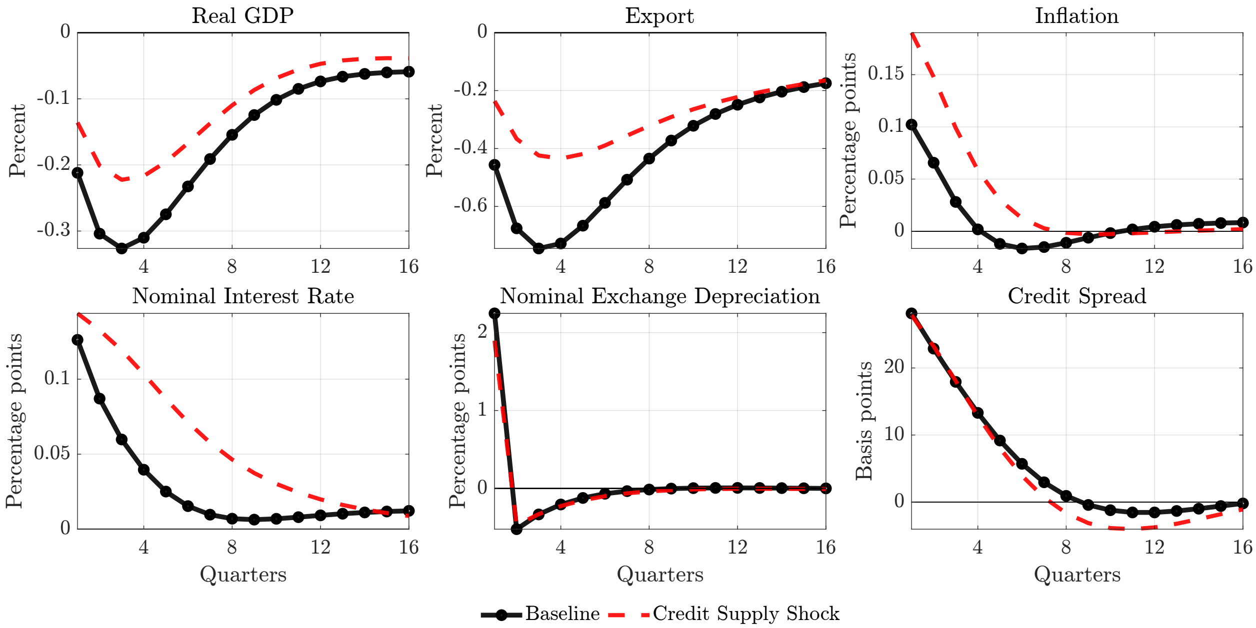
B.11 High Share of FX Liabilities

In this section, we study the sensitivity of our results regarding the transmission of Foreign monetary policy shocks under different exchange rate regimes to the share of foreign currency liabilities in the Home country.

The small estimated share of foreign currency liability (2% at the posterior mode and just above 5% at the posterior median) implies that the benefits of a stable exchange rate in terms of balance sheet mismatch are negligible relative to the costs of losing monetary policy independence for domestic stabilization.

Figure B.2 repeats the comparison across different degrees of exchange rate targeting in section 5.1 with a higher share of foreign currency liabilities ($x = 0.5$). With a more significant currency mismatch, the exchange rate depreciation associated with the Foreign monetary policy contraction leads to a larger response of Home spreads and a deeper recession. The policy implication is that exchange rate stability is relatively more desirable. While a more aggressive exchange rate targeting still increases macroeconomic volatility, the gap with the baseline regime of quasi-flexibility is notably smaller (about 150 basis points in real GDP space at the trough, compared to almost 300

Figure B.3: The response to a Foreign credit supply shock.



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

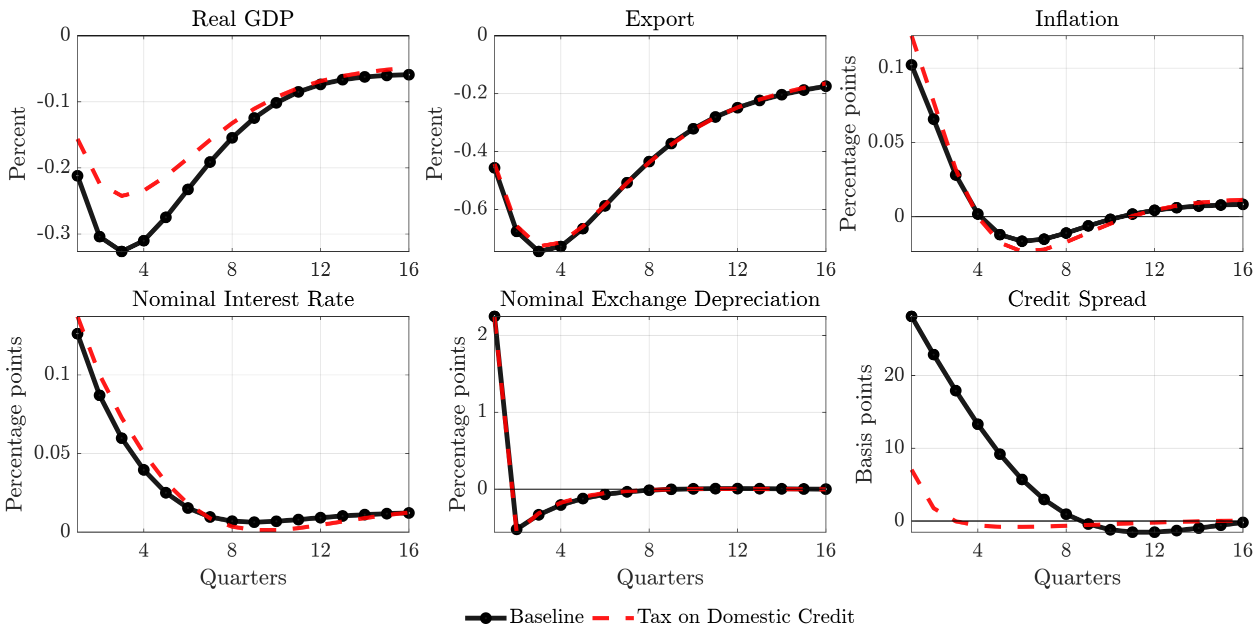
with a low share of foreign currency liabilities).

B.12 Foreign Credit Shocks

The empirical literature has analyzed other potential drivers of the GFC besides monetary policy (see Miranda-Agrippino and Rey, 2022, for a survey). Rogers et al. (2025) run a horse race among several potential candidates and find an important role for financial shocks, such as those to the excess bond premium (Gilchrist and Zakrajsek, 2012) or to leverage of US brokers-dealers (Cesa-Bianchi et al., 2018).

Figure B.3 compares the response of the same Home country variables that we study in the rest of the paper to a credit supply shock in the Foreign country (dashed red line) to the baseline exercise (solid black line). The credit supply shock corresponds to an unexpected increase of the parameter that governs the tightness of the financial friction for Foreign banks (θ^*), which in this exercise is assumed to follow an AR(1) process in log-deviations from steady state. We calibrate the size of the credit supply shock and its persistence to match the dynamic response of Home credit spreads to the monetary policy shock. As the figure shows, the credit supply shock causes a similar depreciation of the exchange rate. The response of real GDP and exports is also qualitatively similar, albeit somewhat smaller quantitatively. Conversely, inflation increases by more, which requires a stronger and, especially, more persistent increase of the domestic interest rate. In spite of these quantitative

Figure C.1: The effects of a tax on domestic credit (baseline specification, all variables).



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 reported in annualized terms.

differences, the bottom line is that our model can generate a GFC also conditional on credit supply shocks in the Foreign country.

C 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 (16) subject to the balance sheet constraint (13), the incentive compatibility constraint (17), and the evolution of net worth with taxes as defined by (38).

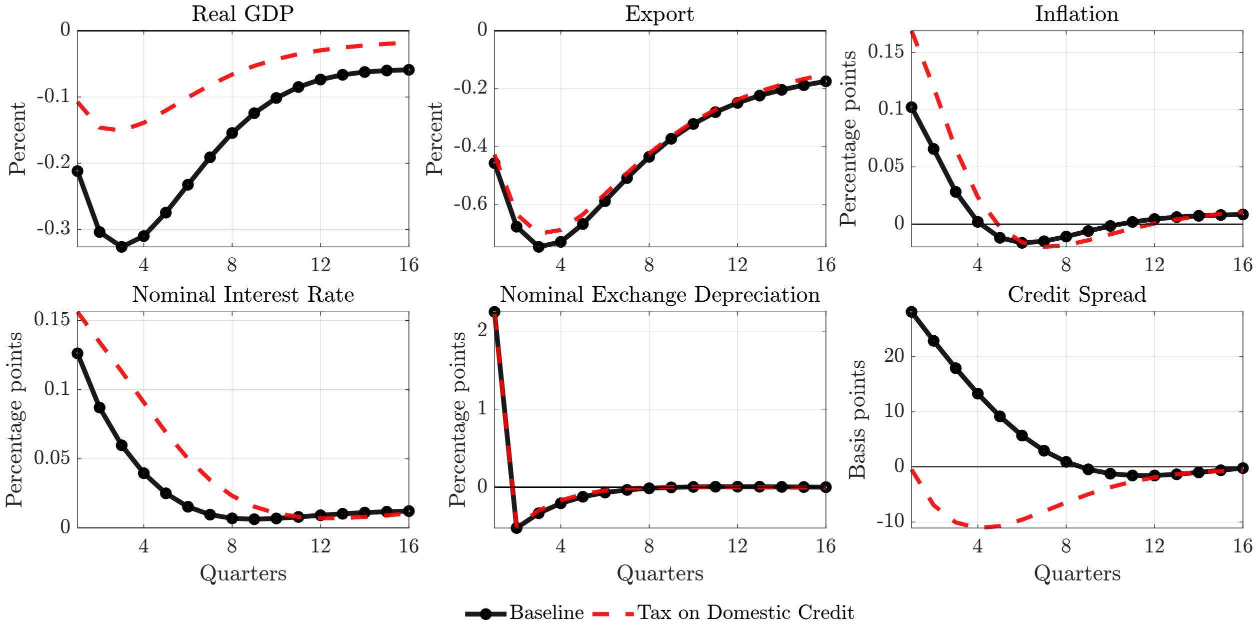
Similar to the optimality condition to the banks' problem without taxes, the leverage ratio is

$$\lambda_t = \frac{\mu_{dt}}{\Theta(x_t) - (\mu_{kt} + \mu_{bt} x_t)}. \tag{A1}$$

However, μ_{bt} in this case becomes

$$\mu_{bt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[\frac{R_t}{\Pi_{t+1}} - (1 + \tau_t^b) \frac{R_{bt}^*}{\Pi_{t+1}^*} \frac{s_{t+1}}{s_t} \right] \right\}, \tag{A2}$$

Figure C.2: The effects of a tax on domestic credit (alternative specification).



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 reported in annualized terms. The coefficient that maximizes welfare for the representative household in the tax feedback rule is $\phi_k^{\text{flex}} = 3.8$.

and μ_{kt} becomes

$$\mu_{kt} = \mathbb{E}_t \left\{ \mathcal{M}_{t,t+1} \Omega_{t,t+1} \left[(1 - \tau_t^k) r_{kt+1} - \frac{R_t}{\Pi_{t+1}} \right] \right\}. \tag{A3}$$

The equations for μ_{dt} and x_t are identical to those for banks without the taxes, which are described by (20) and (23), respectively.

Finally, the aggregate net worth evolves according to

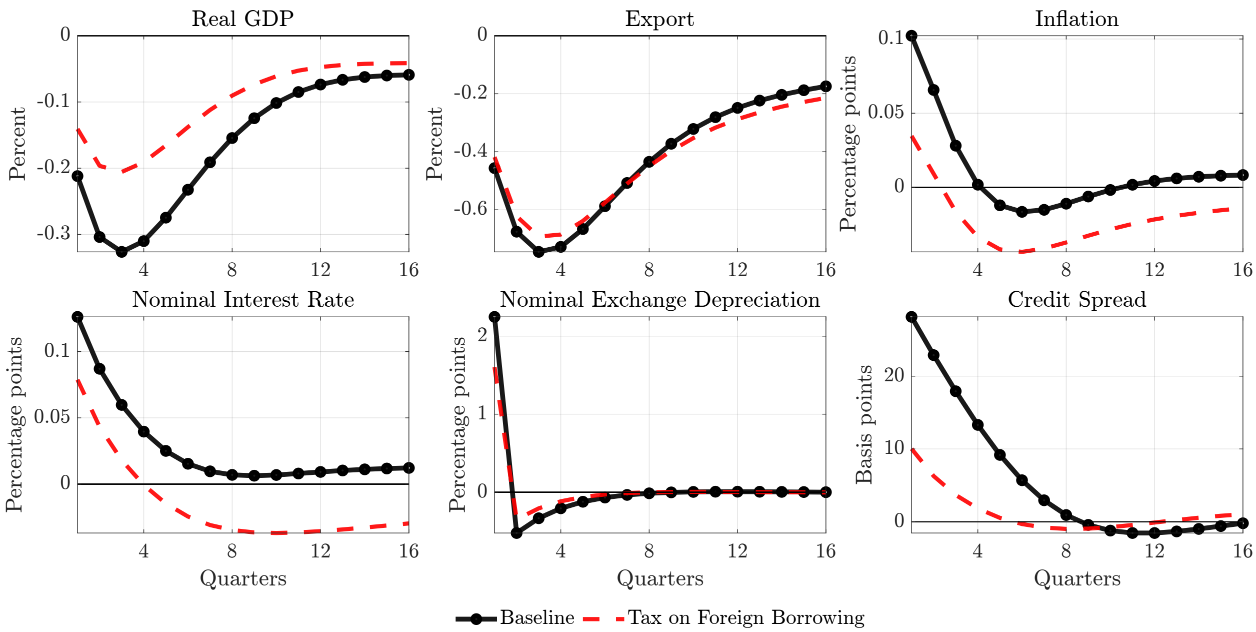
$$n_t = (\omega + \xi_b) r_{kt} q_{t-1} z_{t-1} - \omega \tau_{t-1}^k r_{kt} q_{t-1} z_{t-1} - \omega \left[\frac{R_{t-1} d_{t-1}}{\Pi_t} + \frac{(1 + \tau_{t-1}^b) R_{bt-1}^* s_t b_{t-1}^*}{\Pi_t^*} \right]. \tag{A4}$$

Figure C.1 reports the full set of results for the case in which we introduce a tax on domestic credit with the baseline exchange rate regime.

C.1 Alternative Specification of the Tax Rules

In this section, we show the results from introducing a tax on either domestic credit or foreign borrowing with a different specification for the policy rule. In particular, we assume that the government in country H sets both taxes in response to deviations of the value of credit from

Figure C.3: The effects of a tax on foreign borrowing (alternative specification).



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 reported in annualized terms. The coefficient that maximizes welfare for the representative household in the tax feedback rule is $\phi_b^{\text{flex}} = 0.5$.

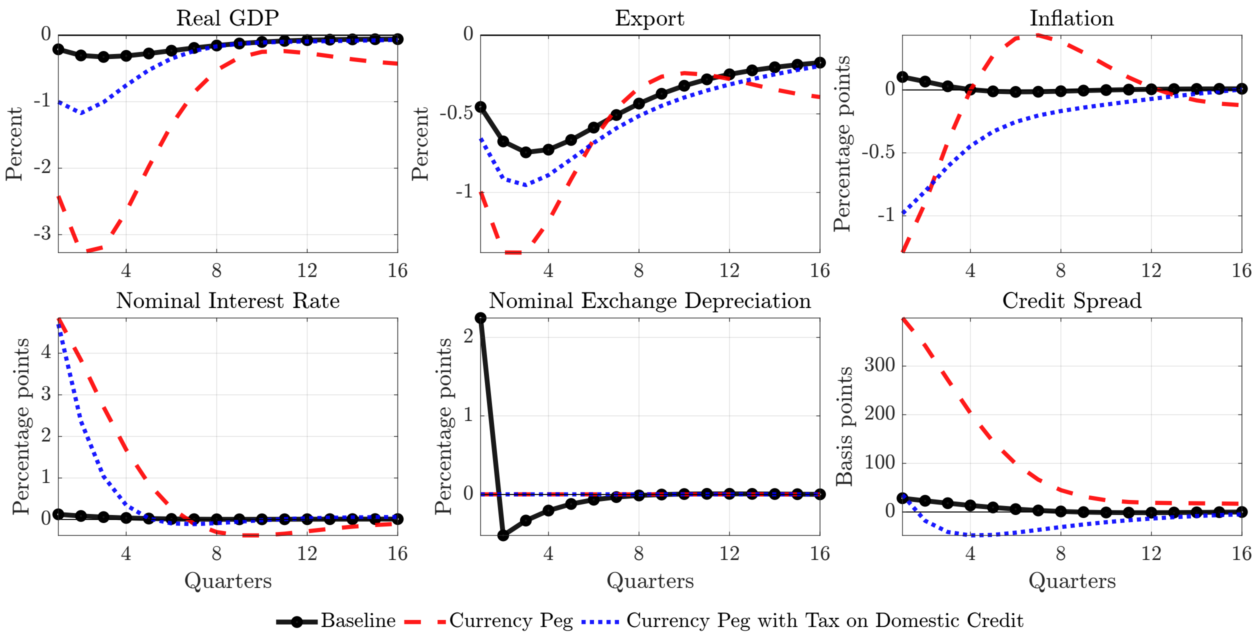
steady state

$$\tau_t^j = \left(\frac{q_t z_t}{qz}\right)^{\phi_j} - 1, \tag{A5}$$

where $\phi_j > 0$ for $j = \{k, b\}$. As in the text, for each experiment, we choose the coefficient ϕ_j to maximize the utility of the Home representative household.

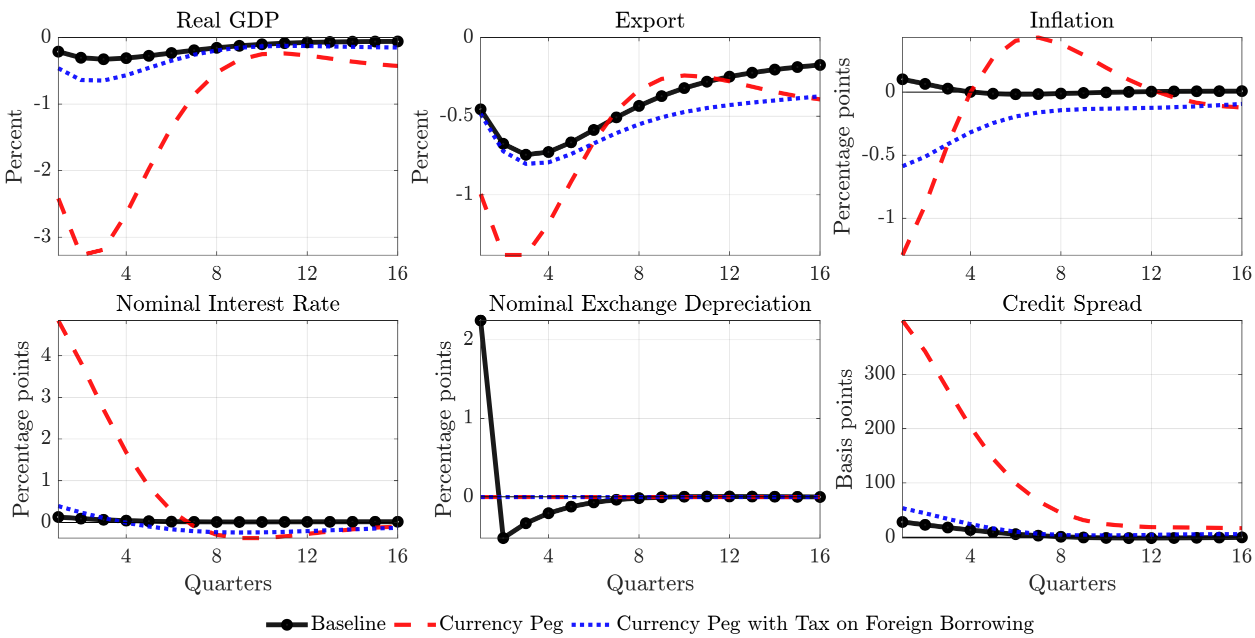
Figures C.2 to C.5 show that the baseline results are robust to the alternative specification. The most notable difference is that, under a peg, a tax on foreign borrowing that responds to deviations of credit from steady state can almost replicate the response of GDP (and, to a large extent, exports) under the baseline exchange rate regime (top-left and middle panels of Figure C.5). However, also in this case, the deflationary pressures remain (top-right panel), leaving our conclusions unchanged, at least qualitatively.

Figure C.4: A tax on domestic credit with a fixed exchange rate (alternative specification).



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 reported in annualized terms. The coefficient of the feedback rule that maximizes welfare of the Home representative household is $\phi_k^{\text{peg}} = 0.8$.

Figure C.5: A tax on foreign borrowing with a fixed exchange rate (alternative specification).



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 reported in annualized terms. The coefficient of the feedback rule that maximizes welfare of the Home representative household is $\phi_b^{\text{peg}} = 0.3$.